Financial Openness, Competition and Productivity

Liliana Varela*

November 2014

Abstract

This paper shows that the expansion in aggregate productivity following financial openness stems from reductions in distortions in capital markets that promote market competition and economy-wide innovation efforts. I use a small open economy model where capital controls distort access to capital markets across firms. Financial openness reduces this distortion and fosters productivity through two different channels. First, it relaxes financing terms and encourages constrained firms to invest in technology. Second, it tightens competition and leads unconstrained firms to invest more in technology as well. I test these two channels using firm-level census data around the deregulation of international financial flows in Hungary. I show that firms that gain access to international funds increased their investments in technology due to greater use of external funds. Responding to the tighter competition, their unconstrained market rivals also increased their investments in technology. Pro-competitive effects are also observed in reductions in markups, industry concentration, and productivity and markup dispersions within sectors. The expansion in all firms' investment in technology coincides with a change in the source of aggregate productivity growth. While prior to the reform reallocation effects were the main source of productivity growth, after the reform its expansion is driven by increases in within-firm productivity.

(Keywords: financial openness, TFP, firm-level distortions, financial frictions, competition. JEL: F36, F41, F43)

*University of Houston, lvvarela@uh.edu. I am grateful to Vasco Carvalho and Romain Rancière for their advice and encouragement, and to Philippe Aghion, Philippe Askenazy, Geert Bekaert, Alessandra Bonfiglioli, Paula Bustos, Nicolas Coeurdacier, Gino Gancia, Roger Guesnerie, David Hemous, Jean Imbs, Luigi Pascali, Thomas Piketty, Peter Neary, Diego Restuccia, Bent Sorensen, Gilles Saint-Paul, Carlos Vegh, Jaume Ventura and Robert Zymek, as well as participants of several conferences and seminars for helpful comments and suggestions. I am also thankful to the Research and Statistics Departments of the National Bank of Hungary for sharing the database for this project. I gratefully acknowledge financial support from the French Ministère de l'Enseignement et de la Recherche and PSE.

1 Introduction

There is a broad consensus among economists that differences in income per capita across countries can be mainly attributed to differences in total factor productivity (TFP).[1] Recent research has shown that these differences can be in part due to policy distortions affecting the allocation of resources and firms' incentives to invest in technology. Restrictions in the access to capital markets are an important source of these distortions, as for example they can prevent firms from investing in more advanced technologies. In the last decades, many countries have lifted capital controls in order to benefit from the expansion of financial globalization. Remarkably, these reforms have been followed by increases in aggregate TFP (Levine 2001; Bonfiglioli 2008; Bekaert, Harvey, and Lundblad 2011). A natural question to ask is then: What are the underlying causes of the expansion in aggregate TFP following financial liberalization episodes?

In this paper I investigate a novel channel linking capital markets, competition and firms' investments in technology that can explain this phenomenon. I propose a simple small open economy model in which capital controls create distortions in the access to international capital markets. The model shows that, in an environment where competition and productivity are endogenous, these distortions not only affect the investments in technology of firms restricted from borrowing from abroad, but also the investments of their market rivals. By removing these distortions, financial liberalization promotes these investments through two sources. First, better credit conditions encourage firms that gain access to international funds to invest more in technology. Second, pro-competitive forces induce their market rivals to do the same. The increase in both firms' investments in technology yields an acceleration of aggregate productivity growth. I test the implications of the model using the liberalization of international financial flows in Hungary in 2001. I focus my analysis on Hungary for two reasons. First, regulations in force prior to the liberalization created asymmetries in the access to international borrowing across firms that I exploit as a source of cross-sectional variation in my empirical analysis. Second, unlike most capital account opening episodes, the liberalization in Hungary was isolated from major reforms (such as trade openness, FDI liberalization, bank deregulation or changes in the competition policy). This case offers a unique event to study the forces at play during financial liberalization episodes.

I first develop a small open economy model in which capital controls create asymmetries in the access to capital markets that distort competition and firms' innovation incentives. The economy is populated by two types of firms - home and foreign - that compete in an oligopolistic market for a homogeneous good. This capital-scarce economy uses foreign funds to finance its investments. However, there are capital controls in force for domestic firms that increase their borrowing costs. In this way, capital controls create a wedge between the cost of capital of domestic and foreign firms. The model shows that this distortion affects competition and the innovation incentives of both types of firms. Greater cost of capital reduces domestic firms' post-innovation profits and, thus, their innovation incentives. Preferential access to capital markets allows foreign firms to earn financial rents, which reduce their innovation incentives. As a result, all firms engage less in these

[1] See Klenow and Rodríguez-Clare (1997), Hall and Jones (1999), and Caselli (2005).

activities and aggregate productivity grows at a slower pace.

The model offers several implications of a reduction in the distortion caused by financial liberalization. First, both domestic and foreign firms increase their innovation efforts. For domestic firms, the improvement of credit conditions raises their post-innovation rents and thus their incentives to undertake these activities. For foreign firms, tighter competition raises their incremental profits from innovating, which encourages their innovation efforts. Notably, since the distortion has a larger impact on domestic firms' innovation activities, their innovation efforts increase relatively more. Second, foreign firms' markups decrease. This reduction stems from two sources: the fall in the extra rents coming from the asymmetric access to capital markets, and the decline in the productivity gap relative to their domestic competitors. Third, the decline in the productivity gap between foreign and domestic firms is inversely related to the initial productivity difference. Fourth, greater innovation efforts lead to an acceleration of aggregate productivity growth.

I then test the implications of the model using the deregulation of international financial flows in Hungary in 2001. This reform provides a good source of arguably exogenous time variation, as it was one of the requirements that eastern European countries had to fulfill in order to join the European Union in 2004. As a source of cross-sectional variation, I use differences in the access to international borrowing prior to the reform. In particular, the regulations in force prior to 2001 created asymmetries in the access to international funds between domestic and foreign firms. Whilst these regulations led domestic firms to only borrow locally in the national currency, foreign firms directly accessed international funds. As reported by previous studies (Desai, Foley, and Hines 2003; and Desai, Foley, and Forbes 2008, among others), this preferential access to international funds offers foreign firms financial advantages over their local competitors. I exploit this asymmetric access to international borrowing to study the differential impact of the reform on home and foreign companies. I use firm-level data, covering the population of manufacturing firms in the period 1992-2008, from firms' balance sheets reported to tax authorities and provided by the National Bank of Hungary (NBH). 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 data on credit market conditions, R&D and innovation activities for a cross-section of firms.

In my empirical analysis, I first study the differential impact of the liberalization on domestic firms' investment in capital, productivity, and R&D and innovation activities. Reduced-form regressions show that domestic firms see a greater increase in capital intensity (25%), labor productivity (5%) and RTFP (3%) relative to their foreign competitors. They also increased their probability of conducting R&D as well as innovation activities (9% and 12%, respectively). The results reveal the pro-competitive forces of financial liberalization: in sectors where competition deepened the most, foreign firms increased their productivity more. Second, I assess the channel proposed in this paper by investigating whether this expansion correlates with higher use of external finance. Empirical results confirm that credit conditions significantly improved for domestic firms, which accordingly increased their indebtedness ratio (23%). These results are consistent with implication 1, which states that financial openness promotes all firms' investments in technology, but those of domestic

firms relatively more. Third, as predicted by implication 2, tougher competition led foreign firms' markups to fall relative to their domestic competitors. This effect was significantly more important in sectors where competition was initially more distorted. Fourth, I find a larger decline of revenue TFP (RTFP, hereafter) and markup gaps between domestic and foreign firms in sectors with higher initial dispersion, in line with implication 3.[2] This finding is consistent with a similar reduction in the concentration index (Lernex index). Finally, a structural-break test confirms the acceleration of aggregate productivity following the financial liberalization stated in implication 4. Overall, aggregate productivity growth rose by 3% per year over the three years following the liberalization. A decomposition exercise indicates that, reversing the previous pattern, this expansion is mainly explained by increases in within-firm productivity (82%). This result is consistent with the mechanism proposed in this paper, emphasizing changes in firms' incentives to invest in technology as a result of the reduction in distortions in capital markets.

Briefly, these results suggest that the decline in distortions in the access to international capital markets fostered domestic firms' investments in technology to a remarkable extent. In turn, pro-competitive forces led their foreign rivals to invest more in technology as well. The greater expansion of domestic firms is associated with decreases in the concentration index and the RTFP and markups dispersion within sectors. At the macro level, aggregate productivity growth accelerated significantly in the years following the reform. I show that these results are not subject to sample selection concerns and are not driven by pre-existing trends. Furthermore, they are robust to controlling for a full set of firm and sector characteristics.

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).[3] Bonfiglioli (2008) finds a positive effect of financial integration in 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. In addition, they find that the expansion of aggregate productivity accounts for the bulk of the increase in income per capita after financial liberalization episodes. However, these cross-country panel regressions do not address in detail the driving forces behind this expansion. Levchenko, Ranciere, and Thoenig (2009) build on this point and, using cross-industry and cross-country data, present evidence of pro-competitive forces. This paper complements these studies, by using, for the first time, firm-level census data around a particular financial liberalization episode to investigate the forces driving the expansion of aggregate productivity.

There is a long line of research addressing the question of whether competition encourages innovation activities. While previous studies find a positive direct effect of competition on innovation,

[2]It is essential 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).

[3]Several studies also emphasize 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).

recent evidence finds that this monotonic relationship is unclear.[4] This paper analyzes the question from a different angle: it identifies a particular distortion undermining competition and asks how its removal affects innovation. The model I introduce is close to the textbook one-period model of Aghion and Howitt (2009), to which I add asymmetries in the access to capital markets. The model shows that these asymmetries affect firms' optimal strategies. The removal of this distortion then tightens competition and encourages both constrained and unconstrained firms to increase their innovation intensities. 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 (see Holmes and Schmitz 2010). Another branch of the literature on innovation investigates whether financial constraints limit these activities.[5] This paper is also closely related to these studies, and particularly to Gorodnichenko and Schnitzer (2010) who find that in non-OECD countries, financial frictions restrain domestic firms from undertaking innovation activities. Supporting this view, I find that the easing of credit conditions indeed fosters domestic firms' innovation activities.

This paper is also related to the literature emphasizing that firm-level distortions can lower aggregate TFP (Restuccia and Rogerson 2008; Hsieh and Klenow 2009; Peters 2012). This paper is closest to Peters (2012) who shows that, in an environment where productivity is endogenous, these distortions affect not only its level, but also its growth rate. My paper departs from Peters' (2012) in that I identify a policy distortion and study how this distortion affects competition and firms' innovation incentives. Then, I use firm-level census data around a case event to test the model's implications. Focusing on financial imperfections, Midrigan and Xu (2012) and Jeong and Townsend (2007) show that financial frictions can preclude credit-constrained firms from adopting more efficient technologies and, in turn, reduce aggregate productivity. While this paper supports this view, it emphasizes the pro-competitive forces underlying movements in aggregate TFP. In a framework where competition is endogenous, asymmetric access to capital markets not only affects credit-constrained firms, but also unconstrained firms. In this way, the strategic interaction among firms amplifies the effect of the distortion in capital markets. In my empirical analysis, I show that this effect can be substantial and can account for an important part of the increase in aggregate TFP following financial deregulation episodes.

The remainder of the paper is structured as follows. In Section 2, I present the model and derive qualitative predictions of a reduction in distortions in the access to capital markets following financial liberalization. Section 3 describes the liberalization of international financial flows in Hun-

[4]For example, Nickell (1996) and Blundell, Griffith, and van Reenen (1999) find a positive and monotonic relationship between competition and innovation. Challenging these results, Aghion, Bloom, Blundell, Griffith, and Howitt (2005) present evidence of an inverted-U shape. Recently, using a panel of French companies, Askenazy, Cahn, and Irac (2013) illustrate that the inverted-U shape flatters when taking firm size into account.

[5]To name a few, Savignac (2008) finds that financial constraints reduce the probability of undertaking innovation activities in a panel of French firms. Czarnitzki and Hottenrott (2011), using a direct measure of the access to external capital on German firms, report that credit conditions restraint expenditures on R&D, especially for small firms. Mulkay, Hall, and Mairesse (2000) and Bond, Harhoff, and Reenen (2010) focus on the relationship between cash flows and innovation activities.

gary and how the regulations in force affected firms' access to international borrowing. 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.

2 Model

In this section, I develop a simple small open economy model to study the impact of distortions in the access to international capital markets on competition and firms' innovation incentives. The model considers three main ingredients. First, I allow for asymmetries in the access to capital markets among firms. In particular, I assume that the economy is populated by two types of firms: home and foreign. I let foreign firms have perfect access to international capital markets, but home firms are subject to capital controls. These controls take the form of a per unit tax that domestic firms have to pay to raise capital abroad. This tax creates a wedge between the interest rates paid by foreign and domestic firms. The model shows that this wedge affects profits and innovation incentives. Second, to account for pro-competitive forces, I consider an endogenous market structure in which foreign and domestic firms compete with one another. As such, firms compete in an oligopolistic fashion in a narrowly defined market. Under this framework, capital controls faced by domestic firms also affect the optimal response of their foreign competitors. Finally, to endogenously generate aggregate TFP growth, I let firms innovate and choose their optimal innovation intensities.

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. Labor is internationally immobile.

Final Sector

The economy is composed of a single final good Y, 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

I let each intermediate industry be composed of two firms: home and foreign (H and F), which differ in their access to capital markets. In addition to their production activities, firms can innovate to increase their initial efficiency level. The timing is as follows: at the beginning of the period, they choose their innovation efforts and, after learning the result of the innovation process,

they decide whether to produce. At the end of the period, firms earn profits and pay the factors of production. 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.* In each intermediate industry, domestic and foreign 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 has to resort 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, so it uses foreign funds to finance its investments. However, this access to international 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 for each unit of funds they raise abroad: $\tilde{\tau}$. 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. In this framework, capital openness can be seen as a decrease in the tax rate, $\tilde{\tau}$. Note that if capital markets were fully integrated, the domestic interest rate would equal the international rate, as in the standard small open economy model. It is also important to note that, similarly to the standard setting, capital flows from abroad until the return of the investment equals the interest rate paid on those funds. This model only differs from the standard in that here, capital markets are segmented. That is, foreign agents bring capital from abroad until the return of their local investment equals the international interest rate. Domestic agents borrow capital until the return of their investment equals their borrowing costs (the international interest rate plus the tax).

-*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 rent 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.

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

$q_{(F,j)} \geq q_{(H,j)}$.[7]

-*Technology and Innovation.* I follow Grossman and Helpman (1991) and Aghion and Howitt (1992), and assume that 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 firms' innovation efforts. Innovations stem from two sources: either F firms improve the existing technology, or H firms innovate aiming to overtake their foreign rivals' technology.[8] If an F firm succeeds in improving its technology, it reaches the next step in the quality ladder and its technology increases by λ. If an H firm produces an innovation, it obtains a new state-of-the-art technology, $\lambda\, q_{(j)}$.[9] Under this specification, the productivity difference between F and H firms in industry j can be expressed as a function of $\Delta_{(j)} \equiv n_{(F,j)} - n_{(H,j)}$, where $\Delta_{(j)}$ denotes the technological gap between F and H firms.

R&D technology is such that if a firm wants to have an innovation intensity of $x_{(s,j)}$, it has to hire Γ units of labor. In particular,

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

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 is equal for both F and H firms (ϕ), but foreign firms might enjoy lower innovation costs. Similarly to Klette and Kortum (2004), Atkeson and Burstein (2010) and Peters (2012), I let larger firms have lower innovation costs. In particular, I follow Peters (2012) and assume that the innovations of F firms are easier when their technological advantage is greater, i.e. $\lambda^{-\Delta}$.[10] These functional forms are also appealing because they ensure that firms' innovation efforts differ solely in their asymmetric access to capital markets, i.e. if firms enjoyed equal borrowing costs, their innovation intensities would be equal. In this way, they allow for the isolation of the mechanism proposed in this paper, namely how distortions in the access to international capital markets affect firms' innovation efforts.

[7] This assumption is not crucial, but it simplifies substantially the exposition. Furthermore, as presented in Section 5, this assumption is consistent with the empirical patterns observed in Hungary prior to the reform. 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 domestics, both in terms of labor productivity and TFP.

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

[9] To be consistent with the literature, 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.

2.2 Firm Behavior

In this section, I study how distortions in the access to international capital markets affect firms' profits and thus their innovation activities. I solve firms' optimal strategies by backward induction. Recall that, at the beginning of the period, firms choose their innovation intensities and, after learning about the results of their innovation, they decide whether to produce. Accordingly, I first compute firms' profits from producing activities at the end of the period, and then their innovation intensities.

In particular, after setting its price and minimizing its production costs, the active firm's profit from production activities is given by $\Pi_{(j)} = (1 - \xi_{(j)}^{-1})Y$, where $\xi_{(j)}$ denotes its markup. This expression shows that a firm's profit is proportional to its markup. I study then how the markup is determined if the firm succeeds in improving the existing technology, or if it keeps its initial productivity level.

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

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

where *post* and *pre* denote the markup if it succeeds in improving its technology or maintains its initial productivity level. τ is proportional to the tax rate, $\tau \equiv (1 + \tilde{\tau})^{\alpha} > 1$, and represents the difference in borrowing costs for domestic and foreign firms.[11] Equations (1) illustrate that, regardless of any technological advantage that foreign firms might have, they enjoy a financial advantage stemming from their preferential access to capital markets. In other words, capital controls raise the borrowing costs that domestic firms face and, thus, their marginal costs. This difference in marginal costs allows foreign firms to set higher prices. By this means, asymmetric access to international capital markets offers foreign firms a source of financial rents.

Then, at the beginning of the period, foreign firms' maximization program is

$$\text{Max}_{x_{(F,j)}}\, x_{(F,j)}\, \Pi_{(F,j)}^{post} + (1 - x_{(F,j)} - x_{(H,j)})\, \Pi_{(F,j)}^{pre} - w\, \Gamma(x_{(F,j)}, \Delta_{(j)}) \tag{2}$$

where $\Pi_{(F,j)}^{post}$ and $\Pi_{(F,j)}^{pre}$ denote the post- and pre-innovation profits from production activities, and w represents the wage.

If the home firm in sector j succeeds in climbing ahead on the quality ladder and becomes the industry leader, its markups will be given by

$$\xi_{(H,j)}^{post} \equiv \frac{p_{(j)}}{MC_{(H,j)}} = \frac{1}{\tau}\, \lambda \tag{3}$$

Otherwise, it will still have higher marginal costs than an F firm and remain out of the market.

[11] 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.

Unlike foreign firms, equation (3) shows that markups of H firms are reduced by the asymmetric access to capital markets. For a domestic firm, capital controls work as a financial burden. Even if an H firm manages to overtake its foreign rival's technology, it still faces higher borrowing costs. The greater borrowing costs limit its ability to set higher prices and, thus, its markups.

Similarly, before producing, home firms choose their innovation intensities so as to maximize their expected profits net of innovation costs. That is,

$$\text{Max}_{x_{(H,j)}}\, x_{(H,j)}\, \Pi^{post}_{(H,j)} - w\, \Gamma(x_{(H,j)}) \tag{4}$$

Firms' optimal innovation intensities, $x^o_{(F)}$ and $x^o_{(H)}$, after maximizing (2) and (4) are given by:

$$x^o_{(F)} = \frac{1}{\tau}\,\frac{\phi(1-\lambda^{-1})}{w}Y \qquad x^o_{(H)} = \frac{\phi(1-\tau\,\lambda^{-1})}{w}Y \tag{5}$$

Equations (5) show that both firms' optimal innovation intensities are reduced by the asymmetric access to international capital markets. Note that firms' innovation intensities are constant across industries and they only differ with firms' borrowing costs (τ). As 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. 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 during this period is given by,[12]

$$g_q = \ln(\lambda)\ (x^o_{(F)} + x^o_{(H)}) \tag{6}$$

From equation (6), it is clear to see that, as both foreign and domestic firms undertake fewer innovation activities, the economy grows at a lower rate.

-Capital Controls, Competition and Innovation

Equations (5) illustrate that capital controls creating asymmetries in the access to international capital markets reduce both foreign and domestic firms' innovation efforts. However, the origin of this decrease differs in each case. For foreign firms, their preferential access to international funds offers them financial rents that reduce their incremental profits from innovating and, thus, their innovation incentives. Intuitively, when these firms are active in equilibrium, the difference in borrowing costs allows them to set higher monopolistic prices. The lower extent of their production activities reduces their innovation incentives aimed at decreasing their production costs.

[12]To see this, 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 (6).

For domestic firms, it is the greater borrowing costs they face that reduces their post-innovation profits and, in turn, their incentives to undertake innovation activities. Therefore, capital controls reduce innovation efforts of both foreign and domestic firms and, thus, their aggregate productivity growth.

To understand the intuition of the mechanism implied by the model, it is useful to think of a case in which the tax rate is such that innovation activities are unprofitable for home firms. This is the case when $\tau > \lambda$.[13] In this case, even if the domestic firm succeeds in obtaining 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, domestic firms have no incentive to undertake innovation activities. Under this framework, only foreign firms are active in equilibrium, and domestic firms just restrict their price-setting behavior. Importantly, the larger the difference in the access to international capital markets, the greater foreign firms' financial rents and the lower their innovation intensities and aggregate growth.[14]

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 financial flows, I take derivatives with respect to τ of the main outcomes. In this way, I compare two steady states with high and low levels of capital controls.

As I show below, by facilitating access to capital markets for home firms, the deregulation of international capital flows deepens market competition and promotes firms' innovation activities. More precisely, the fall in the cost of capital raises domestic firms' post-innovation rents and, therefore, their innovation efforts. In turn, the decrease in the difference in borrowing costs increases foreign firms' profits from innovating and, thus, their incentives to undertake innovation activities. Since the expansion in the innovation intensities is greater for domestic firms, their technology gap with foreign competitors declines. This fall is larger in sectors where the initial gap was greater. Greater innovation intensities accelerate aggregate productivity growth. Propositions 1-4 formally state these effects. Finally note that throughout this section, I assume that $\lambda > \tau$ so innovation is

[13] Note that domestic firms' post-innovation profits are $\Pi_{(H)}^{post} = (1 - \xi_{(H)}^{-1})Y = (1 - \frac{\tau}{\lambda})Y$. Then if $\tau > \lambda$, home firms' post-innovation profits would be negative.

[14] Note that I assume workers are able to insure against the innovation risk, as in Peters (2012). 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.

profitable for both domestic and foreign firms, and they both undertake innovation activities.[15][16]

Proposition 1: Firms' innovation intensities*. By reducing the asymmetry in the access to capital markets (decreases in τ), financial liberalization increases all firms' innovation intensities. Notably, innovation intensities increase relatively more for domestic firms.*

Proof: In equilibrium, from equations in (5), $\frac{\partial x^o_{(F)}}{\partial \tau} < 0$ 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 innovation intensities increase for both domestic and foreign firms; however, the reasons for this expansion are different. The reduction in the asymmetric access to capital markets decreases foreign firms' ability to set higher prices and, therefore, to obtain financial rents. It is this fall that encourages them to innovate more. More precisely, a lower ability to set prices reduces both post- and pre-innovation profits. However, pre-innovation profits fall more. Since foreign firms' innovation incentives depend on the difference between post- and pre-innovation profits, this differential fall increases their profits from innovation activities.[17] Pre-innovation profits fall more because foreign firms' financial rents affect profits more when they are technologically closer to their local competitors. For home firms, it is the better access to capital markets that raises their post-innovation rents and, thus, their incentives to undertake innovation activities. Since the distortion discourages domestic firms' innovation intensities the most, its reduction induces a larger expansion in their innovation activities.

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

$$\begin{cases} \xi^{post}_{(F,\Delta)} & \text{with probability} \quad x^o_{(F)} \\ 0 & \text{with probability} \quad x^o_{(H)} \\ \xi^{pre}_{(F,\Delta)} & \text{with probability} \quad (1 - x^o_{(F)} - x^o_{(H)}) \end{cases} \tag{7}$$

[15] I assume an additional technical restriction on $\lambda < 2$. This assumption is common in the literature. The parameter λ is related with 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.

[16] See the appendix for detailed proofs of the propositions.

[17] This mechanism is analogous to the "escape competition" effect studied by Aghion, Bloom, Blundell, Griffith, and Howitt (2005).

Under the law of large numbers, a continuum of industries ensures that the foreign firm's markup will be equal to its expected value. More precisely,

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

Then, $\frac{\partial \xi^{e}_{(F,\Delta)}}{\partial \tau} > 0$. Intuitively, the pro-competitive forces at play reduce foreign firms' markups in two ways. First, the decrease in their preferential access to capital markets undermines their ability to set higher prices and, hence, their financial rents. Second, more favorable credit conditions encourage domestic firms to undertake greater innovation efforts, which reduce the technology gap with their foreign rivals.

Proposition 3: Change in the productivity gap and its initial level*. Reductions in τ lead to a negative relationship between the change in the technology gap between foreign and home firms and its initial level.*

Proof: At the end of the period, $\frac{\partial \Delta^{e}}{\partial \tau \partial \Delta} > 0$, where Δ^{e} is the expected technology gap in the sector and is equal to $\Delta + x^{o}_{(F)} - (1+\Delta)x^{o}_{(H)}$. Greater innovation intensities of domestic firms imply that they overtake their foreign rivals' technology levels. The decrease in the productivity difference will therefore be larger in sectors where foreign firms are far ahead of domestic producers.

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

Proof: From equations (5) and (6), $\frac{\partial g_q}{\partial \tau} < 0$.

The intuition in proposition 4 is simple: as both firms increase their innovation activities, innovation, and thus aggregate productivity growth, increase.

The new result of the model is that, by removing asymmetries in the access to capital markets, financial openness promotes all firms' investments in technology. What makes innovation more profitable is not only the improvement of credit conditions for home firms, but also the more competitive environment faced by their foreign rivals. It is important to note 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.[18]

[18] One way to think of this is to consider that firms pay their inputs for both production and innovation activities in the beginning of the period. To pay them, firms raise external funds. As I show formally in Appendix B, firms'

3 The Deregulation of International Financial Flows in Hungary

This paper analyzes the impact of firm-level distortions in capital markets on competition and on investments in technology. The model above has illustrated that capital controls, generating asymmetries in the access to foreign funds, can undermine both of these. A comparative static exercise has shown that the removal of these distortions can yield pro-competitive forces and promote firms' investments in technology. In the next sections, I use a particular deregulation episode -the liberalization of international flows in Hungary in 2001- to test the model's implications against the data.

Countries implement capital controls to regulate financial flows into and out of the economy. Regulations in the foreign exchange (FX) market are one of these controls, as they limit the extent to which agents are able to acquire foreign currency, hedge the exchange rate risk and, therefore, conduct international financial transactions. 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.[19] The extent of this reform 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. This Act used two main tools to limit financial transactions in foreign currency. First, it banned all forward instruments between the Hungarian forint (HUF) and foreign currencies -chiefly among them, FX swaps, and forward and future contracts. These forward contracts are main tools to raise foreign funds as they allow agents to hedge against currency depreciations. Lacking these instruments, agents are exposed to the currency risk. Second, it imposed important regulations on the spot market that limited the availability of foreign currencies and the extent to which agents could exchange them.[20] These regulations on spot transactions resulted in a small and illiquid

optimal innovation intensities, equations (5), 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.

[19] In accordance with the 1993 Copenhagen Criteria, EU membership requires that countries ensure free movement of capital. The complete deregulation of international financial flows was the only missing requirement that Hungary had to accomplish to fulfill these criteria. It is important to note that major reforms such as trade openness, FDI liberalization, banking deregulation, privatization of public companies, and changes in the competition policies had already taken place by early nineties (see section 5.2 for a detailed discussion).

[20] Under this Act, only authorized financial institutions and for authorized transactions could conduct operations in foreign currency. In addition, the regulations prevented non-resident agents from undertaking foreign exchange transactions in the local market. This last restriction had important consequences on the liquidity of the FX market, as these agents (principally, foreign pension and mutual funds) are big suppliers of foreign savings into the economy. Finally, there were important limitations on financial transactions in foreign currency for firms and households. For example, only after reporting income from abroad, resident firms could open bank accounts in foreign currency.

FX market. By binding the spot and forward FX markets, the Act XCV thus severely limited international financial flows.

The local financial sector was crucially affected by these regulations. As shown by previous studies (Smith and Walter 2003, 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.[21] 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.

Importantly, the regulations in the FX market significantly affected firms' ability to raise foreign funds. More precisely, they divided firms into two groups: those that were constrained by the local regulations, and those that could circumvent these regulations by directly accessing foreign funds. On the one hand, there were domestic firms, for which FX controls limited their foreign loans. Two reasons explain the lack of foreign loans to these firms. First, inasmuch they faced serious obstacles to acquire foreign currency and could not hedge movements in the exchange rate, they were themselves discouraged from using this type of funding. Second, financial institutions were also reluctant to offer them this type of loan, as they were considered highly risky under the regulations in force. In this context, domestic firms limited their financing to local credits in the national currency. On the other hand, there were foreign companies that, unlike domestic firms, could avoid the local restrictions by directly obtaining international funds. 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.[22] Second, they intensively used internal capital markets with their parent companies. 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.

[21] It is important to note that the absence of financial instruments to hedge currency risk not only discouraged banks from raising international funds to lend in local currency, but also in foreign currency. This is because by allowing hedging the currency risk, financial derivatives also allow extending the maturity of loans. To see this, consider a bank that obtains foreign funds for a length of three years. This bank would grant this loan up to three years. If it granted it for more years, at the end of the third year it would have to use domestic deposits to pay back its liability. As domestic deposits are in local currency, the bank would be exposed to exchange rate fluctuations.

[22] The link between the parent company and its bank was highly used by subsidiaries in transition economies, as it helped them avoiding the local financial imperfections and allowed benefiting from international credit conditions. See for example Weller and Scher (1999) and Weller and Scher (2001).

In this way, FX controls created asymmetries in the access to international borrowing between foreign and domestic firms. Whereas the former would have access to foreign funds, domestic firms would only finance themselves locally, in a tighter credit market. In Section 5, I exploit this asymmetry 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' bank indebtedness. Data from the National Bank of Hungary reveals that, before the liberalization, the short-term loans-to-sales ratio was more than a third lower for domestic firms.[23] In addition, the BEEPS survey indicates that in 2001 - the year of the reform - less than 5% of domestic firms could obtain credit in a foreign currency.[24] The survey also reveals that credit conditions were also tighter for domestic firms. They paid interest rates 2.5 percentage points higher than foreign firms, and the required value of the collateral on total debt was 58% greater (see Table 1).[25]

In 2001, the regulations on foreign exchange transactions were lifted. Crucially, the Act XCIII removed all restrictions in the spot market and allowed forward instruments between the HUF and foreign currencies. This deregulation of the forward market enabled the emergence of financial instruments aimed at hedging the currency risk. 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.[26] 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 (Figure 1, left chart). This expansion had a substantial impact on their external debt, which by 2004 had more than tripled (Figure 1, right chart). In parallel, banks started employing intensively financial derivatives. Both cross-border and local derivatives soared following the deregulation (Figures 2 and 3). As Figure 3 illustrates, the expansion of the turnover in the local FX market is mostly explained by FX swaps.[27]

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

[23]This information comes from firms' balance sheets of the APEH database that I use in the empirical section. Unfortunately, there is no information on the total amount of firms' debt with banks, only short-term loans are reported. I present the database with more detailed in Section 4.

[24]In a similar vein, data from the National Bank of Hungary reveals that, in 2000, credit in foreign currency was only granted to large firms (Table 1).

[25]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' credit conditions before 2001, and therefore do not allow knowledge of their characteristics in the years prior to the reform. See Section 4 for further details.

[26]Most of the firms did not have direct access to international credit markets. According to data from the National Bank of Hungary, less than 100 firms in the manufacturing sector enjoyed some kind of transaction with non-resident financial institutions in 2004, of which only ten were domestic companies.

[27]This increase in global banking operations had a large impact at aggregate level. Overall, the economy became much more integrated with the rest of the world. By 2004, total capital inflows of the financial account had doubled (Figure 6, left chart) and the net foreign asset position had deteriorated by 25 percentage points (Figure 6, right chart).

ratio had grown by more than a third.[28] 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 decrease in the lending interest rate (row 3 of Table 1).

Critically, the expansion of the credit supply substantially improved credit conditions for domestic firms. According to the BEEPS survey, by 2004, the interest rate differential between domestic and foreign firms had fallen three-fold from 0.22 to 0.07, and the difference in the value of the required collateral had dropped four-fold from 0.58 to 0.11 (rows 5 and 6 of Table 1). In addition, data from the National Bank of Hungary reveals that small and medium enterprises (SME) increased their proportion of total credits by 15 percentage points. 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. 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. The RTFP measure is computed using the Olley and Pakes (1996) method to estimate the parameters of the production function. To obtain real values, I use price indexes at four-digit NACE industries for materials, investment, value added, and production. I estimate markups as a wedge between the firm's labor share and the labor elasticity of production.[29] 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' indebtedness, 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%.

[28] To be consistent with my empirical analysis of Section 5, I present the values for the three years following the reform (2004). It is worth remarking that financial deepening continued throughout the decade.

[29] I will discuss this measure in Section 5.5. See also De Loecker and Warzynski (2012).

In Sections 5.3 and 5.4, I focus my analysis 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. The balanced panel accounts for 77% of value added and 70% of employment in the manufacturing sector. In Sections 5.6 and 5.7, I analyze the impact of the deregulation of international financial flows across the entire population of firms. I use the years prior and following the reform 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",[30] and this emphasis on "what is new to the firm" is of special interest to this study. 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 $R\&D$.[31] BEEPS surveys also contain information on firms' credit conditions. 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, I use this information to test econometrically whether domestic firms' credit conditions 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

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

[31] 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.

the amount of investment that cannot be financed through internal cash flows.[32]

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 the mechanism proposed in this paper by investigating whether this expansion correlates with a higher use of external finance. I also investigate the presence of pro-competitive forces by evaluating whether foreign firms react to the threat of competition. Section 5.5 evaluates the change in foreign firms' markups (proposition 2). Section 5.6 analyzes whether changes in the productivity gap between foreign and domestic firms within sectors are inversely related to their initial level (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.

5.1 Patterns in Aggregate Data Before the Reform

As discussed in Section 3, the regulations in force prior to 2001 created asymmetries in the access to international borrowing for foreign and domestic firms. Whereas the former would have access to foreign funds, domestic firms would only finance 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 illustrated in Table 2, foreign firms' share in total value added was 74%, and the Lerner index of industry concentration was high at 0.22.[33] Furthermore, at the three-digit industry level, the share of foreign firms was positively correlated with high levels of RTFP and markup dispersions, as well as with industry concentration (Table 3).[34] Importantly, by 2004, three years following the liberalization, the share of foreign firms in value added had dropped six percentage

[32] 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.

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

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

points and the Lerner index had shrunk by 10%.[35]

5.2 Identification Strategy

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

The identification strategy of the effect of financial liberalization 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 and tests the model's implications in two steps. First, I estimate the differential impact of the reform on domestic firms' investments in technology. Second, I test the financial channel implied in this paper, namely, whether this expansion correlates with a greater use of external funds. To this end, I employ another source of cross-sectional variation: sector financial needs. This allows exploiting three sources of differences: time, sector dependence on external finance, and firms' access to international borrowing prior the reform. Hence, I test the differential impact of the reform on domestic firms conforming to their financial needs. I also use data on indebtedness to check whether firms use bank credit more intensively.

Differences in sector reliance on external finance also allow testing for pro-competitive forces. That is, asymmetric access to international borrowing among rival firms should have distorted competition more in sectors requiring external funds more intensively. Then, market competition should deepen differentially more in those sectors. In this way, I can use 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 for a balanced panel of 5,548 firms, and presents sample means in the initial year by type of firm (1998). Prior to the reform, foreign firms were larger in terms of value added, employment, labor productivity and RTFP. In addition, as stated in the model, they also enjoyed higher markups. Despite the fact that firms were similar in age (the average age was 5.4 and 4.9 years for foreign and home firms, respectively), their difference in means is statistically significant.[36] Since the difference in means in these variables is significant at the one percent level, in my reduced-form regressions I control for them.[37]

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

[36]This feature is important as it goes against the argument that results could be driven by the expansion of new foreign investments in Hungary. On average, foreign firms had joined the market in the mid 1990s.

[37]The BEEPS survey also reveals important differences between foreign and home firms. As noticed in section 3, prior to the reform, foreign firms enjoyed lower interest rates and the value of the required collateral was smaller. In

A main assumption of this empirical strategy is that prior to 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 4 plots the evolution of the main outcomes analyzed: labor productivity, RTFP, capital intensity, markups and indebtedness. 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 indebtedness. 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 significant 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 average capital intensity and productivity growth at the four-digit NACE industry level in Hungary before the reform (1996-1997). Second, since sectors' productivity might be growing at a different pace in the global economy, I also control for capital intensity and productivity growth rates in the United States. Third, as a robustness test, I also consider sector-fixed effects at four-digit NACE industry level.

A critical hypothesis underlying the study is that the sample is not subject to selection issues; that is, pro-competitive forces may not only affect outcomes, but also the probability of a firm being observed. If this probability differed between domestic and foreign firms, 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 7).[38]

The general context of the reform and its timing make it likely to be exogenous with respect to

addition, foreign firms had higher probability of conducting innovation and R&D activities than home firms. Table 5 shows that the differences in means between foreign and home firms are statistically significant in all these variables.

[38] Although the reform did not differentially affect the survival probability of domestic and foreign firms, it indeed led only more productive firms to survive. Table D1 shows that firms in the unbalanced panel are substantially smaller and less productive. Notably, this difference remains after considering firms with more than five employees.

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 (EU).[39] 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.[40]

Even though the preceding points address the reverse causality problem, any event occurring in the years of the reform and affecting firms' investment choices 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 occurred in Hungary. 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.[41] Also, major reforms had already taken place during the early 1990s (such as privatization of public companies, bank deregulation or competition laws).[42] Furthermore, the EU did not require any further reform that could affect the development of the manufacturing sector. Finally, accession to the EU did not aimed at a major economic integration with the EU. By 2001, the Hungarian economy was already deeply integrated with the EU and particularly the manufacturing sector, whose exports to the EU accounted for 80% of total exports (see Figure 5).

5.3 Impact on Home Firms' Investments

The model illustrated 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,

[39] 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.

[40] 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.

[41] 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 7). Moreover, Hungarian external trade did not seem to have particularly suffered from the world recession in 2001. As shown in Figure 8, the volume of exports and imports continued to grow during that period.

[42] 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.

I test whether they expand more in terms of R&D and innovation activities.

5.3.1 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:

$$y_{it} = \delta_0 H_i + \delta_1 T_t + \delta_2 (H_i \, \mathrm{x} \, T_t) + \varepsilon_{it} \tag{8}$$

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 effect of the reform on domestic firms' outcomes.

A potential pitfall of regression (8), estimated with yearly firm-level data, is that residuals might 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.[43] 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 (8) in first differences becomes:

$$\Delta y_i = \delta_1 + \delta_2 H_i + \Delta \varepsilon_i \tag{9}$$

I cluster the OLS standard errors at four-digit NACE industries to take into account the correlation across firms within sectors. Regression (9), 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 (9), 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.[44] 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

[43] Since the reform took place during 2001, I omit this year to avoid distorting the estimations.

[44] 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.

2004, ψ_j.[45] The final statistical model I estimate is:

$$\Delta y_{ij} = \delta_1 + \delta_2 H_i + \delta_3 Z_i + \delta_4 X_j + \delta_5 \Delta\psi_j + \Delta\varepsilon_{ij} \tag{10}$$

The estimation of equation (10) by OLS is reported in Table 8. 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. 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 an increase of 0.032 logs points (t = 2.03) for domestic firms.

In Table D2, 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), export status (column 2), wholly foreign companies (90% of shares) (column 3), foreign firms used as export platforms (column 4), 1% of top firms (column 5), and firms that change their ownership status between the pre- and post-reform periods (column 6). 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. Table D3 confirms that the results are robust to different estimates of RTFP.

5.3.2 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,

$$y_{ijt} = \delta_0 H_{it} + \delta_1 T_t + \delta_2 (H_{it} \,\mathrm{x}\, T_t) + \delta_3 Z_{it} + \mu_j + \varepsilon_{ijt} \tag{11}$$

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).[46] To control for sector-specific characteristics, I add sector fixed effects: μ_j. I cluster the standard errors at sector level. Equation (11) with fixed effects cannot be consistently estimated by probit (incidental parameters problem), so I estimate 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.

[45] 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.

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

Columns 1-3 in Table 9 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).

It is interesting to remark on the estimated coefficients on the dummy for home firms prior to the liberalization, δ_0. The estimated coefficient across specifications is negative, which suggests that before the reform there was a lower probability of domestic firms undertaking both R&D and innovation activities than foreign firms. This finding is consistent with previous studies highlighting the negative impact of credit constraints on innovation activities. In particular, this is closely related to Gorodnichenko and Schnitzer (2010), who report that financial constraints restrict domestic firms' innovation activities in non-OECD countries.

The above results suggest 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 firms' expansion.

5.4 Investigating the Financial Channel

This section studies whether the expansion in firms' investments is correlated with greater exposure to external funds, as implied by the financial liberalization. I investigate this hypothesis through two steps. First, I analyze whether domestic firms with a greater need of external finance benefited more from the liberalization. Additionally, I examine the presence of pro-competitive forces on foreign firms. Second, using data on credit conditions and firms' indebtedness, I test whether domestic firms' expansion is supported by a deeper use of external funds.

5.4.1 Investment in Capital and Productivity

I test the financial channel by exploiting cross-sectional variations in sector financial needs. That is, I study three sources of variations: time, sector reliance on external finance, and firms' asymmetric access to international borrowing prior to the reform.

The use of this third cross-sectional dimension allows exploring two main implications of this paper. First, better credit conditions should encourage domestic firms to invest more in technology. Intuitively, this effect should be greater in sectors where the needs of external financial are larger. In this way, I evaluate whether domestic firms in more financially dependent sectors expand more after the liberalization. Second, pro-competitive forces should induce foreign companies to invest more

in technology as well. In particular, foreign firms' responses should also vary with the exposure to external finance. The reason is that the asymmetric access to international capital markets distorted competition more in sectors where firms use external finance more intensively.[47] Accordingly, both firms' productivity should expand in accordance with sector financial needs. Notably, as the distortion affected domestic firms more (as shown in proposition 1 of the model), conditional on the sector, domestic firms should expand more.

To evaluate these two implications, I include the cross-sectional variation in sector financial needs in equation (8). In particular, I consider the following model,

$$y_{it} = \delta_0 H_i + \delta_1 T_t + \delta_2 (H_i \,\mathrm{x}\, T_t) + \delta_3 (FD_j \,\mathrm{x}\, T_t) + \delta_4 (H_i \,\mathrm{x} FD_j \,\mathrm{x}\, T_t) + \delta_5 FD_j + \varepsilon_{it} \qquad (12)$$

where j denotes four-digit NACE industries and FD_j is the index of external finance of Rajan and Zingales (1998). Coefficient δ_3 in equation (12) captures the differential impact of the reform on foreign firms across sectors. This is, 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 their financial needs. Importantly, it indicates whether domestic firms expand more than their foreign market rivals with the same level of reliance on external funding. In this way, equation (12) allows identifying the expansion of foreign firms and the potential differential growth of domestic firms in accordance with sector financial needs.

As discussed earlier, a potential pitfall of estimating equation (12) with yearly firm-level data is that residuals could be serially correlated. To avoid serial correlation in the error term, I estimate (12) in first differences. After the inclusion of firm-level and sector controls, the final model I estimate is,

$$\Delta y_{ij} = \delta_1 + \delta_2 H_i + \delta_3 \, FD_j + \delta_4 \, (H_i \,\mathrm{x}\, FD_j) + \delta_5 Z_i + \delta_6 X_j + \delta_7 \, \Delta\psi_j + \Delta\varepsilon_{ij} \qquad (13)$$

Similarly to equation (12), 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 (10). I cluster the standard errors at four-digit NACE industries.

Columns 1-3 in Table 10 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 firm's initial characteristics and local and global trends (column 3). After including all controls, the estimated coefficient implies that domestic firms expanded 0.252 log points (t = 2.02) in the average external financial sector, i.e. machinery and equipment (corresponding to an index of 0.27). It is

[47] One way to think of this through the lens of the model is to consider that sectors have different capital intensities: α_j. Then, as $\tau_j = (1+\tilde{\tau})^{\alpha_j}$, a tax on capital imports ($\tilde{\tau}$) affects sectors heterogeneously. From equations in (5), it is straightforward to see that $\frac{\partial x^o_{(F)}}{\partial \tilde{\tau}}$ and $\frac{\partial x^o_{(H)}}{\partial \tilde{\tau}}$ increase in absolute value with α_j.

important to remark on the estimated coefficient for foreign firms, δ_3. This coefficient is not statistically significant in any specification, i.e. foreign firms did not expand their capital intensity in accordance with their needs of external finance. This result suggests that these firms might not have been credit constrained before the liberalization.

Columns 4-6 report the results for labor productivity. The estimated coefficients are consistent with the mechanism proposed in this paper. The coefficient δ_3 implies an increase of 0.09 log points (t = 2.50) of foreign firms' labor productivity in the sector with average financial dependence (machinery and equipment) 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. They differential increase in the average sector is 0.04 log points (t = 3.17) compared with the expansion of foreign firms.

Results on RTFP confirm the growth of firms' productivity in accordance with their financial needs (columns 7-9). After considering all controls, the estimated coefficients suggest that foreign firms in the sector with average financial dependence increase their RTFP by 0.07 log points (t = 3.02) (column 9). Just like the trends in labor productivity, domestic firms expanded more: in the sector with average financial dependence, their RTFP grew 0.04 log points (t = 2.48) above the increase of their foreign rivals.

The expansion of foreign firms' labor productivity and RTFP could also be interpreted as these firms being credit constrained. To account for this possibility, I assess whether these results are affected when considering different ownership structures. For example, one could think that firms with larger shares of foreign ownership would enjoy tighter links with parent companies and, thus, would be less credit constrained. If this were the case, the estimated coefficient on δ_3 would not be statistically significant. I estimate regression (13) on foreign firms with more than 50% foreign shares. The results presented in Table D4 attest against this argument, showing that the estimated coefficient remains positive and statistically significant. Together with the fact that foreign 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.[48]

5.4.2 Credit Conditions and Firms' Indebtedness

As discussed in Section 3, 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 credit conditions improved for domestic firms. Second, I use information on firms' short-term debt 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 11 reports

[48]This evidence is also consistent with previous industry-level studies reporting that increases in competition induce incumbent firms to raise their productivity (Holmes and Schmitz 2010).

the estimated coefficients of regression (11) on these outcomes. The coefficient on home firms is positive and significant before the reform, indicating that domestic firms did indeed face tighter credit conditions 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 financial flows improved credit conditions 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 illustrate 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' indebtedness by using APEH database to estimate regression (10) on the debt-to-sales ratio. The results presented in Table 6 confirm that domestic firms use bank indebtedness 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 the average domestic firm (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 mechanism proposed in this paper using equation (13) on firms' indebtedness. Column 4 shows that, as expected, the increase in indebtedness is larger for firms with greater financial needs. In the average financially dependent sector (i.e. machinery and equipment), domestic firms enjoyed an even greater expansion of 0.14 log points (t = 1.98). It is worth noting that foreign firms did not increase their indebtedness in accordance with sector financial needs. Instead, the estimated coefficient is negative and statistically significant. This decrease could indicate a reallocation of financial funds towards domestic firms, as it was suggested in line 4 of Table 1.

Throughout this section, I have investigated the channel implied in this paper. This is, whether the expansion in domestic firms' productivity correlates with a greater use of external funds. I have tested this channel in two steps. First, I have shown that domestic firms with greater financial needs increased their capital intensity, productivity and RTFP more. Second, I have provided direct evidence of this financial channel. I have illustrated that credit conditions improved substantially for domestic firms after the liberalization, and that they expanded their indebtedness ratio accordingly. As expected, the upsurge in the indebtedness ratio was greater for domestic firms in more financially dependent sectors. In addition, I have reported the presence of pro-competitive forces. The empirical results indicate that in sectors where asymmetric access to capital markets distorted competition more, foreign firms' productivity increased differentially. In the next section, I advance the analysis of pro-competitive forces by studying changes in firms' markups.

5.5 Foreign Firms' Markups

As illustrated by the model, firms' markups are proportional to the productivity advantage and the difference in firms' borrowing costs. Financial liberalization affects both of these. In particular, the second implication of the model stated that capital openness should reduce foreign firms' markup through these two sources. First, less distorted capital markets decrease their market power and thus their ability to charge higher prices. Second, their technological advantage decreases as domestic firms invest more in technology. Accordingly, foreign firms' markups should decrease after the reform. In this section, I test this prediction.

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

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

$$\xi_{(i,j,t)} = \frac{1}{\theta_{(i,j,t)}}\, \beta_j \tag{14}$$

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[49]; 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 (14), 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,

$$\Delta\xi_{ij} = \delta_1 + \delta_2 F_i + \delta_3 Z_i + \delta_4 X_j + \delta_5 \Delta\psi_j + \Delta\varepsilon_{ij} \tag{15}$$

where F_i is a dummy for foreign firms. δ_2 captures the differential effect 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 (10).

Column 1 in Table 13 regresses changes in markups on a dummy for a foreign firm. As predicted by the model, the estimated coefficient illustrates 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

[49]Recall that in the model, $\beta = 1 - \alpha$. See details in Appendix C on the estimation of the elasticities of the production function.

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 D3 confirms these patterns. Results are also robust to using the price-cost margin as a proxy for markups (see column 3 of Table D3).

It is important to note that the asymmetries in the access to capital markets should affect foreign firms' markups more in sectors with greater financial needs. As firms in those sectors use external funds more intensively, the difference in the borrowing costs should offer foreign firms greater market power and distort domestic firms' investments in technology more. To assess this implication, I test whether foreign firms' markups in these sectors decrease more by interacting the dummy for foreign firms with the financial dependence index of Rajan and Zingales (1998). The estimated equation is,

$$\Delta y_{ij} = \delta_1 + \delta_2 F_i + \delta_3 FD_j + \delta_4 (F_i \,\mathrm{x}\, FD_j) + \delta_5 Z_i + \delta_6 X_j + \delta_7 \Delta\psi_j + \Delta\varepsilon_{ij} \tag{16}$$

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 13. As expected, the reform produced a relatively greater decline in foreign firms' markups in sectors with higher needs for external finance. In the average financially dependent sector (machinery and equipment) their markups fell by 0.05 log points (t = 4.74). 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 hypothesis of this paper is that by removing distortions in capital markets, financial liberalization promotes competition and encourages firms' 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. Additionally, using cross-sectional variations in terms of sector financial needs, I have illustrated that domestic firms with a greater need of external finance expanded the most after the liberalization. I have provided direct evidence that their expansion is associated with an improvement in credit conditions and greater use of bank credit. The rise in their debt-to-sales ratio reflects this. In this way, better credit conditions following the reform seem to have encouraged domestic firms to invest in technology. Second, the empirical results also point to the presence of pro-competitive forces. In sectors where the asymmetric access to international borrowing distorted competition more, firms already enjoying access

to foreign funds increased their labor productivity and RTFP more. Notably, these firms did not increase their capital intensity nor their indebtedness in accordance with their exposure to external finance. In addition, their markups decreased regarding their domestic competitors. Importantly, this decline was larger in sectors with greater financial needs. As domestic firms' RTFP increased relatively more in those sectors, foreign firms' cost advantage fell more and so did their markups. In this way, reductions in distortions in the access to capital markets are associated with tougher competition.

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. In this section, I assess the validity of this proposition and investigate whether this decline works together with changes in the industry concentration.

Proposition 3 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 illustrated in equations (1) and (3), 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.[50] Therefore, I use differences in markups and RTFP between foreign and domestic firms as proxies for the physical productivity gap. Proposition 3 can be evaluated by estimated the following regression,

$$\Delta\kappa_j = \alpha + \beta\kappa_j + \varepsilon_j \tag{17}$$

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 and statistically significant β will support proposition 3.

A potential drawback of regression (17) 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:

$$\Delta\kappa_{jt} = \alpha + \beta_1\kappa_{jt} + \beta_2 T_t + \beta_3(\kappa_{jt} * T_t) + \varepsilon_{jt} \tag{18}$$

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

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

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).[51] The change after the reform, taking into account pre-existing trends, is then captured by the coefficient β_3 of the interaction term.

Table 14 presents the results for the dispersion of RTFP and markups. Column 2 reports the estimation of regression (17) for the reform period. In line with proposition 3, it illustrates a greater decrease in the RTFP gap in sectors where its initial level was larger. The estimated coefficient is -0.201 (t = 2.57) and implies that, in the sector with the average RTFP dispersion, the gap between foreign and domestic firms fell by 21%. Note that the inclusion of pre-existing trends, as in equation (18), 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 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 the larger decline in the differences in markups after the reform.

As discussed in Section 2, asymmetric access to external finance distorts market competition. This distortion could lead to higher levels of industry concentration. By removing distortions in the access to capital markets, financial liberalization deepens market competition and affects industry concentration. The reduction in industry concentration, however, should be heterogeneous. Intuitively, following the decline in the productivity gap, the fall in concentration should be larger in sectors in which its initial level was larger.[52] Following the standard literature, I use the Lerner index as a measure of concentration.[53] Column 9 in Table 14 including pre-existing trends confirms this hypothesis and shows that the reform caused a larger decrease in more concentrated sectors. The estimated coefficients imply a fall in concentration of 6% in a sector where the Lerner index was initially 0.25 (for example, basic metals).

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' investment in technology. Proposition 4 in the model states that greater investments in technology should accelerate aggregate productivity growth. In this section, I test this prediction on the population of manufacturing firms over the period 1992-2008. Next, to examine the contribution of firms' investments in technology to aggregate productivity growth, I break down the growth into improvements in firms' technical efficiency and

[51] This period consists in the average of two years (1996-97), instead of three as the other two periods. I exclude the year 1995 from the analysis, as an important downturn hit the Hungarian economy that year. Including that year could misrepresent the actual level of dispersion.

[52] Recall that firms with a greater productivity advantage have lower marginal costs that allow them to capture larger market shares.

[53] See Nickell 1996, Aghion, Bloom, Blundell, Griffith, and Howitt 2005, among others.

reallocation effects across firms.

To assess proposition 4, 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,

$$RTFP_t = \alpha + \beta_1 T_t + \beta_2 SB_t + \varepsilon_t \tag{19}$$

where t denotes year; T 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 capital openness. Column 1 in Table 15 reports the results of a regression where only the time trend is included. The estimation of equation (19) 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 financial liberalization. Columns 3-5 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 productivity growth after the trade liberalization in 1996. Columns 5 and 6 include falsification tests for structural breaks in slopes in the year 1998 and the year of joining the EU (2004). None of these controls affects the estimated coefficient for the acceleration of aggregate productivity growth following the financial liberalization.

Sources of Aggregate Productivity Growth

The results presented above associate the deregulation of international financial flows in Hungary with an acceleration of aggregate RTFP growth. In this section, I explore the sources of this growth and investigate how they relate to the increase in firms' productivity reported above.

I follow Petrin and Levinsohn (2011) to estimate aggregate RTFP and study the sources of its growth. First, I 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.[54] 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. Formally, I break

[54] See Restuccia and Rogerson (2008); Hsieh and Klenow (2009), among others.

down aggregate RTFP as,[55]

$$\Delta\, RTFP_t = TE_t + RE_t = \sum_{i,t}^{N_t} D_{it}\, \Delta RTFP_{it} + \sum_{i,t}^{N_t} \sum_{i,z,t} D_{it}(\varepsilon_{izt} - \theta_{izt})\Delta Z_{izt} \tag{20}$$

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 16 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 was mostly explained by reallocation effects, which accounted for 4.8% per year (columns 2 and 3). This pattern of growth was fully reversed after the financial liberalization. In the three years following the reform, within-firm productivity grew at an average pace of 7.9% per year and 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%. Importantly, the rise in within-firm productivity is mostly explained by the balanced panel of firms used above (column 4 of Table 16).[56]

What creates these two opposite patterns of growth before and after the liberalization? 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. More precisely, according to the mechanism studied in this paper, distortions in the access to capital markets reduce competition and innovation incentives. It is then natural that before the liberalization, within-firm productivity grew at a low pace. Financial liberalization reduced distortions in the access to international capital markets. As illustrated in the model, this fall in distortions encourages investments in technology by all firms; not only do firms that gain access to international funds invest more in technology, but so do their market rivals. It is the tougher competition that leads the latter to do so. In this way, by affecting all firms' incentives to invest in technology, financial liberalization can entail important changes in within-firm productivity. Throughout this paper, I have presented firm-level evidence of this mechanism. At the aggregate level, the expansion of within-firm productivity is also consistent with the mechanism.

[55] I present in Appendix C the derivation of equation (20) in detail.

[56] Interesting, if market shares are held constant to the initial year (1998), the rise in within-firm productivity still explains the bulk of the expansion in aggregate productivity of the balanced panel (more than 70%).

6 Conclusion

Financial liberalization has been associated with increases in aggregate productivity. What are the underlying causes of this expansion? This paper argues that this expansion is due to decreases in distortions in capital markets that encourage firms' investments in technology and promote competition.

Using a simple small open economy model, I have shown that capital controls can create distortions in capital markets that undermine competition and firms' innovation incentives. By removing these distortions, financial liberalization triggers pro-competitive forces and encourages all firms to increase their investments in technology. Under this framework, it is the greater innovation efforts undertaken by all firms that drive aggregate productivity growth. Unlike previous studies, I focus on the effect of financial asymmetries on competition. As I have shown, these frictions can have substantial effects on growth, as they affect not only constrained firms but also their market rivals.

I have used the deregulation of international financial flows in Hungary in 2001 to test the implications of the model. I did so using firm-level data covering the population of manufacturing firms over 17 years. This is the first paper to assess the effect of financial liberalization using such detailed information. The use of a long panel of census data is crucial because it enables to accurately test the mechanism proposed in this paper, whilst simultaneously controlling for pre-existing trends. The empirical results indicate that domestic firms benefited greatly from the liberalization. The improved access to credit markets allowed them to considerably increase their investments in technology and to close the technological gap with their foreign rivals. The latter responded to the threat of competition by also raising their investments in technology. At aggregate level, the rise in firms' investments in technology accelerated aggregate productivity growth by 3% over the three years following the reform. This faster growth led Hungary to reduce its income per capita gap with the OECD economies by more than 10%.

Once one starts to think about the impact of distortions in capital markets on competition, other questions emerge. For example, can pro-competitive forces explain why financial frictions on small firms have been found to have large effects on aggregate productivity? The conjecture that follows from this paper is that if financial frictions reduce competition, they can also discourage large firms from upgrading their technology. Since these firms have large market shares, their underinvestment can have sizable implications for aggregate productivity. With an international perspective, one could ask whether these asymmetries in capital markets can help to explain the lack of convergence of developing economies. The presence of large financial frictions that usually characterize these economies could damage pro-competitive forces. In this way, both the lack of financial opportunities and the poor competitive environment could significantly reduce innovation incentives and, thus, economic growth.

This paper also informs the current debate on global imbalances. It has been argued that large amounts of capital inflows can destabilize growth. In response, some countries have introduced capital controls to protect their economies. This paper warns of some potential implications of those measures. If capital controls were to introduce asymmetries in capital markets, they could

undermine competition and growth. Finding the right balance between the potential pitfalls of international financial integration and the benefits of ensuring equal financial opportunities across firms is one of the major challenges currently faced by policy makers in developing economies.

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 (1992): "A Model of Growth through Creative Destruction," *Econometrica*, 60(2), 323–51.

——— (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.

Blundell, R., R. Griffith, and J. van Reenen (1999): "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms," *Review of Economic Studies*, 66(3), 529–54.

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.

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.

Caselli, F. (2005): "Accounting for Cross-Country Income Differences," in *Handbook of Economic Growth*, ed. by P. Aghion, and S. Durlauf, vol. 1 of *Handbook of Economic Growth*, chap. 9, pp. 679–741. Elsevier.

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).

Czarnitzki, D., and H. Hottenrott (2011): "R&D investment and financing constraints of small and medium-sized firms," *Small Business Economics*, 36(1), 65–83.

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.

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.

Hall, R. E., and C. I. Jones (1999): "Why Do Some Countries Produce So Much More Output Per Worker Than Others?," *The Quarterly Journal of Economics*, 114(1), 83–116.

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.

Jeong, H., and R. Townsend (2007): "Sources of TFP growth: occupational choice and financial deepening," *Economic Theory*, 32(1), 179–221.

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.

Klenow, P., and A. Rodríguez-Clare (1997): "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?," in *NBER Macroeconomics Annual 1997, Volume 12*, NBER Chapters, pp. 73–114. National Bureau of Economic Research, Inc.

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

Kátay, G., and Z. Wolf (2008): "Driving Factors of Growth in Hungary - a Decomposition Exercise," MNB Working Papers 2008/6, Magyar Nemzeti Bank (National Bank of Hungary).

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

Levchenko, A. A., R. Ranciere, and M. Thoenig (2009): "Growth and risk at the industry level: The real effects of financial liberalization," *Journal of Development Economics*, 89(2), 210–222.

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 (2012): "Finance and Misallocation: Evidence from Plant-level Data," NBER Working Papers 15647.

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. (2012): "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.

Savignac, F. (2008): "Impact Of Financial Constraints On Innovation: What Can Be Learned From A Direct Measure?," *Economics of Innovation and New Technology*, 17(6), 553–569.

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

Smith, R., and I. Walter (2003): *Global Banking*. Oxford University Press.

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

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

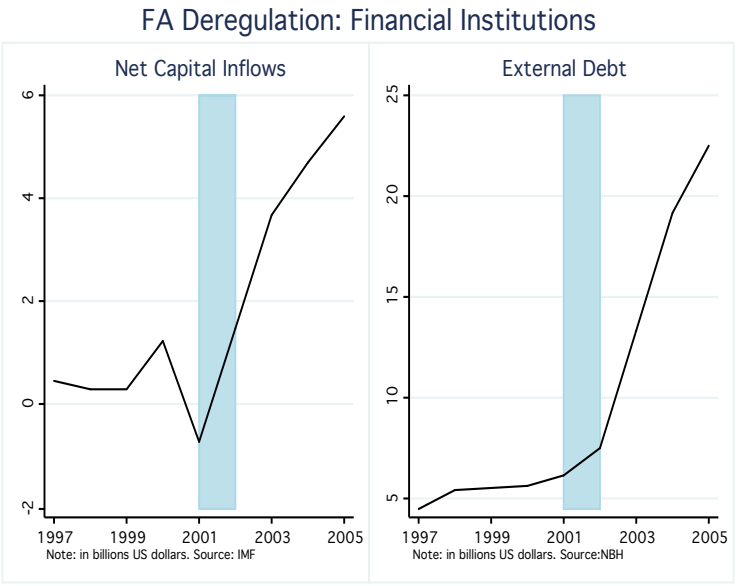


Figure 1: Impact on Financial Institutions International Borrowing

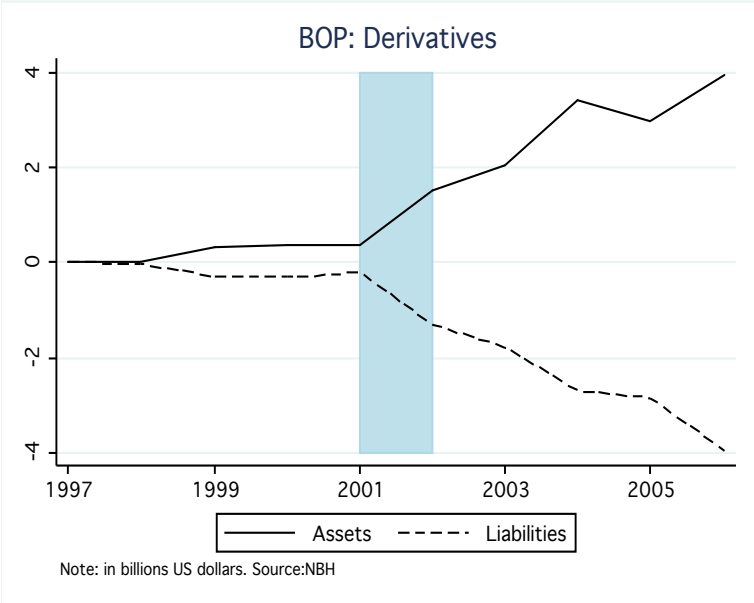


Figure 2: Impact on Financial Derivatives

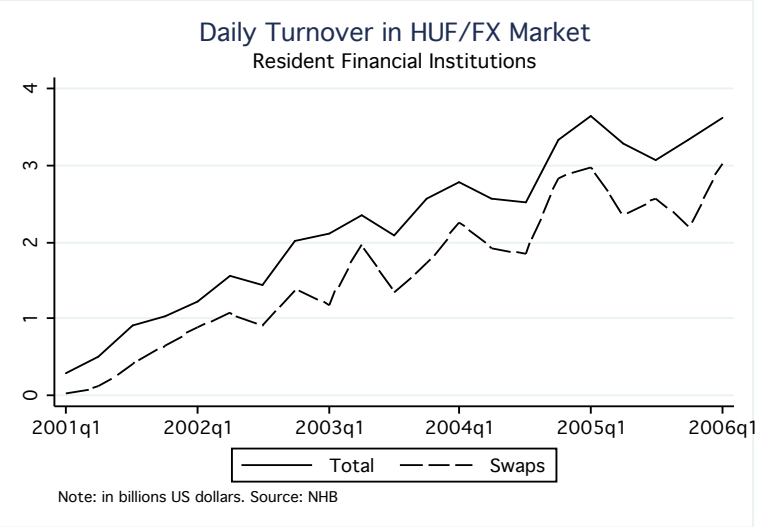


Figure 3: Deregulation of the Foreign Exchange Market

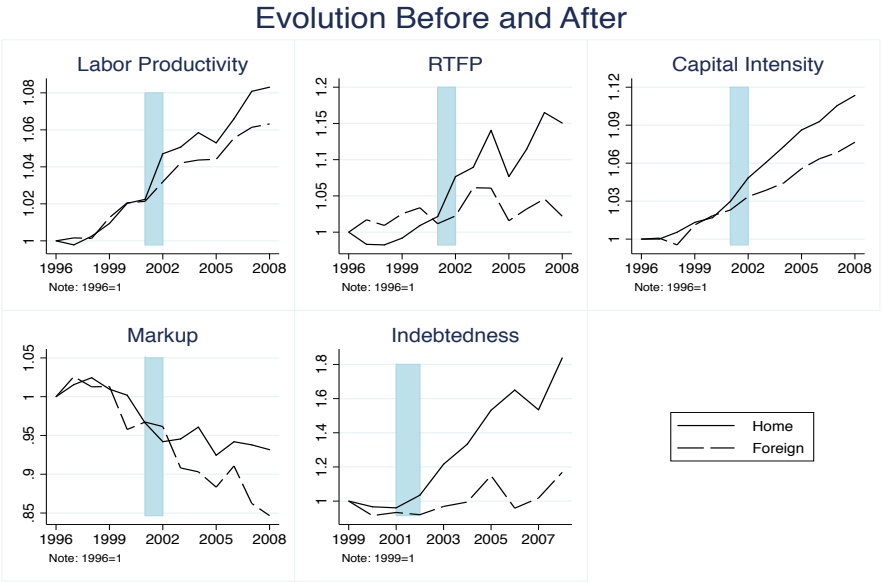


Figure 4: Evolution of Main Variables Before and After the Reform

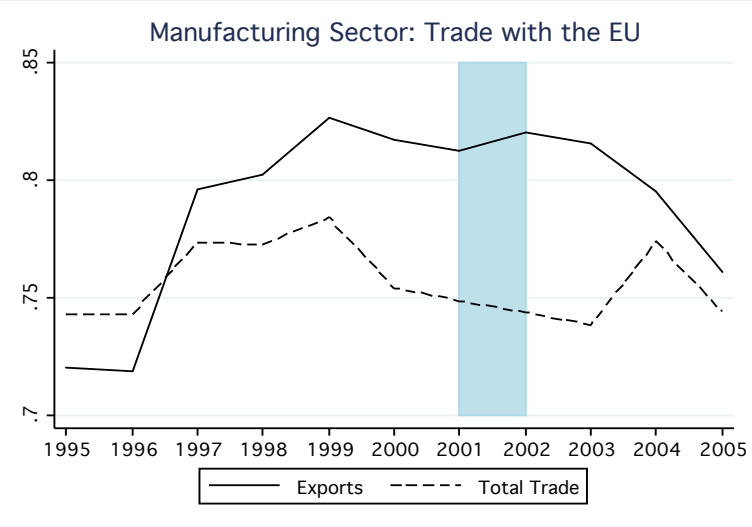


Figure 5: Total trade and exports with the European Union

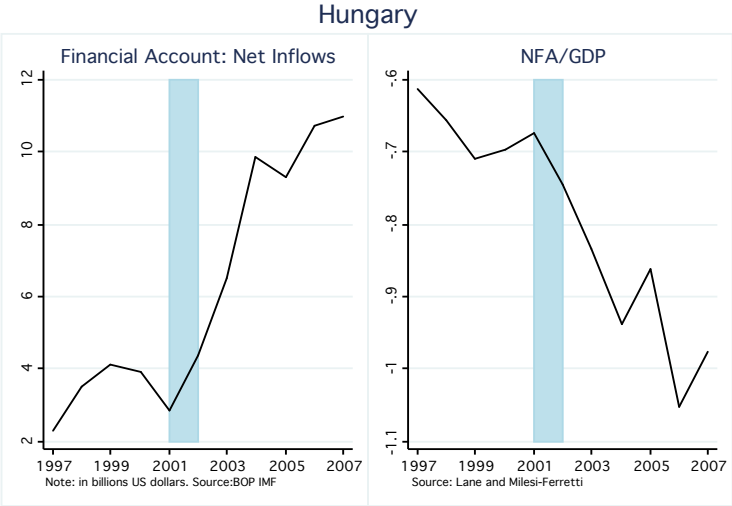


Figure 6: Impact of the Liberalization on the BOP and the Net External Position

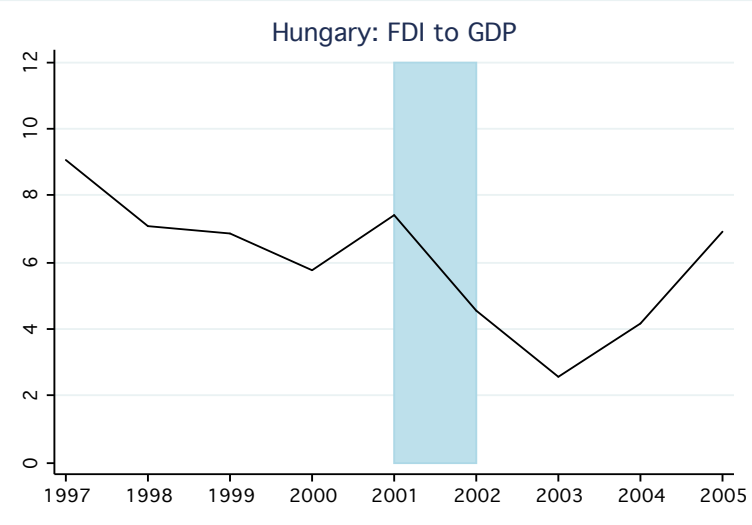


Figure 7: Evolution of Foreign Direct Investment

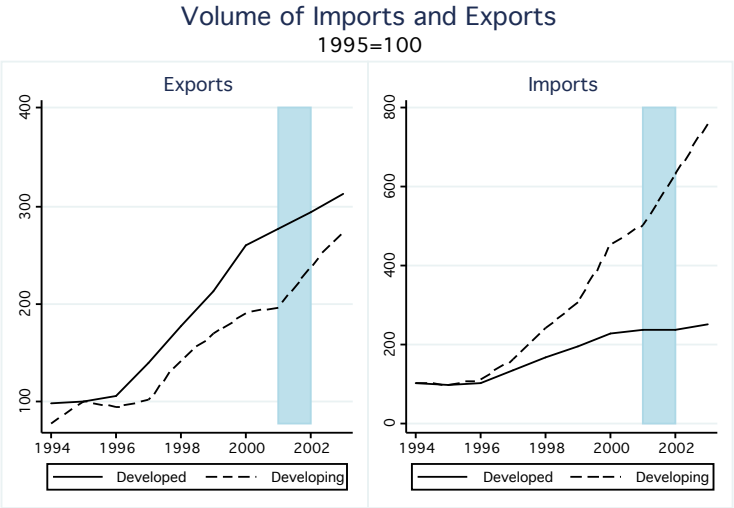


Figure 8: Evolution of Trade

Table 1: Credit Market Before and After the Liberalization

Aggregate Indicators	Before	After
Credit-to-GDP Ratio	0.27	0.44
Credit-to-Deposit Ratio	0.83	1.13
Lending interest rate	0.13	0.07
Firms		
Credits to SME	0.34	0.51
SME debt in FX	0.00	0.33
Interest rate differential b. Home and Foreign	0.22	0.07
Differential in collateral b. Home and Foreign	0.58	0.11

Notes: Rows1-5: source: National Bank of Hungary, before: December 2000, after: December 2004. Rows 6-7: Business Environment and Enterprise Performance Survey (World Bank and EBRD).

Table 2: Market Concentration Before and After the Reform

	Before	After
Share of Foreign on VA	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 (4)
Share of Foreign Firms	0.74	0.3568***	0.2184**	0.2394**
on Industry VA		(0.0003)	(0.0335)	(0.0118)
N	82	82	78	82

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Column 1 is the average across industries of the share of foreign owned firms on 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: Comparison of the Difference in 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)
Debt/Sales	-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: 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 the reform (in 2000), surviving = 1 if the firm did not exit within the 3 years following the reform (2004), and 0 otherwise. Source: APEH.

Table 8: 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
Constant	0.112***	0.216***	0.213***	0.176***	0.386***	0.353***	0.038**	0.402***	0.350***
	(0.018)	(0.052)	(0.052)	(0.018)	(0.037)	(0.040)	(0.017)	(0.076)	(0.042)
R^2	0.019	0.030	0.030	0.004	0.027	0.040	0.008	0.075	0.088
N	5448	5448	5448	5448	5448	5448	5448	5448	5448

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. Global industry controls include capital intensity and TFP growth rate of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rate 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 9: 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 10: 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)	(0.021)	(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)	(0.156)	(0.092)
Constant	0.120***	0.217***	0.211***	0.108**	0.334***	0.299***	0.001	0.373***	0.332***
	(0.021)	(0.039)	(0.044)	(0.050)	(0.076)	(0.089)	(0.046)	(0.082)	(0.050)
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	0.035	0.074	0.081	0.022	0.111	0.120
N	5143	5143	5143	5143	5143	5143	5143	5143	5143

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. Financial Dependence is the Rajan and Zingales' (1998) index. Global industry controls include capital intensity and TFP growth rate of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rate 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 11: Credit Market Conditions

	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 12: Indebtedness Ratio

	Δ Indebtedness Ratio			
	(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)
Constant	0.393***	0.085	0.105	-0.007
	(0.064)	(0.150)	(0.161)	(0.146)
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	2742	2742	2742	2457

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. Financial Dependence is the Rajan and Zingales (1998) index. Global industry controls include capital intensity and TFP growth rate of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rate 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: 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)
Constant	-0.098***	-0.101***	-0.101***	-0.115**
	(0.006)	(0.025)	(0.030)	(0.049)
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	5376	5376	5376	5086

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. Financial Dependence is the Rajan and Zingales (1998) index. Global industry controls include capital intensity and TFP growth rate of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rate 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 14: 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. *, **, *** significant at 10, 5, and 1 percent. Std errors in parenthesis. 3-digit NACE industries correlations. Source: APEH.

Table 15: 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 (FL)		8.992***	8.407***	9.115***	8.897***	11.083***
		(1.120)	(1.194)	(1.351)	(2.368)	(2.100)
Structural break in level (FL)			7.015			
			(5.620)			
Structural break in slope (TL)				-0.673		
				(3.769)		
Structural break in slope (Falsification test) (1998)					0.116	
					(2.527)	
Structural break in slope (Falsification test) (2004)						-3.513
						(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. *,**, *** significant at 10, 5, 1%, respectively. Source: APEH.

Table 16: 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 Static

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 (5). Furthermore, $|\frac{\partial x^o_{(F)}}{\partial \tau}| < |\frac{\partial x^o_{(H)}}{\partial \tau}|$.

Proposition 2. At the end of the period, the technology gap between foreign and home firms within a industry j will be,

$$\begin{cases} \Delta + 1 & \text{with probability} \quad x^o_{(F)} \\ -1 & \text{with probability} \quad x^o_{(H)} \\ \Delta & \text{with probability} \quad (1 - x^o_{(F)} - x^o_{(H)}) \end{cases} \tag{21}$$

Then, under the law of large numbers, the expected technology gap is,

$$\Delta^e = \Delta + x^o_{(F)} - (1 + \Delta)x^o_{(H)} \qquad \text{and} \qquad \frac{\partial \Delta^e}{\partial \tau} > 0$$

Under the law of large numbers and equation (7), foreign firms' expected markups are,

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

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

Proposition 3. From $\Delta^e = \Delta + x^o_{(F)} - (1+\Delta)x^o_{(H)}$, 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.

Appendix B Model: 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, asymmetries in the access to capital markets would affect firms' innovation activities more. This decrease would be even greater for domestic firms.

One way to study how credit constraints would affect innovation activities is by considering that firms have to pay their inputs in advance. To pay them, firms raise external funds. From equations (2) and (4), firms' expected profits net of innovation costs become:

$$\text{Max}_{x_{(F,j)}}\, x_{(F,j)}\, \Pi^{post}_{(F,j)} + (1 - x_{(F,j)} - x_{(H,j)})\, \Pi^{pre}_{(F,j)} - (1+r^*) w\, \Gamma(x_{(F,j)}, \Delta_{(j)}) \tag{22}$$

$$\text{Max}_{x_{(H,j)}}\, x_{(H,j)}\, \Pi^{post}_{(H,j)} - (1+r) w\, \Gamma(x_{(H,j)}) \tag{23}$$

Similarly as in the paper, firms choose their optimal innovation efforts so as to maximize their expected profits net of innovation costs, (22) and (23). They optimal innovations efforts are:

$$x^o_{(F)} = \frac{1}{\tau}\, \frac{\phi(1-\lambda^{-1})}{(1+r^*)\, w} Y \qquad x^o_{(H)} = \frac{\phi(1-\tau\,\lambda^{-1})}{(1+r)\, w} Y \tag{24}$$

Note that $\tau \equiv 1+\tilde{\tau}$ and is higher than in the paper. Recall that in the paper the asymmetric access to external finance only concerned capital 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 is greater, and affects firms' profits and innovation efforts relatively more. In addition, differences in interest rates also affect firms' innovation activities directly. Equations (24) illustrate that both firms' innovation efforts are reduced by the interest rates. Importantly, the higher interest rate paid by domestic firms decreases 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' profits from

production activities, which indirectly affects their innovation incentives. Notably, this distortion reduces domestic firms' innovation activities relatively more. It is worth mentioning that while a reduction in the tax rate, $\tilde{\tau}$, 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.

Appendix C Definition of Variables

Value Added

The database contains information on firms' output, materials, employment, capital, sales and exports. It also provides information on price indexes at the four-digit NACE industry level of materials, investment, producer and value added. With this information, I construct real value added as the real output minus real expenses in materials, deflated at the producer and the materials price indexes, respectively.

Capital Stock

The database provides information about the book value of tangibles and intangibles capital. Following the perpetual inventory method and Kátay and Wolf (2008) considerations for the Hungarian database, I estimate capital stock as the real value of fixed assets. To compute the capital stock, I use the entire period that the sample offers: from 1992 to 2008. First, I construct investment flows. As the database provides no information about firm's investment, I estimate it as a residual from the increase in the accounting capital in the year plus the depreciation value.

$$p_{jt}^{I} I_{ijt} = \Delta AK_{ijt} + \delta_{it} AK_{ijt-1}$$

where p_{jt}^{I} is the price of investment in the 4-digit NACE sector j at period t; I_{ijt} is firm's investment; ΔAK_{ijt} is the increase in the accounting value of fixed assets; $\delta_{it} AK_{ijt-1}$ is the depreciation value. After constructing the value of the nominal investment for each firm and year, I can estimate the series of capital stock for each firm:

$$K_{it} = (1 - \delta_{it}) K_{it-1} + I_{it}$$

where both capital and investment are deflated at the four-digit NACE price index, and the initial condition of the capital stock is the value in the year the firm enters in the database.

Firm's RTFP

From the Cobb-Douglas production function, I estimate firm's RTFP:

$$P_{it} Y_{it} = RTFP_{it}\, L_{it}^{\beta_s}\, K_{it}^{\alpha_s}$$

where i, s and t denote firm, two-digit industry sector and year; β_s and α_s are the estimated elasticities of the production function; and Y_{it} denotes the firm's value added. For robustness, I use the three most commonly used methodologies to estimate those elasticities: Petrin and Levinsohn (2011), Olley and Pakes (1996), and De Loecker and Warzynski (2012). Then, the firm's total factor productivity becomes:

$$ln\hat{RTFP}_{it} = lnY_{it} - (\hat{\beta}_s lnL_{it} + \hat{\alpha_s} lnK_{it}) \tag{25}$$

where the $\hat{}$ represents estimated values.

Industry Concentration

I estimate the level of concentration in each sector using the Lerner Index (LI) for each three-digit industry,

$$LI = \frac{\text{operating profit} - \text{financial costs}}{\text{sales}}$$

Operating costs are computed as total sales minus payroll and materials costs. The financial cost of capital is the net capital stock valued at the interest rate. The level of concentration is the weighted sum of the Lerner index of firms within the industry,

$$C_{jt} = \sum_{i \epsilon j} s_{ijt} LI_{ijt}$$

where s_{ijt} is the market share of firm i in the three-digit sector j at year t, and C_{jt} is the concentration index.

Aggregate RTFP Growth

Following Petrin and Levinsohn (2011), I define aggregate RTFP as the sum of firms' value added minus their total expenditures of inputs,

$$RTFP = \sum_{it}^{N_t} VA_{it} - \sum_{it}^{N_t} \sum_{izt} W_{izt} Z_{izt}$$

where i and t denote firm and year; N is the total number of firms in the economy; VA represents the value added; W is the price of input z; and Z denotes inputs: capital and labor. Then, the change in aggregate RTFP is,

$$dRTFP = \sum_{it}^{N_t} dVA_{it} - \sum_{it}^{N_t} \sum_{izt} W_{izt} dZ_{izt} \tag{26}$$

Consider firms production function as:

$$Q_{it} = Q^i(Z_{zit}, TFP_{it})$$

multiplying this expression by firms prices P_{it} and differentiating totally,

$$VA_{it} = P_{it}\, dQ_{it} = P_{it} \sum_{zt} \frac{\partial Q_{it}}{\partial Z_{it}}\, dZ_{it} + P_{it}\, dTFP_{it} \tag{27}$$

Replacing equation (27) in (26) yields the change in aggregate RTFP,

$$dRTFP_t = \sum_{it}^{N_t} \sum_{izt} \Big(\underbrace{P_{it} \frac{\partial Q_{it}}{\partial Z_{it}}}_{VMP_z} - W_{izt} \Big) dZ_{it} + P_{it}\, dTFP_{it} \tag{28}$$

where VMP_z is the value of the marginal product of input z. The term in brackets represents the wedge between the value of the marginal product of the input and its price. Rearranging the terms, the growth rate of aggregate RTFP becomes,

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

where D_{it} is the firm's share in total value added; ε is the input elasticity; and θ is the input share in value added.

Appendix D Robustness Tests

Table D1: Firm Survival

	Unbalanced and Balanced Panels Comparison		
	Unbalanced Panel	Balanced Panel	Difference in Means
Value Added	7.5285	9.6780	-2.1494***
	(0.0162)	(0.0220)	(0.0296)
Employment	1.7471	3.2182	-1.4711***
	(0.0126)	(0.0177)	(0.0226)
Labor Productivity	5.9570	6.4597	-0.5026***
	(0.0109)	(0.0115)	(0.0183)
RTFP	0.9814	1.3003	-0.3188***
	(0.0108)	(0.0118)	(0.0180)
Age	1.0841	1.8948	-0.8106***
	(0.0068)	(0.0047)	(0.0115)
N	14,701	5,448	

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors in parenthesis. All variables are in logs. The table reports the mean of a variable for the unbalanced and balanced panel in the year prior to the reform (2000). Source: APEH

Table D2: Robustness Test 1

	Δ Capital Intensity					
	(1)	(2)	(3)	(4)	(5)	(6)
Domestic	0.249***	0.260***	0.171***	0.254***	0.241***	0.282***
	(0.026)	(0.040)	(0.031)	(0.027)	(0.026)	(0.026)
Domestic * Exporter		-0.019				
		(0.050)				
Exporter		0.008				
		(0.044)				
Constant	0.205***	0.204***	0.306***	0.224***	0.281***	0.180***
	(0.053)	(0.058)	(0.059)	(0.055)	(0.061)	(0.053)
Firm-level controls	yes	yes	yes	yes	yes	yes
Sector-fixed effects	yes					
Local trends		yes	yes	yes	yes	yes
Global trends		yes	yes	yes	yes	yes
R^2	0.060	0.030	0.019	0.029	0.029	0.031
N	5448	5448	4747	4950	4881	5158
	Δ Labor Productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
Domestic	0.046***	0.041*	0.070***	0.052***	0.061***	0.060***
	(0.015)	(0.024)	(0.020)	(0.018)	(0.016)	(0.017)
Domestic * Exporter		0.006				
		(0.030)				
Exporter		-0.030				
		(0.029)				
Constant	0.456***	0.362***	0.342***	0.346***	0.327***	0.334***
	(0.030)	(0.043)	(0.045)	(0.043)	(0.042)	(0.042)
Firm-level controls	yes	yes	yes	yes	yes	yes
Sector-fixed effects	yes					
Local trends		yes	yes	yes	yes	yes
Global trends		yes	yes	yes	yes	yes
R^2	0.235	0.041	0.040	0.039	0.029	0.040
N	5448	5448	4747	4950	4881	5158
	Δ RTFP					
	(1)	(2)	(3)	(4)	(5)	(6)
Domestic	0.032*	0.035*	0.057***	0.031*	0.039**	0.039**
	(0.016)	(0.021)	(0.020)	(0.018)	(0.017)	(0.018)
Domestic * Exporter		0.006				
		(0.023)				
Exporter		0.010				
		(0.029)				
Constant	0.369***	0.370***	0.323***	0.343***	0.352***	0.341***
	(0.033)	(0.042)	(0.047)	(0.045)	(0.043)	(0.042)
Firm-level controls	yes	yes	yes	yes	yes	yes
Sector-fixed effects	yes					
Local trends		yes	yes	yes	yes	yes
Global trends		yes	yes	yes	yes	yes
R^2	0.155	0.082	0.088	0.086	0.077	0.087
N	5448	5448	4747	4950	4881	5158

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors are clustered at 4-digit NACE industries. Global industry controls include capital intensity and TFP growth rate of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and TFP average growth rate 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 controls for export status, where exporter is defined as having an average export share larger than 0.05 between 1998 and 2000. Column 3 removes those foreign firms whose foreign shares exceed more than 90% of total shares on average between 1998 and 2000. Column 4 restrict the analysis to foreign firms that are not used as export platforms (more than 90% of exports). Column 5 removes the top 1 percentile of firms (in value added). Column 6 controls for firms that change the ownership status between the pre- and post-reform periods. Source: APEH.

Table D3: Robustness Test 2

	Δ RTFP		Δ Markups		
	WLP	DLTL	PCM	WLP	DLTL
	(1)	(2)	(3)	(4)	(5)
Domestic	0.028***	0.081***			
	(0.009)	(0.026)			
Foreign			-0.127**	-0.034***	-0.024*
			(0.051)	(0.011)	(0.013)
Constant	0.285***	0.627***	-0.159*	-0.109***	-0.143***
	(0.037)	(0.118)	(0.082)	(0.022)	(0.040)
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	4864	4839	5029	4864	4839

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors are clustered at 4-digit NACE industries. Global industry controls include capital intensity and TFP growth rate of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and TFP average growth rate 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 (14). Source: APEH

Table D4: 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)
Domestic	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)
Domes.* 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)
Financial Dependence	-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)
Constant	0.089***	0.187***	0.183***	0.106**	0.323***	0.290***	0.004	0.371***	0.332***
	(0.027)	(0.047)	(0.052)	(0.042)	(0.073)	(0.086)	(0.036)	(0.045)	(0.048)
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	4915	4915	4914	4915	4915	4914	4915	4915	4915

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors are clustered at 4-digit NACE industries. 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 rate of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rate 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