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Competition and Firm Productivity: Evidence from Firm-Level Data

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Competition and Firm Productivity: Evidence from Firm-Level Data

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Abstract

This paper presents empirical evidence on the impact of competition on firm productivity. Using firm-level observations from the World Bank Enterprise Survey database, we find a positive and robust causal relationship between our proxies for competition and our measures of productivity. We also find that countries that implemented product-market reforms had a more pronounced increase in competition, and correspondingly, in productivity: the contribution to productivity growth due to competition spurred by product-market reforms is around 12-15 percent.

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Contents

Page

I. INTRODUCTION

We investigate empirically the impact of competition on firm productivity. We use firm observations compiled by the World Bank Enterprise Survey database. The database provides variables that have been identified in the recent empirical literature as determinants of productivity at the firm level. This allows us to isolate the effects of competition on our measures of firm-level productivity. We find a positive and robust causal relationship between our proxies for competition at the firm level and our measures of firm productivity. We also find that firm productivity growth is higher in countries with more substantial product-market reforms. Countries that reformed during the period had a more pronounced increased in competition, thus providing a channel by which productivity is affected by reform.

Over the last twenty years, many countries at different stages of development have undertaken significant regulatory reforms of their product markets. However, product market regulations still vary substantially across countries. For example, according to the World Bank's "Doing Business" database, the costs associated with a business start-up in 2003 amounted to 0.7 percent of GDP per capita in the United States compared to 16.8 percent in Italy and 1316.4 percent in Angola. What is the impact of changes in regulation on competition, productivity, and growth?

According to conventional wisdom, product market regulations affect the market structure of an economy. Reforms that lead to more effective regulations, e.g. a reduction in entry costs, are expected to spur competition between firms within and across sectors. An increase in competition is expected to reallocate resources from lower to higher productivity firms.[1]

The literature on endogenous growth, however, offers contrasting views on competition and productivity. The standard model of endogenous technological change (Romer (1986) and Aghion and Howitt (1992)) that an increase in product market competition between intermediate producers will reduce expected future profits from innovations and hence the rate of technical change ("rent dissipation effect"). In addition, more intense competition will lower the expected durability of new innovations ("creative destruction") and hence the incentive to innovate. Aghion et al. (2001), however, argue that an extension of the basic framework could allow for a positive relationship between market competition and growth. They consider an oligopolistic intermediate sector where innovation enables a firm to break away from intense competition for a certain period of time. The incentive to innovate in order to escape competition is stronger, the closer a firm is to the technological frontier.[2] It follows, in their model, that an increase in competition involves an innovation-tradeoff: it reduces monopoly rents, but enhances the incentive to innovate in order to escape competition.[3] Thus, a positive relationship between product market competition and growth, is not an implication of all theoretical work.

Empirical research into the link between competition-enhancing reforms and productivity (and growth) has been relatively scant, with the exception of reforms related to trade liberalization (Schi-

[1] See Bergoeing, Loayza, and Repetto (2004) and Poschke (2009).

[2] That is, high-productivity firms face strong competition for innovations with other high-tech firms while low-productivity firms simply adopt low-cost vintage technologies.

[3] Aghion et al. (2005) extend this framework to an "escape entry effect," whereby the threat of potential entrants augments the incumbents' incentives to innovate.

antarelli, 2005). One reason appears to be the lack of adequate data. The existing empirical evidence typically examines the effects of changes in product-market regulation on growth at the aggregate level. Several cross-country studies look at the effect of regulation on growth through channels such as changes in mark-ups, entry, exit, or turnover rates. However, the results are ambiguous. Loayza, Oviedo, and Serven (2002) identify a positive effect of product market deregulations on productivity growth through increases in the turnover rate among firms, and Barseghyan (2008) estimates that an increase in entry costs by eighty percent of income per capita would reduce total factor productivity by 22 percent. On the other hand, empirical research on the effects of product market (de-) regulations on the effects on innovation and R&D typically find a negative relationship.[4] The recent use of micro data allows for more detailed empirical analysis with larger sample sizes that help reduce the problem of unobserved (endogenous) institutional heterogeneity in the observations. However, firm- or industry-level studies are typically limited by the lack of appropriate disaggregate measures of product-market regulation and competition. As a result, most of these types of studies are conducted for developed countries. They generally find (small) positive effects of product market competition on productivity growth; for example, Nickell (1996), using data on U.K. companies, finds that competition, measured by increased numbers of competitors or by lower levels of rents, is associated with higher total factor productivity growth.[5] Among studies using developing country data, Srivastava (1996) and Ramaswamy (1999) find large positive effects of product market deregulations in India on firm-level productivity growth. Kaplan, Piedra, and Seira (2007) find a positive impact of entry deregulations on business start-ups in Mexico.[6]

There are several possible explanations for the ambiguous empirical findings. First, they might stem from the difficulty in measuring product market regulations. Second, deregulations of product, labor, or financial markets often take place simultaneously and are complementary to one another. For example, a substantial reduction in entry costs might not be effective if small firms have no access to finance. Measuring the direct effects of an increase in competition stemming from entry deregulation, per se) on firm productivity requires the inclusion of appropriate variables to control for a firm's access to capital and labor inputs. Third, regulatory instrumental variables are only available at the industry or country level. However, it is plausible to argue that industry-level measures of product market regulations are endogenous with respect to the (expected future) performance of a given industry. For example, policymakers might aim to promote entry into sectors with prospects of high productivity growth. Fourth, the ambiguous results might simply reflect a non-linear relationship between competition and growth.

The contribution of our research is many-fold. The use of firm-level measures on competition together with an exogenous variation of product market reforms across countries observed in our sample allows us to draw some conclusions on causality while avoiding aggregate measurement errors or the endogeneity of regulatory instrumental variables at the industry level. Moreover, the detailed information on institutional, financial, and labor market frictions at the firm-level from the World Bank Enterprise Survey makes it possible to isolate the direct effect of competition on productivity. Importantly, as the Survey provides information on employees' educational levels

[4]See Griffith and Harrison (2004) and Cincera and Galgau (2005)

[5]See also Nicoletti and Scarpetta (2003) for additional evidence.

[6]See Cole et al. (2005) for a survey of industry case studies that address the relation between competition and productivity in several Latin American countries.

for each firm, we are able to improve upon previous measures of firm productivity.[7] Finally, our sample of emerging-market countries is of particular interest since (i) productivity improvements were the main source of economic growth among this group of countries from 1999–2005 and (ii) a wave of product market deregulations occurred in a number, but not all, of these countries. Hence, we are able to test if potential growth effects from deregulations are larger for countries with a higher initial degree of regulatory frictions. And given that the changes in the degree of product market regulation appear to have been mainly determined by political factors, we can analyze the causal relationship between competition and firm productivity.

The rest of the paper is organized as follows. In Section II, we describe the data and the empirical methodology. Section III measures the empirical relationship between competition and growth, while Section IV examines causality. The last section concludes.

II. Data and Empirical Methodology

A. Productivity

We measure firm productivity in four different ways.[8] First, we measure firm-level total factor productivity (TFP) as a residual from an augmented Cobb-Douglas production function. We use the methodology of Olley and Pakes (1996) to estimate input elasticities rather than setting input elasticities equal to factor shares, which would require the assumption of perfect competition. This needs to be weighted against the assumption that input elasticities are the same across sectors.[9] Second, we measure TFP as an index relative to the industry median following Caves, Christensen, and Diewert (1982). This measure differs from the first measure in that (i) it is a relative measure; and (ii) we use the observed indexed firm factor shares as input elasticities by assuming constant returns to scale. Third, we measure firm labor productivity. In our natural experiment, reported in Subsection B of Section IV, we use the growth rate of total factor productivity.

In order to estimate firm-level productivity we need information on output, capital and labor inputs at the firm level. We use firm data for 27 countries in 2004.

For each country i, we estimate input elasticities (in logs) as

$$y_{ji} = \theta_i^k k_{ji} + \theta_i^h h_{ji} + \eta_s , + \varepsilon_{ji} \tag{1}$$

where y_{ji} denotes firm j's value added in country i, k_{ji} and h_{ji} are physical and human capital inputs of firm j, η_s is a vector of industry specific effects,[10] $\theta^i = (\theta^{ik}, \theta^{ih})$ is a vector of average input elasticities in country i, and ε_{ji} represents the error term.

[7] Maudos, Pastora, and Serrano (1999) document how the inclusion of human capital has a significant effect on the accuracy of TFP measurement.

[8] See Van Biesebroeck (2003) for a detailed comparison of different methods of estimating productivity.

[9] An alternative is to estimate input elasticities per industry. However, the number of observations per sector per country is not enough to yield trustworthy estimates. The exceptions are the manufacturing sector and the wholesale sector. We report results for the manufacturing sector in Table 9.

[10] The industry specific effects are based on one digit NACE codes.

The World Bank Enterprise Survey provides information for y_{ji}, k_{ji}, and h_{ji} and η_s. We use value added as our output measure in 2004. We are constrained to 2004 as the information on intermediate inputs is not available in 2001 while it is for 2004.[11] [12] Physical capital input is measured as the net book value of fixed assets after depreciation.[13] We use aggregate price levels of output and capital services from the Penn World Tables to deflate the two respective series. Disaggregated price levels would be preferable as deflators but the data are not available. However, the addition of country fixed effects and various firm characteristics to (1) should account for possible vertical shifts in the TFP distribution across countries and industries.

We are able to get a more accurate measure of labor services as the Survey provides detailed information on the educational level of firm's full-time employees. Our measure of labor services is a measure of labor adjusted by human capital H. Following Caselli (2005) we measure human capital as $H = L \exp \phi(s)$, where L is the number of full-time employees and $L_h = \exp \phi(s)$ is the average human capital per employee, s being the average years of schooling of the stock of employees. $\phi(s)$ is linear with slope 0.10. The slope reflects the average returns on education for an additional year of schooling in emerging economies (Hall and Jones, 1999).

We estimate (1) in logs to obtain average country input elasticities θ^k and θ^h from the firm-level data. The estimation of (1) involves a well-known endogeneity problem as a firm's demand for human capital is expected to depend on its contemporaneous productivity level which is captured in the error term. To get around this problem, we employ the two-step procedure of Olley and Pakes (1996) to extract consistent estimates of the average input elasticities in our sample.[14] A detailed description of this procedure is given in Appendix B.

Table 1 presents the estimated elasticities for physical and human capital using the Olley–Pakes as well as the conventional OLS procedure. If the Olley–Pakes procedure successfully corrects for biases, one would expect to find a decrease in the coefficients on human capital and an increase in the physical capital coefficients relative to the OLS results (Olley and Pakes, 1996). Table 1 shows that the human capital coefficients move in the predicted direction in 18 out of 19 cases, while the magnitude of the capital coefficient increases in 15 out of 19 cases. Thus, the Olley–Pakes correction appears to be working quite well.

Our second measure of productivity is based on Caves, Christensen, and Diewert (1982). The methodology employs firm-level factor shares of human capital an intermediate inputs (measured by firm- and industry-level factor shares) to compute input elasticities. We compute the factor share of the physical capital stock by assuming constant returns to scale. TFP is measured as an index using the industry-level median as a reference point. In (2), we measure output as sales and explicitly include intermediates inputs on the right hand side.[15] The output and input measures,

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[11] Olley and Pakes (1996) also use value added. Nickell (1996) employs value added as well as sales.

[12] Information on the level of inventories per firm is not available. We assume that the ratio of inventories relative to total sales is not correlated with a firm's level of physical or human capital.

[13] Fixed assets comprise machinery, vehicles, and equipment as well as land and buildings.

[14] The World Bank Surveys of 2004 and 2001 contain corporate investment and human capital levels for the three years leading up to the Survey, which we use as lagged values of investment and human capital in the Olley–Pakes procedure.

[15] Measuring output as value added would yield a TFP measure with a .88 correlation coefficient with the Caves TFP measure we ultimately use in our subsequent estimations.

(i.e sales, intermediate inputs (m), physical and human capital) are all measured relative to an industry-level (s) median:

$$TFP = \left(y_{jsi} - \tilde{y}_{si}\right) - sh^{h}_{jsi} \times \left(h_{jsi} - \tilde{h}_{si}\right) - sh^{m}_{jsi} \times \left(m_{jsi} - \tilde{m}_{si}\right) - \left(1 - sh^{h}_{jsi} - sh^{m}_{jsi}\right) \times \left(k_{jsi} - \tilde{k}_{si}\right) \quad (2)$$

where a tilde ($\tilde{\cdot}$) denotes the industry level median of the variable, $sh^{x}_{jsi} = (sh^{x}_{jsi} + \overline{sh}^{x}_{si})/2$, $x = (h, m)$, sh_{jsi} is the firm j-level factor share, and $\overline{sh}_{is}$ is the industry s-level average factor share within each country.[16]

Our third measure, labor productivity, is provided as a benchmark. Labor productivity is measured as a ratio of firm sales to human capital. Figure 1 graphs the distributions of the three productivity measures. All three distributions are skewed to the right but there are differences across our measurements of productivity in dispersion and range. There appears to be a lot of heterogeneity in productivity at the firm level.

Table 2 shows the correlation coefficients between the three different measures. The correlation coefficients are positive and relatively high but not uniform.[17] Thus, we choose to report results for all three methodologies. Finally, the growth in total factor productivity from 2001 to 2004 is measured as a Solow residual. The methodology is described in Appendix C.

B. Competition

The World Bank Enterprise Survey provides detailed information on the degree of product market competition at the firm level including markups (ln-*markup*) and cost competition (*comp-cost*). Mark-ups are measured as sales over operating costs. Cost competition is a discrete variable with values from 1 (of low importance) to 4 (of high importance) representing the firm's response to the Survey question: "How important is *pressure from domestic competitors* on key decisions about your business with respect to *reducing the production costs of existing products or services*?" [emphasis added]. A value of 1 indicates

The Survey also includes information on corporate control variables which capture firm-level differences as well as differences between countries or industries. In particular, we account for the following firm-specific characteristics: a firm's age (*age*), the firm's size (*size*),[18] and four dummy variables that are equal to 1 if the firm's headquarters are located in a foreign country (*foreign*); if the firm exports (*exports*); if the firm was established through privatization of a state-owned enterprise (*privatized*); and if a new technology was introduced that substantially changed production (*new techno*).[19]

[16] Table 10 provides the input elasticities per industry per country using this procedure.

[17] Van Biesebroeck (2003) reports correlation coefficients with a range of $-.02$ and 0.99 for his different measures of productivity. See Table 4 of Van Biesebroeck (2003).

[18] Firms are categorized as "small" if they have fewer than 50 full-time employees, "medium" if they have in between 50 and 249 full-time employees, and "large" if they have 250 or more full-time employees.

[19] See Melitz (2003), Helpman, Melitz, and Yeaple (2004), Calderón and Servén (2005), and Beck and Levine (1999) for arguments on the use of some of these variables as controls.

To account for competition in input markets, we include the percentage of investments that are financed from retained earnings (*ret-earn*); a dummy variable (*stock*) which is one if the company is listed in a stock market and zero otherwise; and the extent of hiring restrictions faced by the firm (*hire*), measured as the manager's reckoning of the percentage by which s/he would increase the firm's regular work force in the absence of restrictions.[20]

The institutional variables include an *audit* variable, the number of power outages per year (*pow-outages*); and "affordable jurisdiction" (*juris*), a qualitative variable that varies from 1 to 6, where one is "never affordable" and six is always affordable. Finally, as we want to identify domestic competition, we include a qualitative variable reflecting external competition from imports. This variable can take values from 1 to 6, where 1 indicates a low degree of competition from imports and 6 a high degree of import competition (*comp-import*).

Table 3 reports the descriptive statistics for these firm-specific control variables in 2001 and in 2004. From these statistics we can infer a high degree of dispersion in firm productivity, as was observed in the histograms. The TFP index displays the least variability and labor productivity the most. Our measures of competition exhibit less dispersion.

C. Reforms

We use the Economic Freedom of the World Index from the Fraser Institute to identify the countries that had major changes in their product market regulations. The indicators are based on a mixture of factual and subjective information. The Fraser database provides an annual index on the "ease of starting a new business" for 1995 and on an annual basis from 2000 until 2004. This index is based on the methodology of the World Bank's Doing Business data and measures the amount of time and money it takes to start a new limited-liability business.[21] The index varies from 1 to 10, in decreasing order of entry costs. Table 4 reports the differences in entry costs across the countries with available data.[22] We use this index to classify countries into reformers and non-reformers during 2001–2004.

Table 4 displays the grouping of countries according to the Economic Freedom of the World index from the Fraser Institute. This database is the only one with information on product market regulations, in particular entry regulations, in European and Central Asian countries for our period of study. The information is available for sixteen countries. We classify a country as a re-

[20]The Survey also provides a measure for firing restrictions. This variable was not significant in any of the estimation specifications.

[21]In particular, the index is based on three different variables: (i) the number of days necessary to comply with regulations, (ii) money costs of the fees paid to regulatory authorities measured as a share of per-capita income and (iii) minimum capital requirements measured as a share of per capita income. These three ratings are averaged to obtain the final index.

[22]The Fraser database provides also a composite index of business regulations consisting of the ease of starting a business, administrative conditions for entry, price controls, time with government bureaucracy and irregular payments. We focus on the former index as it was the one that varied the most during our period of study but also because (i) it is a more objective measure, since it is based on directly observable information on official number of procedures and fees; (ii) it varies substantially across countries and over time relative to the other indices for the period of interest and (iii) the methodology complies with the measure of the "costs of starting a business" from the World Bank Doing Business database.

former if the Fraser index of "the ease of starting a business" improved by at least 40 percent from 2001 to 2004. The index increased by an average of 69 percent in the reformer group (ten countries), with the largest increase of 147 percent in Romania. In contrast, all countries in the non-reformer group experienced a decline in the index on average by 1.4 percent corresponding to an increase in the costs of starting a business from 2001 to 2004. The exceptions were Poland and the Czech Republic, where the index increased by 22.3 percent and 10.6 percent between 2001 and 2004, respectively. We classify these two countries as non-reformers based on their overall performance during 1995–2004, as shown in Table 4.[23] Overall, the group averages were pretty similar in 2004 and 2001 (5.8 and 5.6) reflecting fairly similar index levels.

We also considered other changes in regulation that might have taken place during the same period. Table 5 reports regulatory indices and changes for international trade, financial, and labor markets from the Fraser database for all countries except for Georgia and Macedonia for which the data was not available. Importantly, these indices do not reveal important changes in regulation (other than entry costs) and the changes that are observed do not differ between the reformer and the non-reformer group of countries. Still, we control for these complementary contemporaneous reforms in the region in our natural experiment exercise. Finally, Table 5 shows the median TFP growth for all countries. Note that the period average median TFP growth for the reformer countries is about double the corresponding growth for non-reformer countries. In Subsection B of Section IV, we formally test for the difference in TFP growth between reformer and non-reformer countries.

III. Empirical Relation between TFP and Competition

In this section we examine the relationship between firm productivity and competition. The previous section described three measures of (log) productivity y_{jit} (ln*TFP-OP*, ln*TFP-Caves*, and ln-*laborprod*) and two measures of competition C_{jit} (ln*markup* and *comp-cost*) that we will use in our estimation. Our procedure is to estimate the empirical model described by equation (3) below to determine how much of the variation in firm-level productivity is associated with variations in competition. The model includes a vector of firm-specific control variables (X_{ji}). In particular, we control for differences across firms in their access to finance, international markets, infrastructure services, legal institutions, and labor markets. We include country (μ_i) and industry (η_s) fixed effects to account for unobservable heterogeneity among industries and countries in the pooled data:

$$y_{jit} = \beta_c C_{jit} + \beta_x X_{jit} + \mu_i + \eta_s + \varepsilon_{jit}, \qquad j = 1,2,\ldots,N \text{ and } i = 1,\ldots,27. \tag{3}$$

N is the number of firms in country i and β_c and β_x are the parameters to be estimated. When the dependent variable is TFP, the observations are from 2004 only, for labor productivity, both 2001 and 2004 observations are used and a time dummy is included in the estimation. ε_{ij} represents the error term.

[23] We still performed all exercises without these two countries for robustness. The results remain qualitatively the same.

Our objective is to identify the sign of the β_c coefficient. When competition is measured using markups, our hypothesis is that an increase in markups (which is indicative of a decrease in competition) will be associated with a decrease in productivity and therefore β_c will be negativley signed. When competition is measured in terms of perceived pressure to reduce costs from domestic competitors, then we expect an increase in this pressure to increase productivity, that is we expect a positive sign for β_c.

The first row of Table 6 shows that markups are negatively correlated with all three productivity measures after controlling for the other firm-level productivity determinants. The corresponding coefficients are significant at the 5 percent level in all three cases. Firms that have 20 percent higher markups, have, on average, 1.2 percent lower corporate TFP levels based on Olley and Pakes (1996) or Caves, Christensen, and Diewert (1982) and 8 percent lower labor productivity.

As the distributions of the measured productivity variables exhibit substantial dispersion (see Figure 1), we would like to explore how the β_c coefficient may differ for firms with different productivities. Additionally, because of skewness in the distributions, the OLS estimators of Table 6 may have substantially higher variance than non-linear estimators such as the least absolute deviation (LAD) estimator.[24] The six graphs in Figure 2 correspond to the six models for which OLS estimators are presented in Table 6. The graphs present the OLS estimators as well as 18 different quantile estimators in increments of 5 percent up to the 95 percent quantile. For example, the dashed line in the top left-hand graph represents the OLS coefficient on log markups when the dependent variable is $\ln \mathit{TFP\text{-}OP}$ ($-.062$). The dotted lines display the 95 percent confidence intervals of the OLS coefficient. The solid line connects the 18 quantile regressions. The corresponding LAD estimate of $-.038$ corresponds to the median. The shaded areas delimit the 95 percent confidence intervals for the 18 different quantile regressions. Note that in 5 of the 6 regressions the LAD estimator has the same sign and is of a similar magnitude to the OLS estimator. The only exception is the model corresponding to column 2 of Table 6. The variation of competition from cost pressures produces a negligible negative response in our TFP-OP measure.

Figure 2 also suggests a systematic non-linearity in the competition-productivity nexus. For the most productive firms, depicted in the higher quantiles, the quantile coefficients reflect a larger impact from competition via markups. This type of non-linearity is consistent with the theoretical approach of Aghion et al. (2001): the incentive to innovate in order to escape competition is stronger, the closer a firm is to the technological frontier.

The results differ when we use cost competition.[25] Although Table 6 shows a positive sign for the OLS estimator β_c, only the estimator for labor productivity is significant.[26] The quantile regressions depicted on the right hand side in Figure 2 show that the correlation differs between high and low productivity firms. For example, the cost competition coefficient is positive and significant if TFP-OP does not exceed the 40 percent quantile but it is not significant at conventional levels thereafter. This type of non-linearity is not consistent with the one between TFP and markups. We note, however, that the cost competition indicator varies only from 1 to 4, hence it

[24] See Koenker and Bassett (1978) on robust estimation and quantile regression.

[25] We do not control for country fixed effects in the cost competition regressions since they appear to be highly correlated with this qualitative indicator.

[26] The correlation between cost competition and labor productivity is .056 and is significant at the 1 percent level if we do not control for the additional firm variables.

might not be appropriate for examining the detailed non-linear pattern of correlation with productivity. Moreover, the other productivity indicators do not confirm this effect for low-productivity firms. The relationship between labor productivity and cost competition appears to be hump-shaped while the one between cost competition and TFP based on Caves, Christensen, and Diewert (1982) does not seem to follow any specific pattern.

Finally, we note that the effects of the additional corporate indicators on all three productivity measures are broadly consistent with the theoretical predictions and the empirical findings in the literature. This is true, in particular, for the TFP measure based on Olley and Pakes (1996). The first column of Table 6 shows that exporting and foreign firms are more productive which is consistent with the findings of Melitz (2003) and Helpman, Melitz, and Yeaple (2004). Firms that apply international audit standards, (which implies a better access to finance) are found to be more productive; a positive link between financial development and firm productivity is also found by Hallward-Driemeier, Wallsten, and Xu (2003) and Christopoulos and Tsionas (2004), among others. Finally, larger and younger firms are associated with higher TFP, which is consistent with Bartelsman and Doms (2000) and Van Biesebroeck (2005). The TFP indicator based on Caves, Christensen, and Diewert (1982), in contrast, is not significantly correlated at the 5 percent level with the foreign ownership, exporting, or auditing status of firms. However, firms that face stronger hiring restrictions are found to have a higher TFP index, which confirms the findings of Scarpetta et al. (2002).

Overall, the findings point to a positive correlation between competition as measured by markups and productivity in our sample of 27 Eastern European and Central Asian emerging economies. These findings are corroborated for two of the three productivity variables when we employ the subjective indicator of cost competition. Moreover, we find that the average OLS coefficients conceal a systematic non-linear pattern in the markup-productivity nexus, which implies that the positive correlation between competition and productivity is increasing in the productivity level of a firm.

IV. Direction of Causality

A. Instrumental Variable Approach

In this section we address causality. The information from the Survey allows us to apply an instrumental variables approach using internal as well as external instrumental variables. As a subset of firms participated in the Survey in both periods, we can use changes in markups between 2001 and 2004 and lagged values of the qualitative competition indicators as internal instrumental variables. In particular, we use as a qualitative indicator, the response to the question: "How important is pressure from domestic competitors on key decisions about your business with respect to *developing new products or services and markets*?" We also use the following external instrumental variables: (i) the country-level index on the *costs of starting a business* from the Fraser database which is outlined in Table 4, and (ii) a qualitative indicator namely, the response (on a 0 to 4 scale) to the question: "How problematic are *anti-competitive practices of other producers* for the operation and growth of your business?"

The usefulness of the first external variable as an instrument relies on the fact that it is an aggregate index measuring competition from entry that varies at the country-level (and is not affected by firm-level variations in productivity). The second external variable reflects a manager's assessment of anti-competitive practices by other producers. We assume that this subjective assessment better approximates a firm's exposure to competition in an industry than the use of anti-competitive practices in general. Specifically, we assume that anti-competitive practices by other producers do not affect a firm's own productivity level apart from their indirect effect on competition and the control variables.

Table 7 summarizes the results of the instrumental variable (IV) estimations.[27] The first column reports the result of the first-stage regressions using aggregate entry costs and the firm-level anti-competitive practices measure in 2004 as instruments. As we use contemporaneous external instruments, the full sample of firms in 2004 can be employed in the estimation. Both instrumental variables are significantly correlated with the measure of cost competition in 2004. The corresponding coefficients are significant at the 1 percent level. The null hypothesis that both instrumental variables are jointly equal to zero (Wald-test) is rejected at the 1 percent level; i.e., we reject the hypothesis that the instrumental variables do not explain variations in cost competition (the endogenous variable). Moreover, both instrumental variables contribute valuable information since the correlation coefficient between the two instruments is only .073.

The results for the IV regression are reported in the second column. They reveal a positive causal impact of cost competition on TFP based on Olley and Pakes (1996). The corresponding coefficient is significant at the 5 percent level. The third and fourth columns of Table 7 report results including lagged values for markups and competition in technologies (internal IVs). Both instruments are significantly correlated with cost-competition. The null hypothesis that all three instrumental variables are jointly equal to zero (Wald-test) is rejected at the 1 percent level. The estimation results, based on the 284 firms for which there was available data in both periods, confirm a causal effect of cost-competition on the Olley–Pakes TFP variable.[28] Columns five to eight of Table 7 report the same IV estimations for the TFP index based on Caves, Christensen, and Diewert (1982). However, the results are ambiguous for this measure of TFP. The internal IV regression finds a positive causal effect from competition to firm-level TFP while the external IV regression finds a negative effect. Finally, the last four columns report the IV estimations for labor productivity. The results show a positive causal impact of competition on labor productivity in both cases. Finally, the Hansen test statistics suggests that we can not reject the validity of the instruments in all of the cases where we find a positive causal impact from competition on productivity. In summary, the results of this section show a causal relation between competition and the Olley and Pakes (1996) TFP measure of productivity as well as with labor productivity; the results for the TFP index based on Caves, Christensen, and Diewert (1982) are ambiguous.

[27] We apply the general method of moments estimator using heteroscedasticity-robust standard errors for the IV estimations.

[28] The corresponding Wald-tests for null hypothesis of zero joint explanatory power of he instrumental variables in the remaining specifications (columns 5, 7, 9 and 11) are always rejected at the 1 percent level.

B. Natural Experiment

The previous sections described our findings on the relationship and causality between competition and productivity. We have found that firms operating in a more competitive environment exhibit higher measured productivity. In this section we investigate if *changes* in competition motivate *changes* in productivity. More precisely, we ask if an increase in competitive pressure increases firm productivity. Productivity growth has been identified as the main source of growth among Eastern European and Central Asian emerging economies during the early 2000s. We argue that the increase in competitive pressure due to entry deregulation is behind the productivity increase.

We take advantage of the fact that several Eastern European and Central Asian economies underwent a wave of product market deregulations in the beginning of the decade. The timing of reforms differed even among very similar economies. For example, the Slovak Republic implemented major product market reforms in 2002/2003 whereas the Czech Republic reformed a few years later. These changes were politically motivated by the potential (future) accession to or cooperation with the European Union. Since the deregulation was not endogenously determined by the countries' productivity performance, we can consider the reform as an exogenous shock to competition. Thus we have a "natural experiment" in which to examine causality from the observed change in competition, brought about by entry reform, on productivity growth. Importantly for our exercise, there were also several of these economies that *did not* deregulate during this period—the non-reformer countries. That is, we have a control group, with similar characteristics to the sample of reforming countries, against which we can observe the impact of reform on productivity. The existence of this control group allows us to perform a difference-in-difference estimation, described below.[29]

It is often argued that the individual impact of deregulations of product, labor, financial, or traded goods markets on real activities are hard to distinguish because several of these reforms tend to be implemented simultaneously. In Section II (Table 5), we argued that regulatory changes affecting the business climate were relatively minor in most of our sample countries for the period of interest apart from the deregulation of entry to product markets. Table 5 shows the average levels of trade and labor regulation indices are almost identical in both groups, while the access to credit is, on average, better in the non-reformer group for both periods.

We estimate the following difference-in-difference equation to measure the difference in the changes in firm productivity levels between reformer and non-reformer countries:

$$\Delta y_{jit} = \beta_1 R_{ji} + \beta_2 X_{jit} + \beta_3 F_{it} + \eta_s + \varepsilon_{jit} \quad (4)$$

where $j = 1,2,\ldots,N$, $i = 1,2,\ldots,16$, $t = 2001, 2004$, Δy is TFP growth, $R_{ji} = 1$ if firm j operates in a reformer country and 0 otherwise, X_{ji} is a vector of firm-level control variables, and F_i is a vector of reform control variables. F_i includes the aggregate GDP level from the Penn World Tables and aggregate reform indices from the Fraser database.

The reformer dummy variable, R_{ji}, reflects the average difference in TFP growth between the reformer and the non-reformer countries from 2001 to 2004. A positive and statistically significant

[29] An alternative, not available to us due to lack of data, is to compare changes within countries before and after the reform.

estimate for β_1 would signify that TFP growth from 2001 to 2004 is higher in the reformer relative to the non-reformer group.

We measure TFP growth using firm-level factor shares of human and physical capital and firm sales as our measure of output. We make an adjustment following the methodology by Kim (2000) to correct for bias in TFP growth arising from the presence of imperfect competition and non-constant returns to scale. Appendix C describes in more detail the computation of TFP growth and the Kim (2000) correction. Table 8 presents the estimation results. The estimate for β_1 is between .19 percent and .25 percent. That is, TFP growth in reformer countries is higher than TFP growth in the non-reformer economies.[30] These results are robust to the inclusion of regulation differences, industry and firm controls.[31] All corresponding coefficients are significantly different from zero at the 1 percent level. These results are non-trivial. The average growth in TFP for all countries in our sample between 2001 and 2004 was 1.64 percent (the median was 2 percent). Thus, an interpretation of our results is that for a reformer country, productivity growth would be between one seventh and one ninth higher than for a non-reformer on average. That is, between 12 and 15 percent of productivity growth is explained by competition spurred by reforms (or between 10 and 13 percent if relative to median).

So far our conjecture is that productivity growth has increased in the reformer countries because competitive pressure increased following entry deregulation. To be complete, we need to investigate if the change in competition is reflected in our measures of competition. The strategy is the same as in the exercise for productivity growth. That is, after controlling for time differences (time dummy, $d04 = 1$ if year 2004, 0 otherwise) and the overall differences in levels of competition in reformer versus non-reformers ($dreform$), we estimate the difference-in-difference coefficient for the interacting term $dreform04$. This variable takes the value 1 if the country is in the reformer group and the year is 2004, and zero otherwise. Our expectation is for this coefficient to be negative when the dependant variable is ln-*markup* and positive if the variable to be explained is $cost - comp$. That is, lower markups (or higher *comp-cost*) indicate that competition on average is higher on reformer countries relative to non-reformer countries during 2001–2004.

The last two columns of Table 8 present the coefficients for the three variables just described. The coefficient of the interaction term between the reformer and the time dummy, the difference-in-difference effect, shows that the increase in the level of competition was more pronounced in the reformer countries relative to the non-reformers in between 2001 and 2004. The coefficient is -.097 and significant at the 5 percent level for the competition measure based on markups.

Overall, we observe higher TFP growth as well as a stronger increase in the degree of competition among firms in reformer countries. Given the exogenous, politically-motivated nature of the product market reforms, the significant impact of entry deregulations on firm-level TFP growth in the reformer relative to the non-reformer economies points to a causal effect of product market reforms on firm productivity growth in the Eastern European and Central Asian countries. The fact that both groups of countries (reformer and non-reformer) are relatively homogenous

[30] If one wants to argue that the reforms are endogenous with respect to a country's productivity performance one would suppose that the reformer countries a priori exhibited a higher TFP level. In contrast, the reformer dummy ($dreform$) in Table 8 indicates that the average TFP level was lower in these countries.

[31] The alternative regulatory variables are not available for Macedonia and Georgia, thus the sample drops to 14 countries when including F_{it}.

with respect to the levels and evolutions of trade, financial, and labor market regulations in our sample confirms this conclusion. These findings corroborate the results of the IV estimations in Section III.

V. Conclusion

Our study used firm-level data for a group of countries in Eastern Europe and Central Asia during a period in which a good number of these countries underwent a simultaneous wave of reforms with the common objective of acceding to the European Union. The data allows for different measures of firm competition and firm productivity and includes firm-level variables that have been noted in the literature to explain firm productivity. We find a positive causal relationship from competition to productivity. Firms that have 20 percent higher markups, have, on average, 1.2 percent lower TFP levels and 8 percent lower labor productivity.

Because not all countries in this region reformed their product markets to the same extent and many of the reform changes were politically motivated, we have a natural experiment in that we can compare changes in competition between the reformers and the non-reformers. We find that countries that reformed during the period experienced a more pronounced increase in competition. The contribution to productivity growth due to competition spurred by these reforms is around 12–15 percent.

Figure 1. Histograms

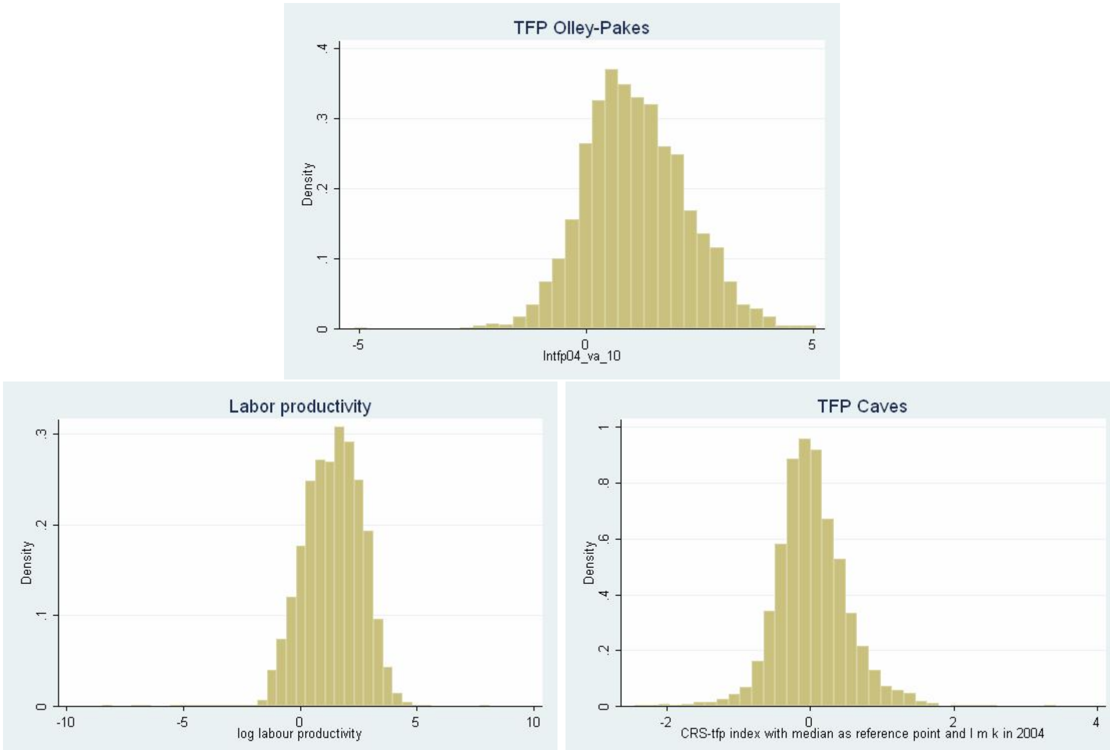

Figure 2. Quantile regressions: TFP and competition

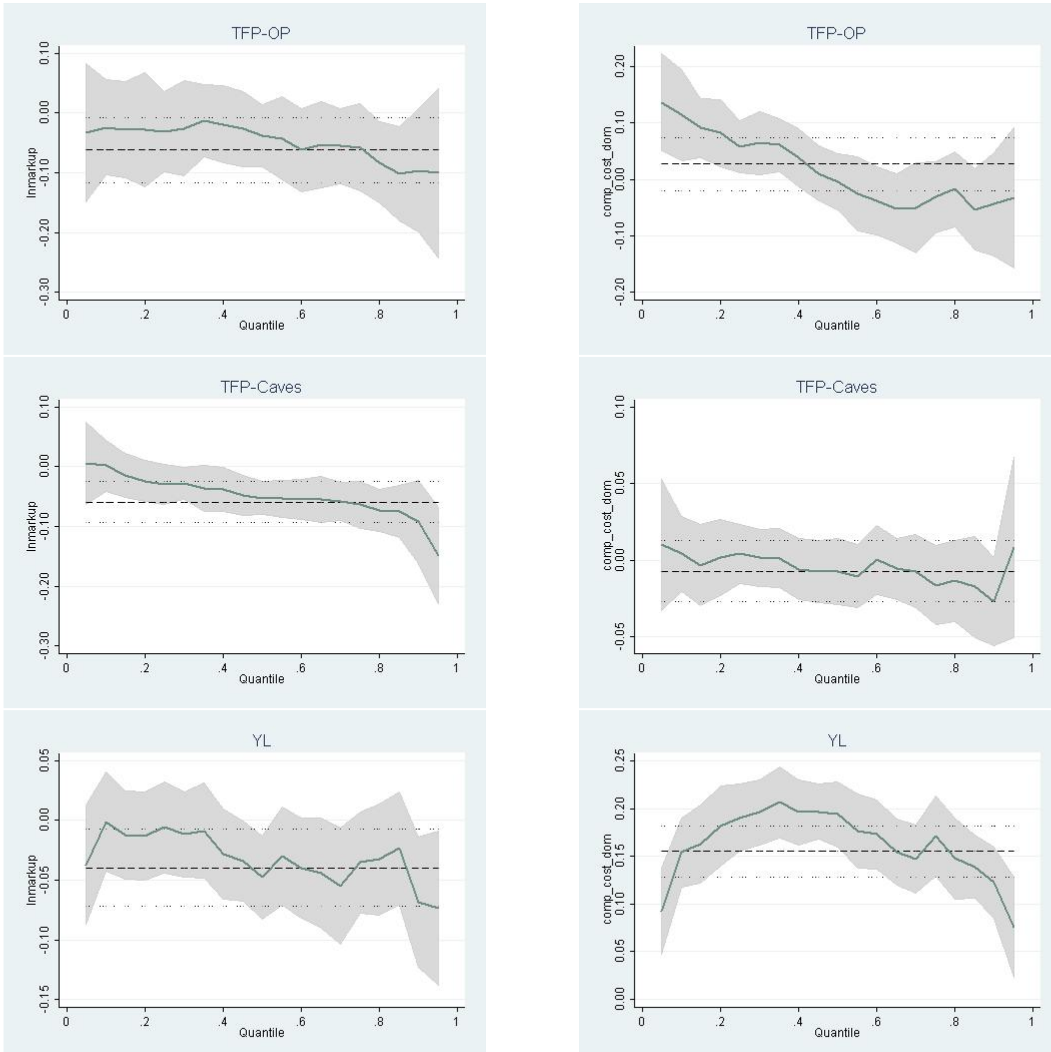

Table 1. Estimated input elasticities: Olley–Pakes versus OLS

Country	Olley–Pakes			OLS			Difference	
	θ_i^k	θ_i^h	sum	θ_i^k	θ_i^h	sum	θ_i^k	θ_i^h
Albania				0.09	0.99	1.08		
Armenia	0.20	0.67	0.88	0.33	0.69	1.02	-	-
Azerbaijan								
Belarus				0.10	0.91	1.01		
Bosnia	0.39	0.59	0.98	0.06	0.94	0.99	+	-
Bulgaria	0.44	0.84	1.27	0.28	0.87	1.15	+	-
Croatia	0.14	0.86	0.99	0.05	0.98	1.03	+	-
Czech Rep.	0.20	0.57	0.77	0.14	0.90	1.04	+	-
Estonia	0.37	0.98	1.35	0.10	1.01	1.11	+	-
Georgia	0.52	0.68	1.20	0.22	1.04	1.26	+	-
Hungary	0.30	0.76	1.06	0.12	0.99	1.11	+	-
Kazakhstan	0.19	0.78	0.98	0.19	0.85	1.04	0	-
Kyrgyzstan	0.30	0.56	0.86	0.15	0.91	1.06	+	-
Latvia	0.27	0.67	0.94	0.09	0.98	1.07	+	-
Lithuania	0.21	0.68	0.88	0.12	0.90	1.02	+	-
Macedonia				0.07	0.99	1.06		
Moldova	0.10	0.92	1.02	0.14	0.86	1.00	-	+
Poland	0.39	0.76	1.14	0.27	0.86	1.13	+	-
Romania	0.24	0.45	0.69	0.24	0.80	1.04	0	-
Russia	0.26	0.73	0.99	0.08	0.92	1.00	+	-
Slovakian Rep.				0.07	1.01	1.08		
Slovenia	0.38	0.88	1.26	0.12	0.90	1.02	+	-
Tajikistan				0.23	0.94	1.17		
Turkey	0.11	0.50	0.61	0.14	0.89	1.03	-	-
Ukraine	0.13	0.67	0.80	0.23	0.78	1.01	-	-
Uzbekistan				0.17	0.87	1.05		
Yugoslavia				0.04	0.96	1.01		

The estimation is based on the following log production function in 2004: $y_{jsi} = \theta_i^k k_{jsi} + \theta_i^h h_{jsi} + \eta_s + \varepsilon_{jsi}$,
where y is measured by value added.

Table 2. Correlation coefficients for productivity measures, 2004

	Ln TFP-OP	Ln TFP-Caves	Ln-laborprod
ln*TFP-OP*	1.0000		
ln*TFP-Caves*	0.4260	1.0000	
Ln-laborprod	0.4513	0.2146	1.0000

Table 3. Descriptive statistics

	obs	mean	sd	obs 2001	mean 2001	sd 2001	obs 2004	mean 2004	sd 2004
ln *TFP-OP*							3461	1.10	1.12
ln *TFP-Caves*							4067	.0270	.4990
ln-laborprod	11715	1.41	1.22	4834	1.04	1.27	6881	1.67	1.11
ln-*markup*	14104	2.87	0.63	5656	2.73	0.69	8448	2.96	0.57
comp-cost	15905	2.76	1.06	6497	2.67	1.06	9408	2.82	1.06
age	16313	15.20	17.77	6666	14.68	18.28	9647	15.57	17.40
size	16321	1.42	0.69	6666	1.46	0.72	9655	1.39	0.66
for	16321	0.11	0.31	6666	0.13	0.34	9655	0.09	0.29
exp	16225	0.26	0.44	6624	0.29	0.45	9601	0.24	0.42
stock	14546	0.02	0.15	5739	0.03	0.18	8807	0.02	0.14
privatized	14474	0.18	0.38	5668	0.19	0.39	8806	0.17	0.37
comp-import	15680	2.90	1.54	6401	2.86	1.54	9279	2.93	1.54
pow-outages	16035	10.29	38.31	6590	11.04	33.21	9445	9.77	41.49
ret-earn	15930	71.36	37.59	6500	70.03	37.84	9430	72.27	37.39
audit	15935	0.49	0.50	6499	0.51	0.50	9436	0.47	0.50
juris	14385	3.14	1.51	5848	3.14	1.51	8537	3.14	1.51
hire	12640	13.84	29.09	4780	13.59	28.28	7860	14.00	29.57
new techno	16146	1.69	0.46	6628	1.72	0.45	9518	1.68	0.47

Table 4. Changes in entry costs from Fraser database

	% change 01-04	index 2004	index 2001	% change 00–01	% change 95–01
Reformer:					
Bulgaria	113.36	4.71	2.21	-12.82	
Georgia	58.86	5.82	3.67		
Latvia	47.38	6.80	4.62	-7.71	
Lithuania	53.16	5.83	3.81	-8.95	
Macedonia	65.49	3.86	2.33		
Romania	147.34	6.47	2.62	-27.33	
Russia	44.88	5.25	3.62	-9.45	3.01
Slovak Rep	46.03	6.80	4.66	55.17	8.70
Turkey	48.86	7.15	4.80	-7.93	-36.37
Ukraine	64.98	4.87	2.95		
average	***69.03***	***5.76***	***3.53***	***-2.72***	***-8.33***
Non-Reformer:					
Croatia	-10.89	4.90	5.50		
Czech Rep.	10.56	5.00	4.52	-18.36	-24.27
Estonia	-6.95	7.07	7.60	-5.45	-10.79
Hungary	-4.68	6.51	6.83	-7.33	6.69
Poland	22.34	5.43	4.44	-36.48	1.60
Slovenia	-18.86	4.87	6.00	4.63	
average	***-1.41***	***5.63***	***5.81***	***-12.60***	***-6.69***

The averages excluding Georgia and Macedonia in the reformer group, first three columns are 70.75, 6.00 and 3.66 respectively

Table 5. Comparison of GDP, trade, credit, labor market regulations and TFP growth: Reformers and Non-reformers

	trade01	%change 01-04	credit01	%change 01-04	labor01	%change 01-04	GDP01	%change 01-04	TFP growth 01-04 median
Reformer:									
Reformer:									
Bulgaria	7.1	3.42	6.9	17.80	4.9	22.23	7454	15.62	2.77
Georgia									13.42
Latvia	7.6	-1.44	8.3	2.21	4.7	23.06	9558	13.11	0.12
Lithuania	7.8	-3.16	6.8	19.35	4.5	21.33	9644	28.51	2.01
Macedonia									0.17
Romania	6.5	5.07	6.7	12.65	5.0	-0.35	5475	20.29	-0.61
Russia	6.8	-0.21	5.1	31.88	4.5	29.79	10049	17.37	4.68
Slovak Rep.	8.3	5.93	7.4	5.97	4.7	41.28	9996	13.33	2.99
Turkey	7.1	-2.52	7.6	-21.92	5.4	-18.95	5250	13.96	1.05
Ukraine	6.8	3.86	5.5	31.04	3.9	24.86	5590	14.97	9.07
average	**7.25**	**1.37**	**6.79**	**12.37**	**4.68**	**17.91**	**7877**	**17.15**	**2.76**
Non-Reformer:									
Croatia	6.5	4.02	9.1	1.56	4.9	12.02	9215	9.95	-0.01
Czech Rep.	8.4	-1.15	6.8	20.43	5.4	-7.59	13964	8.15	1.99
Estonia	8.9	-4.29	9.0	0.11	5.1	18.75	11575	19.03	0.27
Hungary	8.5	-0.48	8.1	0.80	5.8	22.64	11948	14.17	1.29
Poland	6.6	6.98	7.7	4.64	4.3	11.27	8728	11.22	3.34
Slovenia	7.2	1.70	6.7	19.23	3.8	49.17	18663	10.71	1.68
average	**7.67**	**1.13**	**7.92**	**7.80**	**4.87**	**17.71**	**12349**	**12.21**	**1.43**

Source: Fraser database, except for TFP growth (own calculations)

Table 6. Pooled estimation: productivity and competition

	TFP-OP	TFP-OP	TFP-Caves	TFP-Caves	$Labor - prod^{1)}$	$Labor - prod^{1)}$
ln-*markup*	-.062**		-.0591***		-.0397**	
	(-2.21)		(-3.21)		(-2.31)	
comp-cost		.0275		-.0074		.155***
		(1.09)		(-.72)		(11.21)
age	-.0023**	-.0003	-.0011*	-.0011*	-.0011	.0096***
size	.1967***	.2507***	.1266***	.1432***	-.0265	-.1625***
for	.1127*	.0705	.0357	.0359	.2223***	.1513***
exp	.0859**	.1181**	.0465*	.0333	.1772***	.5386***
stock	-.0417	-.2843*	.1115	.0335	.15**	.4739***
privatized	-.0499	-.2238***	-.033	-.0113	-.01	-.5182***
import comp.	.0141	.0326**	.0115	.0098	.0026	-.0074
power-out	-.0008	-.0055***	.0003	.0006***	-.0003	-.0029***
fin-ret-earn	.0006	-.004***	.0004	.0006**	-.0007**	-.0024***
audit	.0778**	-.006	.0049	.0065	.0884***	.2424***
juris	.0086	-.0454***	.0022	.001)	.0156**	.0049
hire	-.0008	-.0023***	-.0007**	-.0009***	.0001	-.0004
new techno	-.0225	.0203	.0198	.0105	-.0446**	.0762***
Countr./Firms	19/2054	19/2143	26/2400	26/2498	27/6163	27/6535
Industry FE	yes	yes	yes	yes	yes	yes
Country FE	yes	no	yes	no	yes	no

Estimation period: 2004. 1) Pooled estimation in 2001 and 2004 including time dummy.
Heteroscedasticity robust s.e. t-statistics in parenthesis. ***,**,* significant at 1%, 5%, 10%.

Table 7. IV estimation: TFP based on Olley and Pakes (1996) and Caves, Christensen, and Diewert (1982)

	comp	TFP-OP	comp	TFP-OP	comp	TFP-Ca	comp	TFP-Ca	comp	Y/L	comp	Y/L
*comp-cost*04		.3038**		.6666**		-.1055*		.2766*		.6251***		1.05***
		(2.27)		(2.06)		(-1.82)		(1.69)		(7.22)		(3.15)
anti-comp04	.1708***				.1695***				.1744***			
	(8.27)				(8.34)				(12.34)			
aggr. entry04	.0871***		.1574**		.0921***				.0749***			
	(2.73)		(2.38)		(2.99)				(4.89)			
Δlnmarkup0104			-.1014*				-.1034*				-.0807*	
			(-1.60)				(-1.89)				(-1.65)	
comp-techno01			.2113***				.1818***				.1375***	
			(3.38)				(3.40)				(2.78)	
Countr./Firms	16/1707	16/1707	19/284	19/284	16/1758	16/1758	26/438	26/438	27/4122	27/4122	27/543	27/543
Firm controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	no	no	no	no	no	no	yes	yes	no	no	no	no
Wald-test	F(2,1684)	-	F(2,1684)	-	F(2,1684)	-	F(2,1684)	-	F(2,1684)	-	F(2,1684)	-
	=39.1	-	=6.9	-	=40.2	-	=7.0	-	=88.6	-	=5.1	-
Hansen test	-	-	-	.072	-	.047	-	.168	-	-	-	.056

Estimation period: 2004. Heteroscedasticity robust s.e. t-statistics in parenthesis. ***,**,* significant at 1%, 5%, 10%.
The correlation between anti-comp04 and aggr. entry04 is .073.

Table 8. Reformers and Non-Reformers: TFP growth and competition

	TFP growth	TFP growth	TFP growth	ln-*markup*	cost-comp
dreform	.2483***	.1937***	.2517***	.0761**	-.4354***
	(4.79)	(3.31)	(2.99)	(2.09)	(-9.99)
d04				.2822***	.1097***
				(8.03)	(2.61)
dreform04				-.0969**	.0470
				(-2.36)	(.87)
Countries/Firms	16/1273	14/1217	14/765	14/5458	14/5928
Industry FE	yes	yes	yes	yes	yes
Reform controls	no	yes	yes	no	no
Firm controls	no	no	yes	yes	yes

Estimation period: 2001 and 2004.
Reformer countries: Bulgaria, Latvia, Lithuania, Romania, Russia, Slovak Republic,Turkey, Ukraine, Georgia and Macedonia.
Non-reformers: Croatia, Czech Republic, Estonia, Hungary, Poland, Slovenia.

Heteroscedasticity robust s.e. t-statistics in parenthesis. ***,**,* significant at 1%, 5%, 10%.

Table 9. Pooled estimation: productivity and competition in manufacturing

	TFP-OP	TFP-OP	TFP-Caves	TFP-Caves	$Labor-prod$	$Labor-prod$
ln-*markup*	-.019		-.0181		.0198	
	(-.48)		(-.80)		(.67)	
comp-cost		.1322***		.0013		.166***
		(3.78)		(.10)		(7.20)
age	-.0012	.004**	-.0017**	-.0021**	-.0032***	.0053***
size	.2609***	.2599***	.1062***	.1435***	.0465	-.1422***
for	.2804**	.3952**	-.0003	.0255	.2671***	.2434***
exp	.0218	.0504	-.0019	-.024	.0467	.4932***
stock	.0456	-.1323	.1085*	.0713	.1663*	.3729***
privatized	.1103	-.181*	.0564	.0657*	.062	-.4394***
import comp.	.0069	.0034	.0036	-.0005	.0087	.0179
power-out	-.001	.0055	.0003	.0008***	.0013**	-.0019**
fin-ret-earn	-.0016**	-.003***	-.0001	.0004	-.0003	-.0013**
audit	.1562***	.2644***	.0052	-.0083	.1128***	.2588***
juris	.0037	-.0265	-.0063	-.0023	.0205*	-.0014
hire	-.0006	-.0007	-.0006	-.0008*	.0001	.0001
new techno	-.1012**	.0987*	-.0004	-.0119	-.1493***	-.0952***
Countr./Firms	7/797	7/826	26/1056	26/1094	26/2152	26/2278
Industry FE	yes	yes	yes	yes	yes	yes
Country FE	yes	no	yes	no	yes	no

Estimation period: 2004. Heteroscedasticity robust s.e. t-statistics in parenthesis.
***,**,* significant at 1%, 5%, 10%.

Table 10. Estimated input elasticities: Caves

ISIC		θ_i^h	θ_i^m	θ_i^k		θ_i^h	θ_i^m	θ_i^k		θ_i^h	θ_i^m	θ_i^k		θ_i^h	θ_i^m	θ_i^k		θ_i^h	θ_i^m	θ_i^k		θ_i^h	θ_i^m	θ_i^k
C-10-14	ALB	0.19	0.63	0.18	CRO	0.29	0.53	0.18	KAZ	0.29	0.46	0.24	MDA				SLN	0.34	0.40	0.26	SER	0.09	0.47	0.44
F-45		0.16	0.56	0.29		0.21	0.41	0.38		0.23	0.50	0.27		0.23	0.59	0.18		0.26	0.48	0.25		0.19	0.42	0.39
D-15-37		0.14	0.53	0.33		0.20	0.44	0.36		0.26	0.50	0.25		0.22	0.56	0.23		0.25	0.45	0.30		0.19	0.45	0.35
I-60-64		0.31	0.35	0.35		0.16	0.55	0.28		0.31	0.35	0.34		0.25	0.40	0.35		0.24	0.34	0.42		0.19	0.42	0.39
G-50-52		0.21	0.57	0.22		0.11	0.56	0.33		0.21	0.56	0.23		0.21	0.54	0.26		0.17	0.52	0.32		0.17	0.52	0.31
K-70-74		0.39	0.32	0.28		0.18	0.24	0.58		0.37	0.30	0.33		0.43		0.57		0.43	0.22	0.35		0.18	0.39	0.43
H-55		0.23	0.31	0.45		0.27	0.31	0.41		0.22	0.43	0.35		0.09	0.38	0.53		0.30	0.35	0.36		0.29	0.35	0.36
O***		0.45	0.34	0.20		0.35	0.31	0.34		0.48	0.29	0.23		0.33	0.36	0.31		0.34	0.29	0.37		0.22	0.21	0.57
C-10-14	ARM	0.25	0.50	0.25	CZE	0.23	0.49	0.29	KGZ	0.33	0.50	0.17	POL				TJK	0.40	0.38	0.23				
F-45		0.14	0.53	0.34		0.17	0.51	0.33		0.25	0.53	0.22		0.17	0.51	0.32		0.29	0.48	0.23				
D-15-37		0.21	0.48	0.31		0.18	0.56	0.26		0.22	0.52	0.26		0.19	0.51	0.30		0.28	0.46	0.25				
I-60-64		0.26	0.52	0.22		0.20	0.50	0.30		0.26	0.39	0.35		0.22	0.46	0.32		0.31	0.50	0.19				
G-50-52		0.16	0.46	0.38		0.15	0.56	0.29		0.17	0.55	0.28		0.15	0.55	0.30		0.23	0.53	0.24				
K-70-74		0.16	0.26	0.57		0.18	0.38	0.44		0.22	0.28	0.50		0.23	0.34	0.43		0.38	0.39	0.23				
H-55		0.17	0.28	0.56		0.20	0.39	0.41		0.33	0.29	0.39		0.25	0.36	0.39		0.38	0.42	0.20				
O***		0.21	0.20	0.59		0.22	0.37	0.41		0.28	0.36	0.36		0.30	0.33	0.37		0.45	0.30	0.25				
C-10-14	BLR				EST	0.21	0.61	0.18	LVA				ROM				TUR							
F-45		0.23	0.46	0.31		0.14	0.58	0.28		0.16	0.59	0.25		0.21	0.52	0.27		0.13	0.58	0.30				
D-15-37		0.24	0.48	0.29		0.22	0.54	0.24		0.24	0.57	0.19		0.20	0.52	0.28		0.16	0.56	0.28				
I-60-64		0.14	0.36	0.50		0.22	0.46	0.33		0.24	0.34	0.42		0.14	0.36	0.51		0.15	0.45	0.40				
G-50-52		0.19	0.53	0.28		0.13	0.56	0.30		0.11	0.60	0.29		0.09	0.61	0.30		0.12	0.61	0.27				
K-70-74		0.35	0.14	0.51		0.26	0.41	0.33		0.22	0.19	0.59		0.18	0.18	0.64		0.11	0.39	0.49				
H-55		0.22	0.31	0.47		0.26	0.46	0.28		0.14	0.23	0.63		0.17	0.43	0.39		0.19	0.42	0.38				
O***		0.27	0.25	0.48		0.16	0.39	0.45		0.35	0.09	0.56		0.20	0.28	0.53		0.21	0.46	0.33				
C-10-14	BIH	0.31	0.40	0.30	GEO				LTU	0.09	0.57	0.33	RUS	0.24	0.44	0.32	UKR							
F-45		0.15	0.46	0.40		0.13	0.52	0.36		0.22	0.47	0.31		0.17	0.55	0.28		0.12	0.51	0.37				
D-15-37		0.20	0.41	0.39		0.18	0.55	0.26		0.20	0.51	0.29		0.23	0.50	0.27		0.20	0.51	0.29				
I-60-64		0.21	0.25	0.54		0.27	0.38	0.35		0.19	0.48	0.33		0.18	0.48	0.34		0.18	0.46	0.37				
G-50-52		0.15	0.58	0.27		0.14	0.59	0.27		0.13	0.59	0.28		0.14	0.56	0.30		0.13	0.57	0.30				
K-70-74		0.28	0.28	0.44		0.23	0.21	0.56		0.38	0.26	0.36		0.28	0.22	0.50		0.30	0.26	0.45				
H-55		0.27	0.44	0.29		0.23	0.43	0.34		0.26	0.54	0.20		0.22	0.42	0.37		0.25	0.42	0.33				
O***		0.19	0.37	0.43		0.26	0.35	0.39		0.35	0.26	0.39		0.23	0.27	0.50		0.39	0.28	0.33				
C-10-14	BGR	0.19	0.33	0.48	HUN	0.13	0.73	0.14	MKD	0.26	0.33	0.41	SLK				UZB	0.14	0.47	0.38				
F-45		0.18	0.49	0.33		0.16	0.59	0.25		0.22	0.50	0.28		0.18	0.52	0.30		0.24	0.51	0.25				
D-15-37		0.22	0.50	0.28		0.16	0.58	0.26		0.16	0.52	0.33		0.16	0.50	0.34		0.18	0.50	0.32				
I-60-64		0.21	0.42	0.37		0.22	0.51	0.27		0.15	0.35	0.51		0.14	0.52	0.34		0.21	0.35	0.44				
G-50-52		0.10	0.63	0.26		0.09	0.68	0.23		0.14	0.57	0.29		0.10	0.56	0.34		0.21	0.52	0.27				
K-70-74		0.22	0.25	0.53		0.23	0.37	0.40		0.19	0.16	0.65		0.24	0.31	0.45		0.43	0.16	0.41				
H-55		0.17	0.38	0.45		0.18	0.52	0.30		0.23	0.25	0.52		0.16	0.29	0.54		0.23	0.25	0.52				
O		0.28	0.27	0.46		0.24	0.37	0.39		0.29	0.18	0.53		0.28	0.27	0.45		0.23	0.15	0.63				

We do not observe intermediates in Azerbaijan. ISIC codes: C: Mining & quarrying, F: Construction, D: Manufacturing, I: Transport & communication, G: Wholesale & retail, trade; repair, K: Real estate & business services, H: Hotels & restaurants, O: Other services (Motion picture & video activities, radio & television activities, other entertainment activities, news agency activities, washing & dry cleaning, hairdressing, funeral & related activities, other service activities).

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Appendix A. Survey Overview

The World Bank's Enterprise Surveys cover information on balance sheet information as well as manager's assessments on major obstacles to enterprise growth of firms in 71 countries. The questionnaires are country specific and changed over time. However, all questionnaires contain core questions that are asked in all countries, for all industries, and in all time periods to generate internationally comparable data. Moreover, the sampling methodology is the same in all countries. Thus, the Enterprise Surveys are designed to provide panel data sets with minimal measurement errors. In addition to certain firm characteristics, balance sheet data, the standardized instruments capture information on the following obstacles to firm growth: infrastructure services, access to international markets, degree of competition and innovation, corruption, crime, business-government relations, finance, the quality of the workforce. The standardized instruments are available for multiple time periods for a subset of 39 countries. That is, the same core questions are asked in 3 years intervals in these countries. The majority of these countries (27) are from Europe and Central Asia, followed by seven Latin America, three African, and two South Asian countries. Thus, the database allows for the application of panel techniques as well comparisons across countries or time.

The sampling of the Surveys is supposed to generate a representative sample of the whole economy. It considers the following industries (ISIC codes): all manufacturing sectors (group D), construction (group F), services (groups G and H), and transport, storage, and communications (group I). The selection of industries is kept similar across regions to facilitate cross-country comparisons. The Survey generates large enough sample sizes for the manufacturing industry, the retail industry, and a group of the rest of industries. In particular, the sample size ensures a minimum precision of 7.5% for the 90% confidence interval about estimates of (i) the population proportion and (ii) the mean of log sales of these industries. A second level of stratification is firm size defined as small (5–19 employees), medium (20–99 employees), and large (100 or more employees). The targeted firms are establishments with at least five full-time employees.[32] The restriction in firm size is supposed to limit the surveys to the formal economy. An establishment is defined as a single physical business location and may be part of a firm. However, establishments are required to make their own financial decisions, have its own managerial oversight, and have books separated from the parent firm. Moreover, targeted establishments are located in major metropolitan areas of a country. Overall, the standardized sample covers an average of 434 establishments for each country and time period. The minimal coverage of 170 establishments is reported in Albania in 2002 while the maximum of 4234 is reported in India in 2006.

The questionnaire is designed to be administered in face-to-face interviews with managing directors, accountants, or other relevant staff. The interviewers as well as all other stuff involved in the survey are thoroughly trained, whereas the World Bank experts supervise the training. The interviewers have to pass an exam in the end of the training in order to qualify for the work. The World Bank assures the strict confidentiality of the survey information. Neither the name of the respondent nor the name of the firm is used in any document based on the survey. The high degree of confidentiality is necessary to avoid biased declarations of respondents. Moreover, the World Bank cares for a wide publicity of the launch of the survey, e.g. via newspaper advertise-

[32]Full-time refers to a minimum of eight working hours per day.

ments, and contacts local agencies to gain the support of the local business communities. This creates a value of potential reform recommendations resulting from the survey and thereby improves a firm's incentives to respond to the questionnaire. In addition, pilot surveys and field experience suggest that the completion of the core Enterprise Survey lasts approximately 45 minutes. This limitation in the length also contributes to the quality of the responses. Finally, any missing data or inconsistencies are are checked by the interviewer and a field supervisor immediately after the interview and after the filing of the data.

The resulting data sets exclusively contain firms that are willing to participate. If randomly selected firms decide not to respond they are replaced by willing participants in order to ensure a sufficient sample size. However, non-respondence might compromise the random nature of the sample if the rationales for it vary systematically with the respondents assessments of the obstacles to firm growth. Thus, the Enterprise Survey provides a field-work report that lists the reasons for non-responds, including the refusals to responds, in each country, industry, and class of firm size (see above).

APPENDIX B. ESTIMATION OF PRODUCTION FUNCTIONS UNDER SIMULTANEITY

The literature on the estimation of production functions from firm-level data points out that the estimation of (1) by OLS may suffer from a simultaneity problem. This problem arises if there is a contemporaneous correlation between the demand for inputs k_{jt}, h_{jt} and the realization of the unobservable technology shock contained in ε_{jt}. In such a case, estimates $\hat{\theta}^k$ and $\hat{\theta}^h$ would be biased. There are several approaches to correct for simultaneity between (k_{jt}, h_{jt}) and ε_{jt} and all of them put additional restrictions on the data. For instance, Olley and Pakes (1996) propose a method, which uses changes in firm's investment decision as a proxy for the productivity shock. However, only firms with non-missing data for 2002 and 2003 on output, capital, labor, and investment can be used for estimation. Depending on the country, this additional requirement can lead to a substantial elimination of firms from our sample. Following the same idea, Levinsohn and Petrin (2003) suggest the use of intermediate inputs instead of the investment variable as a proxy.[33] Finally, as described in Blundell and Bond (2000), the simultaneity problem in estimation of production function can also be bypassed by a GMM system estimator, though it requires a long time-series of cross-sections and is therefore not attractive for our analysis.

Aware of these simultaneity problems mentioned above and following Olley and Pakes (1996), we consistently estimate (1). The method is based on a two-step procedure and requires following assumptions: (i) labor is the only input which contemporaneously responds to a technology shock, (ii) capital stock is predetermined and hence uncorrelated with a contemporary technology shock, (iii) changes in corporate investment decisions depend on the contemporaneous technology shock and the capital stock of a firm, (iv) investments are monotonically increasing in the technology shock for a given value of and capital. Under these assumptions, the technology

[33] They motivate their choice by weaker data requirements and argue that an adjustment in intermediate inputs is likely to have better properties as an instrument for a technology shock than an adjustment in investment.

shock can be instrumented as a function of capital and investment. The estimation of this function is carried out by a series estimator.

We consider the model (1) and decompose the error term ε_{jt} into two elements, i.e., $\varepsilon_{jt} = \omega_{jt} + \varepsilon_{jt}$, where ω_{jt} is the productivity shock and ε_{jt} is the true error term. Further, a_{jt} measures a the age of a firm. Hence, we can write

$$Y_{jt,\text{Olley–Pakes}} = \alpha_0 + \alpha^k k_{jt} + \alpha^h h_{jt} + \omega_{jt} + \varepsilon_{jt} \tag{5}$$

The simultaneity problem arises if ω_{jt} is correlated with at least one of the regressors. In the recent literature on the estimation of production functions, one generally assumes that the demand for labor is the only input which is potentially correlated with ω_{jt} as capital stocks are assumed to be predetermined. As a remedy, Olley and Pakes (1996) propose a two-stage procedure for a consistent estimation of (5) in which they advocate the use of a firm's log investment i_{jt} to identify the productivity shock. In doing so, they define the investment function ι such that $i_{jt} = \iota_t(\omega_{jt}, k_{jt}, a_{jt})$. If investments are monotonically increasing in the technology shock for a given value of capital, this allows to express the unobservable technology variable as a function of contemporaneous investments and capital. Hence, they define the inverse investment function by m_t so that $\omega_{jt} = m_t(i_{jt}, k_{jt})$. Thus, one can rewrite (5) as

$$Y_{jt} = \alpha_0 + \alpha^k k_{jt} + \alpha^h h_{jt} + m_t(i_{jt}, k_{jt}) + \varepsilon_{jt}.$$

Further, we define

$$\phi_t(i_{jt}, k_{jt}) := \alpha_0 + \alpha^k k_{jt} + m_t(i_{jt}, k_{jt})$$

and approximate this term by a third order polynomial series in k and i.[34] Consequently, we can write

$$Y_{jt} = \alpha^h h_{jt} + \phi_t(i_{jt}, k_{jt}) + \varepsilon_{jt} \tag{6}$$

Since we control for contemporaneous movements in productivity by the inverse investment function, OLS estimation of (6) yields consistent estimates of α^h.

The second stage is necessary to identify α^k. Therefore, we assume that productivity follows a first order Markov chain, i.e., $\omega_{jt} = E(\omega_{jt}|\omega^j_{t-1}) + \xi_{jt}$, where ξ_{jt} denotes the innovation in the productivity, which is assumed to be uncorrelated with capital in period t. Defining v_t as output net of the contributions of labor and substituting $h_{t-1}(i^j_{t-1}, k^j_{t-1})$ into the function

$$g(\phi^j_{t-1} - \alpha^k k^j_{t-1}),$$

we can write[35]

$$v_{jt} = \alpha_0 + \alpha^k k_{jt} + g(\cdot) + \xi_{jt} + \varepsilon_{jt} \tag{7}$$

Note that we restrict capital and lagged capital to have the same coefficient. Consequently, as the coefficient enters the regression equation twice we estimate it efficiently and consistently by applying a non-linear least squares procedure to (7).

[34] In particular, we define $\phi_t(i,k,a) = \theta_0 + \sum_{p=1}^{3}(\theta^i_p i^p + \theta^k_p k^p + \theta^{ik}_p (ik)^p)$.

[35] Note that we do not need to correct for sample attrition since, by construction, our database consists of two independent random samples of firms in 2001 and 2004.

APPENDIX C. COMPUTATION OF TFP GROWTH AND THE KIM (2000) CORRECTION

In this section we outline the computation of TFP growth and the methodology developed by Kim (2000) to correct for the bias in our TFP growth measure due to imperfect competition and non-constant returns to scale. Consider the following firm-level production function of firm j at time t (all variables are measured in in real terms):

$$Y_{jt} = A_{jt} F(K_{jt}, H_{jt}, M_{jt}) \tag{8}$$

Assuming a Cobb-Douglas or trans-log production function, taking logs and first differences of (8) yields ("d" refers to changes and lower-case letters refer to logs):

$$\begin{aligned} dTFP_{it} &= \frac{da_{jt}}{a_{jt}} \\ &= \frac{dy_{jt}}{y_{jt}} - \alpha_j^k \frac{dk_{jt}}{k_{jt}} + \alpha_j^h \frac{dh_{jt}}{h_{jt}} + \alpha_j^m \frac{dm_{jt}}{m_{jt}} \end{aligned}$$

The input elasticities α_j^m and α_j^h are measured by factor-level factor shares. The factor shares are measured by the ratio of a firm's cost of employees over sales and a firm's expenses for intermediates over sales, respectively. The input elasticity of capital is computed as $\alpha_j^k = 1 - \alpha_j^h - \alpha_j^m$.

The above procedure to compute TFP growth assumes perfect competition and constant returns to scale. Thus, the resulting measure of TFP growth is biased from the effects of imperfect competition and non-constant returns to scale. However, according to Hall (1988), the difference between the *standard* TFP growth measure that ignores both imperfect competition and non-constant returns to scale and the *true* TFP growth measure ($dTFP^*$) can be shown as:

$$\begin{aligned} dTFP_{jt} = (\mu_{jt} - 1) &\left[\alpha_j^h d \ln \left(\frac{H_{jt}}{K_{jt}} \right) + \alpha_j^m d \ln \left(\frac{M_{jt}}{K_{jt}} \right) \right] \\ &+ (\phi_{jt} - 1) \ln K_{jt} + dTFP_{jt}^* \end{aligned} \tag{9}$$

where $(\mu_{jt} - 1) = \delta_{dz_{ij}} + \delta_{Rz} \times R_{ij}$ and $(\phi_{jt} - 1) = \delta_{dK_{ij}} + \delta_{RK} \times R_{ij}$. Here, $\delta_{dz_{ij}} + \delta_{Rz} \times R_{ij}$ captures the effects of imperfect competition on TFP growth while $\delta_{dK_{ij}} + \delta_{RK} \times R_{ij}$ captures the effect of non-constant returns to scale.

Against this background, Kim (2000) shows that the following equation corrects for the effects of imperfect competition and non-constant returns to scale effects on the *standard* measure of TFP growth:

$$\begin{aligned} dTFP_{ijt} = \beta_1 R_{ij} + \beta_2 X_{ij,t-1} + \beta_3 F_{i,t-1} + \delta_{dz_{ij}} dz_{ijt} + \delta_{Rz}(R_{ij} \times dz_{ijt}) \\ + \delta_{dK_{ij}} d \ln K_{ijt} + \delta_{RK}(R_{ij} \times d \ln K_{ijt}) + \varepsilon_{ijt} \, , \end{aligned} \tag{10}$$

where $dz_{ijt} = \alpha_j^h d \ln \left(\frac{H_{jt}}{K_{jt}} \right) + \alpha_j^m d \ln \left(\frac{M_{jt}}{K_{jt}} \right)$. The coefficient β_1 in (10) hence measures the relation between a reform (R_{ij}) and an unbiased or "true" measure of TFP growth.