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Competition, Innovation and Growth in Transition:
Exploring the Interactions between Policies

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Competition, Innovation and Growth in Transition: Exploring the Interactions between Policies[*]

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Abstract

Transition has entailed the introduction of policies to stimulate product market competition, to establish effective corporate governance and to harden enterprise budget constraints. How do these policies interact? Are they substitute policy instruments or does one policy reinforce the effect of another? Although early endogenous growth models predicted a negative relationship between competition and innovation, Aghion, Dewatripont and Rey (1999) showed that this could be reversed if agency considerations were introduced. In their model competition acts as an incentive mechanism to reduce managerial slack, which produces the additional prediction that competition and corporate governance are substitutable. But in a profit-maximizing framework in which incumbent firms innovate to escape competition, there will be complementarity between increased product market competition and governance and between competition and hard budget constraints (Aghion and Howitt 2002). We use the EBRD-World Bank Enterprise survey of over 3,000 firms in 25 transition countries to test for interaction effects between policies. We find that competition and hard budget constraints are complementary. We also find that competitive pressure (a) enhances the performance of old firms, which is suggestive of a role of agency effects and hence of policy substitutability and (b) enhances the performance of new firms, which is consistent with complementarity. Finally, the evidence points to the prevalence of financing constraints facing new firms.

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1 Introduction

Transition in post-socialist economies has entailed the introduction of multiple structural reforms. The aim of reforms has been to improve contract enforcement and property rights protection and to establish effective corporate governance through both privatization and fostering the formation of new private firms. Reforms have sought to increase competition and factor mobility. They have been directed at hardening firms' budget constraints by cutting off support from the state, enacting new bankruptcy codes and reforming the financial system. How do these different types of reform interact? Does success with one reform alleviate the need to press forward with others or are the benefits from one reform only available once reforms have been implemented elsewhere?

Policies implemented in transition have assumed that competition is good for performance. Yet prevailing endogenous growth models predicted a negative impact of competition on innovation. In the mid 1990s, interest reemerged in pinning down the theoretical and empirical relationships between product market competition and productivity growth (i.e. dynamic economic performance rather than static efficiency). Although partly motivated by the big stylized fact about competition and innovation in the two economic systems, the subsequent theoretical and empirical work developed largely outside the specific context of transition. Meanwhile pro-competition policies were being implemented alongside other reforms in the transition economies.

Our objective in this paper is to extract from the recent theoretical literature insights directly relevant to transition. In particular, we seek to clarify the economic mechanisms through which policies to increase competition may interact with other reform policies. We focus on the interplay between competition and the hardening of enterprise budget constraints, between competition and the governance of firms and between competition and credit rationing. To test the predictions of the models we use firm-level data from more than 3,000 firms in 25 transition countries collected in the EBRD's Business Environment and Enterprise Performance (BEEPS) survey implemented in 1999.

The paper is organized as follows. Section 2 motivates the relevance of endogenous growth models to the context of transition economies and summarizes previous results relevant to our question. Section 3 provides the theoretical underpinning for the paper by presenting the models and using them to analyze how the interplay between product market competition and corporate governance, soft budget constraints and credit rationing affects innovation. Section 4 describes the BEEPS data and the measures of competition, 'governance', soft budget constraints and innovation available in the data-set. Section 5 sets out the econometric testing strategy and presents the results. Section 6 concludes.

2   Motivation

It is useful to think of the dynamics of improved performance in the enterprise sector in transition economies as being driven by two processes. In the first process, old enterprises that existed under the planned economy are restructured. Unconditional state support for the survival of the enterprise and its work-force is removed. To survive, old enterprises have to take restructuring actions such as hiving off activities and reducing over-manning. Markets have to be found for their output. This is referred to as reactive restructuring. In a second process, enterprises make investments and innovate. So-called 'strategic restructuring' (innovation) is undertaken by some old enterprises and also by new firms. Aggregate performance of the enterprise sector improves as a result of shrinkage or closure of the weakest old firms and through successful innovation by both old and new firms.

In a transition economy, an example of an innovation is the introduction of a product that is new to the market or the modification of an existing one. When the reform process began, gaps in the provision of goods and services were revealed and an important step in understanding growth in transition is to understand what has determined the speed with which such niches have been filled. The introduction of technologies and forms of organization new to the economy such as quality control systems are also 'innovations'. Such innovations fall into the category of 'strategic restructuring' in the transition literature (Carlin, Van Reenen and Wolfe 1995, Grosfeld and Roland 1997). As we shall see, the tools of endogenous growth theory offer a way of modelling the incentives and constraints on managers to invest resources and effort in identifying and filling niches.

It is only recently that the endogenous growth literature has focused on the effects of corporate governance on innovation and growth. For example in Romer (1990) or Aghion and Howitt (1992), the financial structure of firms that innovate has no effect on the equilibrium amount of R&D. The models assume perfect capital markets, so that the Modigliani-Miller theorem applies. Equilibrium R&D is determined by the total net present value of monopoly rents from innovating. And the effect of product market competition in these models is unambiguously negative.

This prediction is in contrast to the empirical evidence on competition and growth in Nickell (1996) and Blundell et al. (1999), who documented a positive impact of competition on productivity growth and the number of innovations for UK firms. More recently, Aghion, Bloom, Blundell, Griffith and Howitt (2002) have reported a robust inverse-U relationship between product market competition and patenting activity by UK firms. The prediction is also contradicted by findings from transition economies reported in Carlin, Fries, Schaffer and Seabright (2001) (henceforth, CFSS) and in Grosfeld and Tressel (2001).

CFSS use the EBRD's BEEPS (Business Environment and Enterprise Performance Survey)survey data (i.e. the same data as used in this paper) and report that in explaining the real growth of sales of firms, two measures of competition were significant: both the number of competitors and an 'elasticity of demand' indicator. They found that competition at the level of the firm has a robust influence on sales growth and that the effect is non-monotonic. Firms facing one to three

competitors grew 10-12% faster than either those with no competitors or those with more than three. Controlling for the number of competitors, it was also the case that firms reporting less elastic demand grew faster. Sales growth was faster in new firms and in firms that had innovated in the sense of undertaking strategic restructuring actions. The likelihood of a firm introducing new products or modifying products was found to be positively affected by the presence both some market power and pressure from foreign competitors or customers. Softer budget constraints and state ownership made such 'strategic restructuring' actions less likely.

A first attempt to develop a growth model consistent with the empirical findings of a *positive* impact of competition on innovation proceeded by introducing corporate governance considerations. Aghion, Dewatripont and Rey (1999) — henceforth ADR — introduced Hart (1983)'s idea of 'competition as an incentive scheme' into the Schumpeterian growth paradigm. The ADR model features two types of firms, profit-maximizing ones and non-profit maximizing ones with 'satisficing' managers. The objective function of satisficing managers is to minimize effort (or delay innovations) subject to remaining in business, in order for them to preserve their private benefits of control. An example of such a firm is one that relies heavily on dispersed outside equity finance[1], so that the monetary returns to managerial innovative effort would mainly accrue to outside financiers.

For the standard Schumpeterian reason, increased product market competition would discourage innovations in an economy that is mainly composed of profit-maximizing firms. However, the effect is reversed in an economy that is mainly composed of firms with satisficing managers. The reason is that the higher the degree of product market competition, the lower the flow of rents to firms that have just innovated, and therefore the sooner a firm needs to make the next innovation in order to remain solvent. This effect is reinforced by the fact that a higher frequency of innovations puts upward pressure on wages as the average firm in the economy competes with more advanced firms for labour. Hence more product market competition stimulates innovation and growth, all the more when managers do not respond much to monetary incentives. Since the model accommodates both profit-maximizing and satisficing firms, it appears to be particularly well suited to the analysis of transition economies. New firms are more likely to be profit-maximizing and state-owned or newly privatized ones are more likely to have managers who behave as satisficers and are confronted with the need to undertake restructuring in order to survive.

Another prediction of this model is that the positive effects of product market competition on innovation tend to be reduced in firms with higher debt-pressure: the reason is simply that higher debt pressure already raises the required frequency of innovation for satisficing managers, thereby substituting for product market competition in inducing innovations. Thus, overall, the ADR model predicts that better corporate governance, as measured by higher managerial stakes in the firm's monetary profits or by a higher debt-asset ratio and higher enforcement power by creditors, tends to *reduce* the impact of product market competition on growth. These results stem directly from the modelling of competition as an incentive scheme.

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[1] See Jensen-Meckling (1976).

This latter prediction has been recently challenged by Grosfeld and Tressel (2001) with data from transition. Grosfeld and Tressel use a panel data set covering 200 firms listed on the Warsaw Stock Market during the period 1990-1998 and report that more product market competition (PMC) raises total factor productivity (TFP)growth.[2] They also report that PMC raises TFP growth and that the effect is stronger for firms with both concentrated and relatively dispersed ownership. The finding that the effect of PMC is enhanced for firms with highly concentrated ownership suggests a *complementarity* between corporate governance and product market competition.

Instead of introducing non-profit maximizing firms, the basic Schumpeterian model is extended by allowing incumbent firms to innovate (Aghion, Harris and Vickers (1997), Aghion, Harris, Howitt and Vickers(2001) and Aghion and Howitt (2002)) For convenience, we refer to this model as AHHV. Firms innovate in order to reduce production costs, and they do it 'step-by-step', in the sense that a laggard firm in any industry must first catch up with the technological leader before becoming itself a leader in the future. In this alternative framework, innovation incentives depend not so much upon post-innovation rents per se, but more upon the difference between post-innovation and pre-innovation rents (the latter were equal to zero in the basic model where all innovations were made by outsiders). In this case, more PMC may end up fostering innovations and growth as it may reduce a firm's pre-innovation rents by more than it reduces its post-innovation rents. In other words, competition may increase the incremental profits from innovating, and thereby encourage R&D investments aimed at 'escaping competition'. Moreover, it will do so to a larger extent when managers have stronger monetary incentives created for example by higher residual claims on the firm's profits and/or if they face a higher expected cost of default (i.e. a harder budget constraint) if they fail to innovate ahead of their competitors. In earlier endogenous growth models, innovation was done only by outside firms or by the most backward ones. The central insight in the AHHV model is that incumbent firms — not only outsiders and laggards — innovate.

In this paper we test for interaction effects between competition and the hardness of firms' budget constraints. The mechanism suggested by ADR would propose that a positive impact of competition on innovation stems from the increased threat to survival of managers in non-profit maximizing firms. If this threat is enhanced by a hardening of enterprise budget constraints, then the impact of competition should be less. Using the BEEPS data, we can test the interaction between budget hardness and competition because we are able to use the broad cross-country nature of the data to construct instruments for the hardness of the budget constraint at enterprise level. Contrary to the predictions of ADR, we find that competition and hard budget constraints are complementary. We also find that competitive pressure induces restructuring in old firms, which is consistent with ADR, and in new firms, which is not. The latter finding is more consistent with the models of competition and innovation in AHHV.

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[2]A table comparing the data sources, definitions and results of Grosfeld and Tressel and CFSS is provided in the appendix, Table A1.

3   Theoretical background

3.1   A model of competition and restructuring for old firms

This subsection outlines the ADR model (see ADR (1997), (1999)). By introducing firms with agency problems, this model is well-suited to the analysis of old firms in transition economies. Suppose a consumption good, taken as numeraire, is produced using a continuum of mass N of intermediate goods, according to the Dixit-Stiglitz technology:

$$y = \int_0^N A_i x_i^\alpha di, \ 0 < \alpha < 1,$$

where x_i denotes the amount of intermediate good i used by the final good sector and A_i is a productivity parameter that measures the quality of intermediate input i. The important feature of this formulation is that final goods producers can substitute between the different intermediate goods available. If the intermediate goods are closer substitutes, then we can say that competition between intermediate goods producers is more intense.

Each intermediate good producer enjoys monopoly power in its own sector, and faces two types of decisions: (i) an output decision for given technology A, which will determine the equilibrium profit flow of the firm for a given technology parameter, and (ii) a decision of when to adopt the leading-edge technology. Intermediate inputs are produced with labour according to a one-for-one technology, and at any point in time an intermediate input producer competes for labour with the most advanced firms. As a result, in steady-state equilibrium wages will grow over time at a rate equal to the rate of technological progress. Now, assuming that intermediate good production involves positive fixed costs, an intermediate goods producer that never innovates will see its gross profit flow shrink, and eventually fall below the level that would allow it to cover its fixed costs. Namely, one can show (ADR (1997)) that the equilibrium net profit flow of an intermediate firm with technological vintage A_τ (where for all s, $A_s = A_0 e^{gs}$) at time $t > \tau$, is of the form:

$$\pi_{t,\tau} = \psi(u, \alpha) e^{gt},$$

where: $u = t - \tau$ is the age the firm's technology at date t and:

$$
\begin{array}{lrcl}
\text{(i)} & \psi(0, \alpha) & > & 0; \\
\text{(ii)} & \psi_u & < & 0, \ \psi_\alpha < 0; \\
\text{(iii)} & \psi(u, \alpha) & < & 0 \ \text{ for } u \text{ sufficiently large.}
\end{array}
$$

The first condition says that the net profit flow of a firm that has just innovated is positive. The second condition says that this profit decreases with age and also with α, which measures the substitutability between intermediate inputs. As noted above, we take this as a measure of product market competition. The third condition

says that the net profit flow becomes negative when the firm has not innovated for too long.

Assuming that technological adoption requires the hiring of f skilled workers at the current wage for one unit of time, one can show that a *value maximizing* firm will choose to innovate every T^* periods, where:

$$T^* = \arg\max_T [\frac{-\omega f + \int_0^T \psi(u,\alpha)e^{-(r-g)u}du}{1 - e^{-(r-g)T}}],$$

with ω denoting the productivity-adjusted wage rate and r is the discount rate. One can show that T^* increases with α — in other words higher product market competition discourages innovations by value-maximizing firms as it reduces the monopoly rents from innovating. This is the Schumpeterian effect of PMC.

Consider now a firm with a 'satisficing' manager who does not respond directly to monetary incentives — her primary objective is to preserve her private benefits of remaining in control. She knows in advance that the monetary returns from her innovative efforts will mostly accrue to the state or to the new outside financiers. If private benefits of control are sufficiently large and the manager finds it costly to innovate (e.g an innovation involves firing workers and spending time becoming acquainted with the new technical knowledge) then the manager will typically delay the next innovation up to reaching the survival limits of the firm, i.e the point at which the firm will not be able to sustain survival.

The equilibrium frequency of innovations will then satisfy:

$$\int_0^T \psi(u,\alpha)e^{-(r-g)u}du = \omega f e^{-(r-g)T},$$

where the left hand side of this expression is the accumulated net profit of a firm that has innovated T periods ago (but evaluated as of the innovation date) and the right hand side shows the cost of making the next innovation (again evaluated as of the date of the last innovation). An increase in PMC as measured by α shifts the accumulated profit curve downward and therefore reduces the equilibrium frequency $\widetilde{T}$ defined by this equation. In other words, by reducing the amount of cash accumulated by an intermediate firm that has innovated, PMC forces that firm to innovate sooner in order to avoid going bankrupt. Thus competition should induce restructuring by state-owned firms or by firms with dispersed ownership — i.e. in firms with the weakest governance. Governance is stronger, the closer are the objectives of the manager to those of the owner(s) of the firm.

An additional prediction of this model is that debt-financing and PMC should be *substitute* instruments in inducing innovations and growth. To see this, let d denote the flow debt repayment obligation contracted by an intermediate firm, and suppose again that the manager is 'satisficing'. The equilibrium frequency of innovations will now satisfy:

$$\int_0^T [\psi(u,\alpha) - (r-g)d]e^{-(r-g)u}du = \omega f e^{-(r-g)T},$$

so that a higher d will have the same effect as that of increasing α, i.e. of increasing PMC, namely to shift the accumulated profit curve downward and therefore to

increase the equilibrium frequency of innovations $\widetilde{T}$. And for d sufficiently large, the effect of PMC on innovation will completely disappear. Similarly, the higher the manager's claims to monetary profits (i.e. the stronger is governance in our terms), the lower her response to increased PMC. The reason is that she will increasingly react like a value-maximizing firm. It is this particular prediction regarding the substitutability between 'governance' and PMC that has been challenged recently by the findings of Grosfeld and Tressel (2001).

3.2   A model of competition and innovation for new firms

We turn now to show how a new model of competition and innovation[3] can help to explain why an increase in product market competition can raise productivity growth even for firms with strong governance (e.g. profit maximizing firms with no agency problems). It is safe to assume that newly formed firms in transition economies are more strongly motivated by monetary incentives than is the case for old firms. Using this model, we shall see that once we introduce outside investors or bankruptcy costs, the impact of increased competition on innovation is reinforced by stronger governance or harder budget constraints.

3.2.1   Consumers

Suppose that final output, y, is produced using input services, x_i, according to the following production function

$$\ln y = \int_0^1 \ln x_i di. \tag{1}$$

Each intermediate goods producing sector i is assumed to be duopolistic with respect to both production and research activities, with final output generated according to

$$x_i = v(x_{Ai}, x_{Bi})$$

where v is homogeneous of degree one and symmetric in its two arguments. A special case is:

$$x_i = (x_{Ai}^\alpha + x_{Bi}^\alpha)^{\frac{1}{\alpha}} \tag{2}$$

where a higher $\alpha \in (0,1]$ reflects a higher degree of substitutability between the two inputs in industry i.

The log-preference assumption made in (1) implies that in equilibrium individuals spend the same amount on each basket x_i. We normalize this common amount to unity by using expenditure as the numeraire for the prices p_{Ai} and p_{Bi} at each date. Thus the representative household chooses each x_{Ai} and x_{Bi} to maximize $v(x_{Ai}, x_{Bi})$ subject to the budget constraint: $p_{Ai}x_{Ai} + p_{Bi}x_{Bi} = 1$.

In the special case where $v(x_{Ai}, x_{Bi}) = (x_{Ai}^\alpha + x_{Bi}^\alpha)^{\frac{1}{\alpha}}$, the demand functions facing the two firms in industry i are:

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[3]The following presentation of AHHV draws on Aghion, Harris and Vickers (1997), Aghion, Harris, Howitt and Vickers (2001) and Aghion and Howitt (2002)

$$x_{Ai} = \frac{p_{Ai}^{\frac{1}{a-1}}}{p_{Ai}^{\frac{\alpha}{a-1}} + p_{Bi}^{\frac{\alpha}{a-1}}} \quad \text{and} \quad x_{Bi} = \frac{p_{Bi}^{\frac{1}{a-1}}}{p_{Ai}^{\frac{\alpha}{a-1}} + p_{Bi}^{\frac{\alpha}{a-1}}}. \tag{3}$$

3.2.2   Technology levels, R&D and innovations

Each firm produces using labour as the only input,[4] according to a constant-returns production function, and takes the wage rate as given. Thus the unit costs of production c_A and c_B of the two firms in an industry are independent of the quantities produced. Now, let k denote the technology level of duopoly firm j in some industry i; that is, one unit of labor currently employed by firm j generates an output flow equal to:

$$A_j = \gamma^{k_j}, \qquad j = A, B, \tag{4}$$

where $\gamma > 1$ is a parameter that measures the size of a leading-edge innovation; (equivalently, it takes γ^{-k_j} units of labour for firm j to produce one unit of intermediate good). An industry is then fully characterized by a pair of integers (l, m), where l is the leader's technology and m is the technology gap of the leader over the follower. We define π_m (respectively π_{-m}) to be the equilibrium profit flow of a firm m steps ahead of (respectively behind) its rival.[5]

For expositional simplicity we shall concentrate here on the simple case where knowledge spillovers between leader and follower are such that the maximum sustainable gap is $m = 1$. That is, if a firm is one step ahead and it innovates the follower will automatically copy the leader's previous technology and so the leader will remain only one step ahead. Therefore, in that case, given that profitability is only dependent on the gap between leader and follower, no innovation will be undertaken by the leader. At any point in time there will therefore be two types of intermediate sectors in the economy: sectors where there is no technological gap between the firms (i.e. $m = 0$) so that firms are 'neck and neck', and leader-follower sectors where one firm is leading the other in the same industry, with a technology gap of one step (i.e. $m = 1$).

We denote by $\psi(n) = \frac{1}{2}\beta n^2$ the R&D cost (in units of labour) of a leader (resp. follower) firm moving one technological step ahead with a Poisson hazard rate of n.[6] Let n_m denote the research intensity put up by each firm in an industry with

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[4]In Aghion et al. (2001) we argue that the model can be easily extended to the case where firms use both capital and labor as inputs according to a CES production technology of the form:

$$x_j = (\alpha k_j^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(A_j l_j)^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}},$$

where A_j measured labor productivity in firm j and is multiplied by $\gamma > 1$ each time firm j innovates.

[5]The above logarithmic technology along with the cost structure $c(x) = x.\gamma^{-k}$ implies that the profit in the industry depends only on the gap m between the leader and follower, and not on absolute levels of technology.

[6]In Aghion et al (2001) we analyze a different model in which the laggard in an industry with technological gap m catches up immediately with the technological leader whenever she innovates, thereby reducing her unit labor cost by γ^{-m}. However, that formulation tends to exaggerate the

technological gap m, and let n_{-m} denote the R&D intensity of the follower in such an industry.

3.2.3 Product-market competition

Boone (2001) makes the convincing argument that any parameter that positively affects the profitability of having lower costs or better quality products than other firms, is a suitable measure of product market competition. The intuition for this relies on the following selection effect of market competition: an increase in product market competition increases the relative market share of firms with lower costs or better products. Thus one possible (inverse) measure of competition would be the profit flow of 'neck-and-neck' firms, π_0. The lower is π_0, the higher is the profit increment $(\pi_1 - \pi_0)$ from innovation. A higher π_0 will typically reflect higher collusion among otherwise similar firms in the same sector, so that a lower π_0 implies higher PMC.

Another potential 'measure' of competition that is also consistent with Boone's theoretical standpoint, is the elasticity of substitution parameter α in the case[7]:

$$v(x_{Ai}, x_{Bi}) = (x_{Ai}^{\alpha} + x_{Bi}^{\alpha})^{\frac{1}{\alpha}} \ .$$

If the two inputs cannot be substituted, then $\alpha = 0$ and there is no competition between the firms; if $\alpha = 1$, then the goods are perfect substitutes and competition is at its maximum (Bertrand competition between producers of undifferentiated goods). It can also be shown that in this model α corresponds to the standard measures of competition such as the elasticity of substitution in demand between the two rivals' output in any industry. It is also an inverse function of the price-cost margin. In Section 4, we shall discuss how these interpretations of α relate to the empirical measures of competition that we use.

3.2.4 Bellman equations

Let V_m denote the steady state value of being currently a leader (or follower if $m < 0$) in an industry with technology gap m, and let w denote the wage rate, which we take as given assuming an infinitely elastic supply of labour. We then have the following Bellman equations:

$$
\begin{aligned}
rV_m &= \pi_m + n_m(V_{m+1} - V_m) + n_{-m}(V_{m-1} - V_m) - w\beta(n_m)^2/2; \\
rV_{-m} &= \pi_{-m} + n_m(V_{-m-1} - V_{-m}) + n_{-m}(V_{-m+1} - V_{-m}) - w\beta(n_{-m})^2/2; \\
rV_0 &= \pi_0 + n_0(V_1 - V_0) + n_0(V_{-1} - V_0) - w\beta(n_0)^2/2;
\end{aligned}
$$

In words, the annuity value rV_m of currently being a technological leader in an industry with gap m at date t equals the current profit flow π_m minus the current R&D cost $(w\beta n_m{}^2/2)dt$, plus the discounted expected capital *gain* $n_m(V_{m+1} - V_m)$

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importance of the 'escape competition' effect and to downplay the Schumpeterian effect of PMC.

[7]See Aghion et al. (2001).

from making an innovation and thereby moving one further step ahead of the follower, minus the discounted expected capital *loss* $n_{-m}(V_{m-1} - V_m)$ from having the follower catch up by one step with the leader. The equation for the annuity value of a follower is similarly explained. Finally, in the Bellman equation for a neck-and-neck firm, note that if each firm only takes into account its own cost of R&D, in symmetric Nash equilibrium both R&D efforts are equal.

Now, using the fact that each firm chooses its own R&D effort to maximize its current value, i.e to maximize the RHS of the corresponding Bellman equation, we obtain the first order conditions:

$$\begin{aligned} \beta w n_m &= V_{m+1} - V_m; \\ \beta w n_{-m} &= V_{-(m-1)} - V_{-m}; \\ \beta w n_0 &= V_1 - V_0. \end{aligned}$$

We shall focus on the special case where the maximum technological gap between leaders and followers is $m = 1$, assuming for simplicity that $w = \beta = 1$[8]. Then, given the spillover assumption introduced above, a technological leader has no incentive to invest in R&D ($n_1 = 0$), and the above Bellman equations become:

$$\left.\begin{aligned} rV_1 &= \pi_1 + n_{-1}(V_0 - V_1) \\ rV_{-1} &= \pi_{-1} + n_{-1}(V_0 - V_{-1}) - (n_{-1})^2/2 \\ rV_0 &= \pi_0 + n_0(V_1 - V_0) + n_0(V_{-1} - V_0) - (n_0)^2/2 \end{aligned}\right\} \tag{5}$$

with corresponding first order conditions:

$$\left.\begin{aligned} n_{-1} &= V_0 - V_{-1} \\ n_0 &= V_1 - V_0 \end{aligned}\right\} \tag{6}$$

Thus, for example, the annuity value rV_1 of being a leader is the current flow of profit π_1 minus the expected capital loss per unit of time from being caught up with by the laggard. The expected loss is the loss in value $V_1 - V_0$ that will occur if the laggard innovates, multiplied by the flow probability n_{-1} of the laggard innovating.

3.2.5 Equilibrium R&D intensities and product market competition

Equations (5) and (6) can be solved for n_{-1} and n_0. Eliminating the V's between these equations yields the reduced form research equations:

$$\frac{(n_0)^2}{2} + rn_0 - (\pi_1 - \pi_0) = 0 \tag{7}$$

$$\frac{(n_{-1})^2}{2} + (r + n_0)n_{-1} - (\pi_0 - \pi_{-1}) - \frac{(n_0)^2}{2} = 0. \tag{8}$$

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[8]We thus take the wage rate as given, with the implicit assumption of an infinitely elastic supply of labor at wage $w = 1$. See Aghion et. al (1997) for a discussion of the case where the supply of labor is inelastic.

This system is recursive, as we can solve the first quadratic equation for n_0, and then given n_0 solve the second quadratic equation for n_{-1}. We obtain the flow probabilities (or hazard rates) of respectively neck-and-neck and follower firms innovating:

$$n_0 = -r + \sqrt{r^2 + 2(\pi_1 - \pi_0)} \tag{9}$$

$$n_{-1} = -(r + n_0) + \sqrt{(r + n_0)^2 + n_0^2 + 2(\pi_0 - \pi_{-1})}. \tag{10}$$

Combining (9) and (10) yields the alternative expression:

$$n_{-1} = -(r + n_0) + \sqrt{r^2 + (n_0)^2 + 2(\pi_1 - \pi_{-1})}. \tag{11}$$

Here, we shall focus on the effects on the innovation probability of an increase in product market competition as represented by a reduction in π_0 leaving π_{-1} and π_1 unchanged. (The analysis and results in the remaining part of this section can be replicated using the elasticity parameter α as an alternative way to parameterize PMC). We immediately see that n_0 (the probability of the neck and neck firm innovating) increases whereas n_{-1} (the probability of the laggard innovating) can be shown to fall.[9]

The latter effect (on n_{-1}) is the basic Schumpeterian effect that results from reducing the rents that can be captured by a follower who succeeds in catching-up with its rival by innovating. The former effect (on n_0) is what we refer to as an 'escape competition effect', namely that more competition induces neck-and-neck firms to innovate in order to escape competition, as the incremental value of getting ahead is increased with higher PMC. Thus, if we were to treat the fractions of 'neck and neck' and 'leader-follower' sectors in the economy as an exogenous parameter, we would get the conclusion that *the higher the fraction of neck-and-neck sectors in the economy, the more positive the effect of product market competition on the average innovation rate.*

3.2.6 Competition and the average innovation rate

An increase in product market competition will have an ambiguous effect on the *steady-state* aggregate innovation rate because it will induce more frequent innovations in currently 'neck-and-neck' sectors and slower innovations in currently 'leader-follower' sectors. The overall effect on the average innovation rate and on average productivity growth will depend on the steady-state fraction of each kind of sector.

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[9]From (9):

$$\frac{\partial n_0}{\partial \pi_0} = -\frac{1}{\sqrt{r^2 + 2(\pi_1 - \pi_0)}} < 0$$

this and (11):

$$\frac{\partial n_{-1}}{\partial \pi_0} = \frac{\partial n_0}{\partial \pi_0} \left[-1 + \frac{n_0}{\sqrt{r^2 + (n_0)^2 + 2(\pi_1 - \pi_{-1})}} \right] > 0$$

More formally, let μ_1 (resp. μ_0) denote the steady-state fraction of 'leader-follower' (resp. neck-and-neck) industries. During any unit time interval, $\mu_1 n_{-1}$ leader-follower sectors become neck-and-neck as the laggard catches up with the leader, and $2\mu_0 n_0$ neck-and-neck sectors become leader-follower as one neck-and-neck firm acquires a lead. In steady state, the two must be equal:

$$\mu_1 n_{-1} = 2\mu_0 n_0.$$

This, together with the fact that:

$$\mu_1 + \mu_0 = 1,$$

implies that the average flow of innovations is:

$$I = \mu_0 2n_0 + \mu_1 n_{-1} = 2\mu_1 n_{-1} = \frac{4n_0 n_{-1}}{2n_0 + n_{-1}}. \tag{12}$$

We then obtain an inverted U relationship between PMC and the average innovation rate. To see this, note that in the steady state distribution:

$$\mu_0 = \frac{n_{-1}}{n_{-1} + 2n_0} \quad \text{and} \quad \mu_1 = \frac{2n_0}{n_{-1} + 2n_0}.$$

In the limit when there is no competition ($\pi_0 = \pi_1$), (9) implies that $n_0 = 0$, so that in the steady state all industries are 'neck-and-neck' ($\mu_0 = 1$), whereas when there is the maximum competition ($\pi_0 = \pi_{-1}$), (9) and (11) imply that $n_0 > n_{-1}$, so that the overall rate of innovation in neck-and-neck sectors is more than twice that in the leader-follower sectors and as a result the fraction μ_0 of neck-and-neck industries in the steady state is less than $1/3$.

Thus, at low levels of PMC, most sectors will be neck and neck so that the escape competition effect dominates on average, whereas at high levels of PMC most sectors will be 'leader-follower' and therefore the Schumpeterian effect of PMC on laggard's R&D investments dominates on average. This in turn implies that an increase in PMC will have a positive effect on innovation at low levels of PMC and a negative effect on innovation at high levels of PMC.

3.2.7 The interplay between policies

In this subsection we explore the interplay between product market competition and corporate governance, hard budget constraints and credit rationing. Corporate governance is measured by managerial claims to monetary profits. The ADR model, where competition enhances growth because it reduces managerial slack in innovating firms, unambiguously predicts that higher managerial claims on monetary profits or higher debt pressure tend to reduce the positive impact of PMC on innovation and growth. However in this subsection we show that these conclusions can be reversed in the step-by-step innovation model where higher managerial claims to monetary profits and higher exposure to bankruptcy costs both reinforce the 'escape competition' effect of PMC on innovation.

Managerial claims to monetary profits Suppose that managers need outside finance in order to set themselves up, and that they choose outside equity financing, which involves the outside investor receiving a fixed share $1-\sigma$ of monetary revenues for that purpose, with the firm's managers receiving the share σ. Thus, under outside equity financing, the Bellman equations for equilibrium R&D investments, become:

$$
\begin{aligned}
rV_1 &= \sigma\pi_1 + n_{-1}(V_0 - V_1); \\
rV_0 &= \sigma\pi_0 + n_0(V_1 - V_0) + n_0(V_{-1} - V_0) - n_0^2/2; \\
rV_{-1} &= \sigma\pi_{-1} + n_{-1}(V_0 - V_{-1}) - (n_{-1})^2/2.
\end{aligned}
$$

By analogy with the previous subsection, we immediately get:

$$
n_0 = -r + \sqrt{r^2 + 2\sigma(\pi_1 - \pi_0)}. \tag{13}
$$

A first remark is that n_0, the probability that a 'neck-and-neck' firm innovates, reacts positively to both an increase in product market competition as measured by a reduction in π_0, and to an improvement in corporate governance as measured by an increase in σ. Now, to analyze the interaction between PMC and σ, a natural next step would be to compute and sign the cross-derivative $\frac{\partial^2 n_0}{\partial \pi_0 \partial \sigma}$. Unfortunately, the presence of a square root term on the RHS of (13), which reflects the concavity of n_0 with respect to π_0 and σ, suffices to make this sign ambiguous in general. A more promising way to capture the complementarity between residual claim and product market competition is to look at the sign of the *compensated* cross derivative

$$
(\frac{\partial^2 n_0}{\partial \pi_0 \partial \sigma})^{comp}.
$$

We define this in the following way: start from a given level of n_0; then consider an increase in σ together with a compensating change — an increase — in π_0 so as to leave n_0 unchanged; $(\frac{\partial^2 n_0}{\partial \pi_0 \partial \sigma})^{comp}$ is then equal to the variation in the derivative $\frac{\partial n_0}{\partial \pi_0}$ along the way. Now, one can easily show that $(\frac{\partial^2 n_0}{\partial \pi_0 \partial \sigma})^{comp} < 0$. In other words the positive effect of PMC on R&D incentives (i.e. the negative of $\frac{\partial n_0}{\partial \pi_0}$) is reinforced by an increase in the manager's share: *there is complementarity between PMC and corporate governance as measured by the residual claim of firms' managers.*

To see this, note that a compensated increase in σ that leaves n_0 constant will also leave

$$
\delta = r^2 + 2\sigma(\pi_1 - \pi_0),
$$

constant by equation (13). Our claim then follows from the fact that:

$$
\frac{\partial n_0}{\partial \pi_0} = -\frac{\sigma}{\sqrt{\delta}}, \tag{14}
$$

which obviously becomes more negative since δ remains constant and σ is increased.

Competition and hard-budget constraints To formalize the interplay between competition and the exposure to bankruptcy costs, we consider the following variant of the basic one-step model: (1) neck-and-neck profit flows, $\tilde{\pi}_0$, are random, i.i.d over time and uniformly distributed over the interval $[\pi_0, \pi_0+1]$; (2) $\pi_{-1} \equiv 0$; π_1 constant with $\pi_1 >> \pi_0 + 1$; (3) firms finance their investments through debt financing, which we define here as involving a fixed flow repayment obligation D, and a flow default cost f incurred per unit of time by the firm whenever $\tilde{\pi}_0 < D$[10].

Consider first the case where exit costs are negligible and where $D \in (\pi_0, \pi_0+1)$; then, the Bellman equations for equilibrium R&D investments, can be expressed as:

$$rV_1 = \pi_1 - D + n_{-1}(V_0 - V_1);$$
$$rV_0 = \psi(\pi_0, D, f) + n_0(V_1 - V_0) + n_0(V_{-1} - V_0) - n_0^2/2,$$
$$rV_{-1} = -f + n_{-1}(V_0 - V_{-1}) - (n_{-1})^2/2.$$

where

$$\psi(\pi_0, D, f) = \int_D^{\pi_0+1} (u - D)du - f \int_{\pi_0}^D du,$$

is the expected flow utility of a manager in a 'neck-and-neck' industry, net of the expected verification costs. From these Bellman equations and the corresponding first order conditions, we obtain the following expression for the equilibrium neck-and-neck firm's R&D:

$$n_0 = -r + \sqrt{r^2 + 2(\pi_1 - D - \psi)} = -r + \sqrt{\delta}, \tag{15}$$

where we re-express ψ as:

$$\psi = \frac{1}{2}(\pi_0 + 1 - D)^2 - f(D - \pi_0).$$

Hence:

$$\frac{\partial n_0}{\partial \pi_0} = -\left(\pi_0 + 1 - D + f\right)/\sqrt{\delta} < 0. \tag{16}$$

Consider now the effect of an increase in the default cost f, which we interpret as a hardening of the firm's budget constraint, together with a reduction in product market competition, i.e an increase in π_0, so as to maintain the innovation rate n_0 constant. From equation (15), this should leave

$$\delta^{\frac{1}{2}} = n_0 + r$$

constant, which in turn from equation (16) implies immediately that the slope $(-\frac{\partial n_0}{\partial \pi_0})$ should decrease (i.e increase in absolute value terms). In other words, the higher the default cost f the more an increase in product market competition will increase the expected default cost incurred by neck-and-neck firms, and therefore the stronger their incentive to innovate in order to escape competition. Thus, unlike the ADR model outlined in the previous subsection, this model predicts complementarity between PMC and the hardness of firms' budget constraints.

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[10]This formulation is inspired from the costly state verification literature (e.g Townsend (1979), Gale-Hellwig (1985)) on debt-financing, in which firms' revenues are assumed to be unverifiable by outside investors, unless they incur a flow verification cost f. For simplicity, we abstract in this section from firms' choice over the optimal financial contract.

Competition and credit rationing So far, we have assumed that R&D costs are non-monetary. Now suppose that these costs are monetary and that firms are credit-constrained to the point where they can only rely on current profits to finance their R&D investments. More formally, if p_m (resp. p_{-m}) denotes the flow probability of innovation by a leader (respectively a follower in an industry with technological gap m), we have:

$$p_m = \min(n_m, \sqrt{2\pi_m}),$$

where n_m is the innovation rate of an unconstrained firm, since the financial constraint imposes:

$$\psi(p_m) = \frac{1}{2}p_m^2 \leq \pi_m.$$

We shall again focus attention on the one-step case $m \leq 1$, and to better concentrate on R&D investments by neck-and-neck firms, we shall also assume that $\pi_{-1} = 0$, but that there is still a positive flow probability h of a laggard firm catching up with the leader. By first order conditions, we have[11]:

$$n_0 = V_1 - V_0$$

and

$$p_{-1} = h,$$

whereas

$$p_0 = \min(n_0, \sqrt{2\pi_0}).$$

Note that the 'constrained' innovation rate p_0 becomes a non-monotonic function of market competition as measured by a reduction in π_0 : too much competition kills innovation as it eliminates the retained earnings necessary for a neck-and-neck firm to innovate. On the other hand it encourages innovations whenever $n_0 > \sqrt{2\pi_0}$, and it does so to a larger extent than before. Indeed V_0 goes down by more than in the absence of credit-constraints when PMC increases, since a reduction in π_0 reduces not only current profits but also the ability of neck-and-neck firms to become leaders in the future. This in turn implies that product market competition will have a stronger positive effect on innovation at low initial levels of competition when the financial constraint for neck-and-neck firms is not binding, but that at high levels of competition a further increase in competition will also have a more negative effect on the aggregate innovation rate since the Schumpeterian effect of PMC on 'follower' firms in 'leader-follower' sectors is reinforced by the negative effect of a reduction in profits on innovation by neck and neck firms.

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[11]The Bellman equations for the V's now become:

$$\left. \begin{array}{l} rV_1 = \pi_1 + h(V_0 - V_1) \\ rV_{-1} = \pi_{-1} + h(V_0 - V_{-1}) \\ rV_0 = \pi_0 + p_0(V_1 - V_0) + p_0(V_{-1} - V_0) - \min\{(n_0)^2/2, \pi_0\}. \end{array} \right\} \quad (17)$$

4 Competition and innovation in transition: concepts and data

As we shall see, for both substantive and econometric reasons, transition provides a rich testing ground for the theories outlined in section 3. We begin with the concept of innovation. When applying the models of section 3 to advanced economies, a measure of the probability of a firm innovating is its patenting activity (see for example Aghion et al. (2002)). However, patenting will be of much less relevance to firms in a transition (or other catching-up) economy. As argued in section 2, in a transition economy, an example of an innovation is the introduction of a product that is new to the market or the modification of an existing one. The BEEPS survey provides us with data on the innovations managers introduced in the three years to 1999. This can be interpreted in terms of the hazard rate of innovating used in the models.

The change of regime in transition economies also prompted managers to take survival-oriented actions such as labour-shedding and plant closures, which have been referred to as 'reactive restructuring'. The incentive for managers to take such actions was their interest in the survival of their enterprise. This motivation is closer to the idea of the satisficing manager who brings forward an innovation so as to maintain her private benefits of control as explained in the ADR model, than of the profit maximizing manager innovating to escape competition in the AHHV model.

In addition to identifying the kinds of 'innovation' taking place in transition, the transition literature emphasizes the difference between managerial incentives in old and new firms. Firms newly established in the post-reform period are entrepreneurial firms and fit more closely the kind of firm modelled in the AHHV model or the profit-maximizing firms in ADR: i.e. firms with strong monetary incentives for managers.[12] By contrast, old firms were established in an economy in which agency problems were enormous. The introduction of product market competition, the withdrawal of subsidies from firms and privatization programmes changed the incentives and the constraints of managers in old firms. Nevertheless, old firms are more likely than new ones to resemble those in the ADR model for which monetary incentives for managers are relatively weak.

The BEEPS data-set comprises a sample of 3,300 firms from 25 countries with a roughly equally split between new and old firms. New firms are defined as those that report that they do not have a state-owned predecessor. Amongst the old firms, there are about twice as many privatized as state firms. Most firms in the sample are small — with less than 200 employees; one-tenth have more than 500 employees. On average, new firms are smaller than old ones. The survey collected data on the reported average growth of sales in real terms over the three years to 1999. The patterns for growth and restructuring have been reported in detail in CFSS (2001)

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[12]Cross-country evidence is beginning to accumulate in support of the importance of the new firm sector in generating growth in transition economies. Berkowitz and DeJong (2002) summarize the evidence and report new findings that variations in regional entrepreneurial activity in Russia are closely related to subsequent variations in regional growth rates.

and can be summarized as follows. The average sales growth was positive for new firms and negative for old firms. All firm types have been active — but old firms do more reactive restructuring, as measured by the closure of a plant or substantial labour shedding. Controlling for size and sector, new firms are more likely to have introduced new products and opened a new plant.

To use the hypotheses suggested by the models in order to test for the interplay between product market competition and the other policies, we need measures of product market competition, governance and budget softness. In the BEEPS survey, firms were asked a series of questions about their competitive environment. A direct measure of PMC is provided by answers to the question of how many competitors the firm faces in the market for its main product. Managers could choose 'none', 'between one and three' and 'more than three'. A second question asked the manager to assess what would happen to the firm's sales if it were to put up its price by 10% in real terms and its competitors were to leave their price unchanged. Managers could answer on a scale from 'all customers would switch away from the firm' to 'customers would continue to buy as before'. Thirdly, managers were asked to estimate the firm's price-cost margin. Each of these measures can be related to the concept of PMC used in the models. In ADR, PMC was parameterized by the degree α of substitutability between intermediate goods. In AHHV, PMC was measured by the profit flow of neck and neck firms (a lower π_o corresponding to a higher level of PMC). An increase in the number of competitors faced by the firm entails a fall in its pre-innovation profits relative to post-innovation profits. Equally, a measure of the way a firm believes its competitors would react to a change in its price provides a measure of product market competition consistent with the models. Finally, the price-cost margin is an inverse measure of PMC to the extent that it captures monopoly rents.

As reported in Carlin and Seabright (2001), the three measures of competition are correlated for the sample as a whole.[13] When we compare the extent of competition faced by each firm type, the following results emerge: state firms are least likely to face many competitors and new private firms are least likely to face none; private firms face more elastic demand than do state firms (CFSS).

Considerable attention has been given to the problem of soft budget constraints in transition economics. A softer budget constraint means that the threat of firm failure or bankruptcy is reduced because a poorly-performing firm will be rescued with external resources, typically by the state. Soft budget constraints were endemic in the socialist economies prior to the start of transition. Although the subsidy regime was tightened as part of the reform package, budget softness has persisted through other means, especially through the condoning of tax arrears by governments at the central, regional or local level (Schaffer 1998), or via arrears to utilities. From the BEEPS survey responses, we take the existence of tax arrears to central and local government as a proxy for the presence of soft budget constraints. 40% of old firms reported tax arrears, as compared with 26% of new firms. There was considerable variation across countries with tax arrears lower in Central and Eastern European

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[13]The group of firms where the measures line up least well is state firms — specifically, the average profit margin was lowest in the state firms that faced between one and three competitors.

countries as compared with CIS countries.

5 Testing the interplay between PMC, soft budgets and governance

5.1 Empirical strategy

In this paper, we extend the CFSS study to test for interactions between policies. Although the BEEPS data has no true time series dimension and lacks detailed ownership information, its attraction is twofold: the richness of the measures of PMC, innovation and soft budget constraints and the presence of firm-level data from 25 countries. It is very difficult to investigate the role of soft budget constraints in growth. If poor performance in a firm is observed in association with a soft budget constraint, this cannot be interpreted as telling us whether an environment of budgetary softness depresses innovation and growth. It only tells us that poorly performing firms are bailed out.

We make use of methodology developed in CFSS to deal with the endogeneity of the soft budget constraint measure. The idea is to use the cross-country variation in the BEEPS data to provide the instruments for the soft budget constraint. As argued in CFSS, the soft budget constraint environment faced by firms varies across countries. Poor performance by a firm in one country may be less likely to generate tax arrears than if it operated in another country. The interaction of country dummies and competition variables is used to provide instruments for the soft budget constraint faced by the firm. Since competition is an exogenous determinant of performance, the regression of the soft budget constraint at the firm level on the interaction between the country dummy and PMC (at the firm level) captures differences in how the state in different countries reacts to performance. We do not estimate the soft budget constraint equation explicitly but simply instrument our soft budget constraint with the country-competition interactions.

The empirical strategy taken in this study is to pool the observations from the sample and estimate a system of equations — sales growth, innovation, in the sense of strategic restructuring, and the soft budget constraint. Unfortunately we are unable to go beyond the CFSS results in relation to reactive restructuring. The reason is that we lack instruments for the measures of reactive restructuring such as labour shedding and plant closures.

Sales growth is defined as the log growth of sales in real terms over the three years previous to the date of the survey (summer 1999). The variable for innovation — in the sense of new product restructuring — was constructed from the first principal component of responses to four questions on whether, in the preceding three years, firms had developed a new product line or upgraded an existing one, opened a new plant or obtained ISO 9000 accreditation. The resulting index was scaled from zero (firm did none of these) to four (firm engaged in all four activities).

In addition to the two measures of PMC discussed above (number of competitors and 'elasticity of demand'), further information on the role of competition in

inducing managers to introduce innovations was gathered. Managers were asked to assess the importance of pressure from competitors (foreign or domestic) and from customers in their decision to develop new products or markets. This variable is used in the 'innovation' equation and is referred to as 'pressure to innovate'.

Controls for firm size (number of employees), sector (a dummy for services) and location (a dummy for location in a big city) along with a full set of country dummies are included in each equation. The structure of the three equation system is shown in Table 1, where exogenous and endogenous variables are listed. For clarity, the structure of the soft budget equation is shown, although it is not estimated explicitly.

[Table 1 here]

The first step is to test whether ownership can be omitted from the sales growth equation: from the ADR and AHHV models, our hypothesis is that ownership affects growth via innovation. From an econometric point of view, the distinction between old firms that existed in some form in the pre-transition period and new firms that did not is useful because it is unambiguously exogenous. Because of endogeneity issues related to privatization, we do not try to distinguish between state-owned and privatized firms.

Ownership is modelled by a dummy for new firms (those with no state-owned predecessor). In the benchmark model structure set out in Table 1, it is omitted from the sales growth equation but appears as an explanatory variable in the innovation equation. Whether it belongs directly in the sales growth equation is a test of a subset of orthogonality conditions of the IV estimation of the equation. The test results support the exclusion of ownership from the sales equation.[14]

After estimating the basic equations, we introduced interactions between policies to test the predictions of the models (see Table 1, where the additional interaction terms are shown in italics).

1. In the sales growth equation, to test for the complementarity or substitutability of PMC and financial pressure, as measured by a harder budget constraint, we introduce the interaction between PMC and the soft budget constraint.

2. In the innovation (new product restructuring) equation, we introduce interactions between PMC and ownership.

The system is identified by the following exclusions: (1) the sales growth equation excludes ownership, interactions of country with competition and interactions of ownership with competition; (2) the innovation equation excludes interactions of country with competition and (3) the soft budget equation excludes ownership interacted with competition and pressure to innovate variables.

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[14]This is the C-statistic test of a subset of orthogonality conditions (Hayashi 2000, p. 232.), the subset in this case being the condition that ownership (an instrument) does not appear as a regressor in the sales growth equation. The p-value of this chi-square statistic is 0.63, meaning we pass comfortably. The p-value of the Sargan statistic for all orthogonality (overidentifying) conditions is 0.31, suggesting that the instrumention in the sales growth equation is adequate overall.

Equations (1) and (2) were estimated one at a time using GMM. Estimation equation-by-equation rather than as a system simultaneously was implemented so that if one equation is misspecified, the results for the others would not be contaminated. The validity of the instruments was tested using the Hansen J-test of orthogonality restrictions. This is a test of the joint hypothesis that the instruments are valid (uncorrelated with the error term) and that none of the instruments should have been included in the set of regressors and were not.

The diagnostic tests for the sales growth equation are broadly reassuring. In particular, the J-test is passed, which means that the instruments are valid, exogenous and do not belong in the set of regressors. However, although the F-statistics of the instruments in the first stage regressions are significant, they are rather low and point to the possibility of a problem of weak instruments. The specification of the innovation equation is less satisfactory as indicated by the diagnostic tests. The J-test is failed and there are also signs of weakness of the instruments.

5.2 Results

We organize this section according to the empirical predictions of the ADR and AHHV models. In each case, we ask whether the econometric findings support or are consistent with a prediction.

5.2.1 We should observe an inverse-U shaped relationship between PMC and growth (AHHV; ADR)

The inverse-U is predicted directly by AHHV. ADR predicts a positive relationship between PMC and growth in firms with managerial slack and a negative relationship between PMC and growth in profit-maximizing firms. If non-profit maximizing firms face low PMC and profit-maximizers face high PMC, an inverse U would be expected.

As shown in column 1 of Table 2, there is indeed an inverse U relationship between the number of competitors and sales growth. Facing one to three competitors (in the domestic market for the firm's main product) raises growth by 6 percentage points.

[Table 2 here]

From column 1 of Table 2 we also find that firms with a soft budget constraint have lower growth. Innovation, in the sense of new product restructuring, has a positive impact on growth. Introducing one restructuring measure raises growth by 11-13 percentage points. It is also the case that smaller firms grow faster than larger ones.[15] The relationship between growth and market power is discussed below.

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[15] A doubling in the size of a firm translates into a one percentage point increase in the growth rate of sales: $\ln 2 \times -0.016 \approx 0.01$.

5.2.2 AHHV predicts that the inverse U is steeper for firms with harder budget constraints: PMC and hard budget constraints are complements. ADR predicts that PMC and hard budget constraints are substitutes and hence the inverse U will be flatter.

Column 2 of Table 2 repeats the sales growth regression but with the number of competitors interacted with the soft budget constraint measure. Once the interactions between PMC and soft budgets are introduced, increasing PMC measured by the number of competitors has a monotonically positive effect on growth and the soft budget constraint variable becomes insignificant. But the interaction term (*more than three competitors * soft budget constraint*) is negative, large and highly significant. This means that a soft budget constraint reduces growth in firms in the most competitive environment (those with more than three competitors). In fact, facing a soft budget constraint more than offsets the positive impact of facing lots of competition (more than three competitors). Putting this result another way, if the firm is already a monopolist, it is sluggish and adding a soft budget constraint has no extra effect.

The most striking aspect of these results is that PMC and budget hardness are clearly complementary as predicted by AHHV. The benefits for growth of more PMC can be lost entirely if budget constraints are too soft. The interpretation of this result using the AHHV model is that soft budget constraints weaken the incentive for firms to innovate to escape competition.

5.2.3 AHHV predicts that competitive pressure will boost innovation in profit maximizing firms; ADR predicts that competitive pressure will boost innovation in firms with managerial slack.

Table 3 presents the results of the innovation regression. In this regression, we have interacted each of our measures of competition (number of competitors, market power and competitive pressure) with ownership. This generates two sets of coefficient estimates for the competition measures: one for old firms and one for new firms. We assume that new firms (i.e. those newly formed in the post-reform period with no state-owned predecessors) are profit maximizers and that old firms are characterized by managerial slack.

Before looking at the interaction effects, we note that new firms innovate more than old ones and that firms facing a hard budget constraint do more innovation. As shown in Table 3, the pressure of competition boosts innovation by both old and new firms. The pressure from foreign competitors seems especially relevant for old firms. For the pressure of competition to boost innovation in *old* firms suggests that the 'innovate to survive' motive of ADR is characteristic of such firms. On the other hand, for competitive pressure to boost innovation in *new* firms suggests that the 'innovate to escape competition' motive is relevant for them. These results are consistent with, although not a direct test of, the idea that PMC can be a substitute for governance for one group of firms (where agency problems are rife) and complementary to governance for another group.

[Table 3 here]

5.2.4 An extension to AHHV predicts that an increase in PMC will reduce innovation in the presence of credit rationing and if the initial level of competition is already high.

The results in Table 2 show that, controlling for the number of competitors, less elastic demand is associated with higher growth. This suggests the presence of financing constraints. Although the BEEPS survey included managerial responses to direct questions about credit availability, the endogeneity of perceived credit constraints means that making use of these answers would face severe econometric problems.

A common finding in the empirical literature, however, is that access to the capital market is especially poor for new firms, and as noted above, the new/old distinction is not subject to endogeneity problems. In addition as shown in CFSS, new firms face higher levels of product market competition than do old firms. Given these priors, we examine the results in Table 3. The estimates for innovation in Table 3 show that new firms are significantly less likely to innovate if they face more than 3 competitors. The impact of increased market power is to increase innovation for both old and new firms, but the effect is more pervasive for the latter. These findings are consistent with the hypothesis that higher PMC inhibits innovation by new firms because of credit rationing, in line with the predictions of the AHHV model.

6 Conclusions

In this paper we have shown how two models of competition and innovation have relevance to the analysis of the interaction between policies in transition economies. We have taken the predictions of the ADR and AHHV models and tested them using firm-level data from 25 transition countries. Innovation in this context is interpreted as the introduction of new products or the modification of existing ones. The exogenously given distinction between firms that existed under the planned economy ('old') and firms that were formed in the post-reform period and had no state-owned predecessors ('new') provides us with a way of distinguishing between firms characterized by agency problems and those that are better modelled as profit-maximizing. In the ADR model it is only firms with agency problems that do more innovation in response to an increase in product market competition. The AHHV model demonstrates why new firms in which monetary incentives are strong may also respond to an increase in product market competition by devoting more resources to innovation so as to 'escape competition'.

We find that new firms are driving the innovation process in the transition economies and that for such firms, competitive pressure raises innovation. For old firms, competitive pressure — especially from foreign competitors — also raises innovation. The former result is therefore in line with the prediction of the AHHV

model and the latter with the ADR model: both models provide useful insights for transition countries.

We also find that hard budget constraints are necessary if competition is to raise growth. Soft budget constraints can more than offset the benefits of more competition. Finally, our results suggest that credit rationing is hampering the ability of new firms to innovate.

If confirmed by subsequent research, these results indicate that priority should be given to eliminating the soft budget constraint environment that persists in many transition economies. More intense product market competition is not a substitute for the elimination of soft budget constraints. The importance of policies to facilitate access of new firms to external sources of finance for investment is clear. Policies to encourage product market competition are likely to have pay-offs both for old firms, where they can substitute for effective corporate governance, and for new firms, where they spur innovation by increasing the incremental profits that come from getting ahead of competitors.

References

Aghion, P, Bloom, N, Blundell, R, Griffith, R, and P. Howitt (2002): 'Competition and Innovation: An Inverted-U Relationship', IFS Working Paper 0204 http://www.ifs.org.uk/workingpapers/wp0204.pdf.

Aghion, P, Dewatripont, M, and P. Rey (1999), 'Competition, Financial Discipline, and Growth', *Review of Economic Studies,* 66, 825-852.

Aghion, P, Harris, C, and J.Vickers (1997), 'Competition and Growth with Step-by-Step Innovation: An Example', *European Economic Review, Papers and Proceedings,* 771-782.

Aghion, P, Harris, C, Howitt, P and J.Vickers (2001), 'Competition, Imitation and Growth with Step-by-Step Innovation', forthcoming in the *Review of Economic Studies.*, Vol. 68, No. 3, 467-492.

Aghion, P, and P. Howitt (1992), 'A Model of Growth through Creative Destruction', *Econometrica, 60, 323-351.*

Aghion, P, and P. Howitt (2002), 'Competition, Corporate Governance, and Growth', unpublished notes.

Blundell, R., Griffith, R. and Van Reenen, J. (1999), 'Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms', *Review of Economic Studies*, vol. 66, 529-554.

Boone, J. (1999): 'Measuring Product Market Competition', Unpublished, Tilburg University.

Carlin, W, Fries, S, Schaffer, M, and P. Seabright (2001), 'Competition and Enterprise Performance in Transition Economies: Evidence from a Cross-Country Survey', CEPR Discussion Paper No. 2840.

Carlin, W. and P. Seabright (2000), 'The importance of competition in developing countries for productivity and innovation'. Background paper for *World Development Report 2001.*

Grosfeld, I, and T. Tressel (2001),'Competition, Corporate Governance: Substitutes or Complements? Evidence from the Warsaw Stock Exchange', CEPR Working Paper DP2888.

Hayashi, F. (2000). *Econometrics*, Princeton: Princeton University Press.

Hart, O (1983), 'The Market Mechanism as an Incentive Scheme', *Bell Journal of Economics,* 14, 366-382.

Nickell, S. (1996) 'Competition and Corporate Performance', *Journal of Political Economy*, 104, 724-746.

Romer, P. (1990), 'Endogenous Technical Change', *Journal of Political Economy,* 98, 71-102.

Schaffer, M.E. (1998), 'Do firms in transition economies have soft budget constraints?' *Journal of Comparative Economics*, Vol. 26, No. 1, pp. 80-103.

Table 1. Basic system: showing included and excluded variables
Additional interactions are shown in italics
X = included

Variables	Sales growth	New product restructuring	Soft budget constraint
Exogenous			
Number of competitors (zero; 1-3; >3)	X	X	X
Market power: predicted response to 10% price rise (from 1 = many customers would change suppliers to 4 = no change in sales)	X	X	X
Ownership (old; new)		X	X
Competition interacted with ownership		X	
Pressure to introduce new product *(interacted with ownership)*		X	
Country interacted with competition			X
Country dummies	X	X	X
Size (log mid-period employment)	X	X	X
Sector (industry vs. services)	X	X	X
Location (rural vs. large city)	X	X	X
Endogenous			
{Sales growth interacted with country}			{X}
Soft budget constraint (zero=hard, 1=soft)	X	X	
New product restructuring	X		
Soft budget constraint interacted with competition	X		

Note: Sales growth interacted with country is enclosed within braces {} to indicate that although the country/government-specific response to a firm's performance is a determinant of the SBC, we do not use this endogenous variable in the estimations because we do not estimate an SBC equation explicitly.

Table 2. Sales growth equation with and without interactions with soft budget constraint: results using GMM estimation

Number of observations = 2245
* significant at 10%; ** at 5%; and *** at 1%

Variables	Sales growth (1)	Sales growth (2)
Exogenous		
No. of competitors (zero is omitted)		
1-3	**0.058****	**0.097****
>3	0.017	**0.103*****
Market power: predicted response to 10% price rise (Many customers would change suppliers is omitted)		
Sales would fall a lot	0.026	0.022
Sales would fall slightly	**0.079*****	**0.077*****
No change in sales	**0.110*****	**0.107*****
Country dummies	Yes	Yes
Size	-0.016***	-0.0145***
Sector (services)	0.033	0.040*
Location (big city)	0.023	0.016
Endogenous		
Soft budget constraint (zero=hard, 1=soft)	**-0.187*****	-0.065
New product restructuring	**0.112*****	**0.125*****
Number of competitors interacted with soft budget constraint		
sbc*(1-3 competitors)		-0.097
sbc*(>3 competitors)		**-0.206*****
Hansen J-test (p-value)	$\chi^2(135)=148.6$ (0.200)	$\chi^2=142.3$ (0.274)
F-test of instruments (p-value)	F(132,2080)	F(132,2080)
SBC	=1.45 (0.001)	=1.45 (0.001)
SBC*(1-3 competitors)		=3.81 (0.000)
SBC*(>3 competitors)		=1.44 (0.001)
New product restructuring	=1.59 (0.000)	=1.59 (0.000)

Table 3. New product restructuring equation – results using GMM estimation

Number of observations = 2245
* significant at 10%; ** at 5%; and *** at 1%

Variables	New product restructuring	
Exogenous		
No. of competitors (zero is omitted)	Interacted with ownership	
	OLD	**NEW**
1-3	0.016	-0.227
>3	0.051	**-0.521***
Market power: predicted response to 10% price rise	Interacted with ownership	
(many customers would change suppliers is omitted)	**OLD**	**NEW**
Sales would fall a lot	0.055	-0.038
Sales would fall slightly	0.112	**0.304***
No change in sales	**0.313***	**0.249**
Ownership (old is omitted) New	**0.736***	
Pressure to introduce new product:	Interacted with ownership	
	OLD	**NEW**
Domestic pressure	0.057	0.005
Foreign pressure	**0.133***	**0.053***
Customer pressure	**0.052***	**0.114**
Country dummies	Yes	
Size	0.113***	
Sector (services)	-0.486***	
Location (big city)	0.137***	
Endogenous		
Soft budget constraint (zero=hard, 1=soft)	**-0.575***	
Hansen J-test (p-value)	$\chi^2(116)=151.1$ (0.016)	
F-test of instruments (p-value) SBC SBC*(1-3 competitors) SBC*(>3 competitors)	F(120,2080) =1.45 (0.029) =3.76 (0.000) =1.24 (0.045)	

Appendix Table A1. Comparison of Grosfeld-Tressel and CFSS results

		Grosfeld & Tressel – Poland	CFSS: 25 transition countries		
Sample	Description	Non-financial listed	Economy-wide sample; majority of firms have less than 200 employees		
	Time period	1994 -1998	1996-1999		
	Number of firms	153	2245		
	Type of data	Accounting	Survey		
Variables	Competition (firm level)	Market share (t-1) (NACE 2); Rents (t-1)	- Number of competitors: none; 1-3; >3 - Elasticity of demand		
	Ownership	Main shareholder with >20%: foreign, CEO, other individual, non-financial, bank, NIF, state	SOE; privatized; new private		
	Ownership concentration	Major shareholder has: > 50% voting rights = conc., Between 20 and 50%; < 20% = disp.	N/A		
	Soft budget constraint	No	Yes		
Method	Single year - panel	Panel	Single 3-year period		
	OLS / IV	IV (GMM)	OLS/IV/GMM		
	Firm specific effects controlled	Yes	No		
	Endogeneity of competition and ownership controlled	Yes	No		
Specification	Performance measure	TFP growth	Sales per worker growth	New product restructuring	Reactive restructuring
	Cobb-Douglas / Translog	C-D constant returns	N/A		
Results	Competition (firm level)	Greater market share – lower productivity growth. Higher rents, lower productivity growth	Inverse U-shaped: Growth higher with 1-3 competitors than with either none or many; Growth higher with moderate market power	No. of competitors not significant. Higher market power (i.e. lower PMC) - more innovation. More innovation when pressure from foreign competitors and customers is important reason for innovation.	No. of competitors not significant. Higher market power (i.e. lower PMC) - less restructuring.
	Ownership	Main shareholder (>20% votes): foreign– higher productivity growth; CEO, bank, NIF - lower productivity growth but if CEO has small stake, productivity growth is higher.	New firms have lower growth.	State firms innovate less.	State firms do more reactive restructuring. New firms do less.
	Ownership concentration	More dispersed ownership *and* more concentrated ownership – higher productivity growth	N/A	N/A	N/A
	Complements / substitutes	Concentrated ownership and competition are *complements*			
	Soft budget constraint	N/A	Not significant	Less innovation when budget constraint is softer.	More reactive restructuring when budget constraint softer.

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