Innovation, Adoption, Ownership, and Productivity: Evidence from Ukraine

J. David Brown, John S. Earle, Hanna Vakhitova, and Vitaliy Zheka*

Revised: May 25, 2009

JEL Codes: D21, D24, F23, G34, L33, O32, P31

Keywords: R&D, information technology, foreign ownership, transition, Eastern Europe, Ukraine

Abstract

How do new and foreign firms achieve superior productivity? Do they conduct more and better R&D? Or do they distinguish themselves through computerization and organizational capital? We investigate the determinants of and returns to several types of investment, using a panel of over 40,000 Ukrainian industrial firms in 2000-2007. Foreign firms engage in more non-technological investment and IT and less in R&D than domestic private firms. Similarly, new firms invest more in non-technological capital and IT and less in R&D than initially state-owned firms. Productivity gains from R&D and non-technology investment are insignificantly different across ownership types, whereas foreign firms achieve much higher returns to IT investment than other firms. These results suggest that foreign firms outperform others via organizational capital that is better able to exploit IT investment. New firm productivity growth is a result of higher investment volume rather than investment efficiency.

*Heriot-Watt University, Upjohn Institute for Employment Research and Central European University (CEU), Kyiv School of Economics, and Kyiv School of Economics, respectively. We give special thanks to Vladimir Vakhitov, who provided significant help and advice with the data. We are also grateful to the European Commission's Sixth Framework Programme, which provided support to Vakhitova and Zheka through the ESCIRRU grant, and to the Kyiv School of Economics for support of data collection and preparation.

1. Introduction

How firm performance varies with ownership types and corporate governance institutions has been extensively researched.[1] But evidence on the channels through which some owners and institutions produce superior performance is quite limited. Similarly, much evidence has been produced about average returns to different types of investment,[2] but less is known about how those returns vary with firm characteristics. Here we investigate a potential link between these literatures: some owners and governance arrangements may better facilitate investment choices and/or implementation, resulting in higher levels of investment or higher returns and hence superior performance. This could be achieved through closer monitoring of management or the transfer of investment-supporting organizational capital. We test how ownership type affects the propensity to invest and the returns to that investment using a panel of over 40,000 Ukrainian industrial firms in 2000-2007.

Left to their own devices, managers may make investment decisions maximizing their own utility at the expense of the owners. They may overinvest in order to increase their power and salary (empire building). They could choose investment projects that most benefit them personally, rather than those with the highest returns. And managers may exert suboptimal effort monitoring the implementation of the investment project, allowing funds to be wasted. Better monitoring by owners could thus prevent managers from overinvesting, choosing the wrong projects, and implementing them poorly.

Organizational changes can enhance the gains from investment. For example, firms can transform their business by combining computer investment with changes in work organization, incentive pay, and centralization of decision-making.[3] New information technologies may also be put to better use by managers trained in those technologies. Owners can facilitate organizational change and provide trained managers.

The effectiveness of some types of investment may increase more with closer monitoring or organizational capital than others. Managers may be able to misappropriate funds for intangible investments more easily than for tangible investments; they are by definition less visible, so monitoring may be particularly valuable for intangible investment implementation.[4] The benefits to organization capital may be higher with IT investment, which requires advanced technical knowledge to select, install, and exploit. IT investment can also open the door to profitable organizational changes that take advantage of the new technology. In contrast, investment in a low-tech replacement machine may require no new knowledge to use or organizational change to fully exploit. Our data contain separate expenditures for tangible asset,

[1] See, for example, Megginson et al. (2001) for a review of the literature on private vs. state ownership, or Coles et al. (2008) on board structure and firm performance.
[2] Sveikauskas (2007) and Kohli and Devaraj (2003) review the literature on returns to R&D and IT, respectively.
[3] See Brynjolfsson and Hitt (2000) for a review of the computer and organizational change literature and Bresnahan et al. (2002) for evidence on the complementarity between computer investment and organizational change.
[4] Note that monitoring could discourage managerial effort in searching for investment projects, however, as argued by Burkart et al. (1997).

intangible asset, R&D, tangible IT, and intangible IT investment, which allow us to test whether owner type matters more for some investment returns than others.

State-owned firms may place less emphasis on firm value maximization than private firms, while putting relatively more weight on employment or other social goals (e.g., Boycko et al., 2006). They thus may be less interested in investing in labor-saving projects, or if they do so, they may not fully exploit the labor-saving potential. State managers may also have weaker incentives to effectively implement investment projects. Within the private sector, foreign owners could introduce superior corporate governance practices and thus monitor management more effectively.[5] Foreign owners should also have more experience using high technology and the organizational practices that best suit it (Crespi et al., 2007). Upon entry, new firms can put in place organizational forms designed specifically for new technology, giving them an advantage over established firms that would have to undertake potentially painful restructuring, so new firms may be expected to achieve higher returns to IT investment.

Firm types may also vary in access to finance. Firms with better access can invest more. Foreign owners are likely to have better access to financing for investment than domestic private firms, especially new ones. If access to finance is the most important difference across firm types, and if returns to investment are concave, then the firm types with better access to financing should also experience lower investment returns.

Some recent studies have estimated the relationship between ownership or other corporate governance institutions and different types of investment returns. Using data on large U.S. firms, Chung et al. (2003) find that the relationship between capital expenditures, R&D expenditures, and Tobin's q is stronger in firms with high analyst following and outsider board member representation, which are proxies for monitoring strength. The main effects of capital and R&D investment are insignificant, suggesting that the returns are only positive when monitoring is strong. A Swedish listed firms study by Eklund et al. (2009) finds a more positive effect of total investment on marginal q in firms with smaller boards of directors (small boards are assumed to more intensively monitor management). Ortega-Argiles, Moreno-Serrano, and Surinach Caralt's (2005) study on Spanish manufacturing firms shows a positive relationship between ownership concentration (a proxy for monitoring) and number of patents, controlling for R&D intensity. A study on Chinese listed companies by Chen et al. (2008) finds a positive relationship between R&D intensity and R&D output (ratio of new product sales to employment) in non-state-controlled firms, while it is negative and insignificant in state-controlled firms. Firms with minority state ownership show a stronger relationship between R&D intensity and R&D output than ones fully privately owned. Foreign ownership has a negative and insignificant effect on the R&D intensity-R&D output relationship. Ho et al. (2007) find that returns on assets (ROA) from IT investment in Taiwanese high-tech companies are statistically insignificant overall, while they are positive when the board of directors is independent. Foreign ownership is positively associated with IT investment returns, but only among small firms.

[5] La Porta et al. (2000) argue that cross-borders takeovers are a way to achieve functional convergence in corporate governance practices.

Bloom et al. (2007) find that US multinationals located in the United Kingdom have higher productivity than other multinationals in the UK or UK domestic firms primarily because they achieve higher IT investment productivity. They suggest that the US multinational IT advantage is due to superior organizational capital. Crespi et al.'s (2007) evidence that US multinationals are more likely to combine IT investment with organizational change than other multinationals, who are in turn more likely to do so than UK domestic companies, is consistent with this story.

More so than in previous studies, our data allow us to categorize investment in various ways, including non-technological vs. R&D vs. IT investment. IT expenditures can be divided into software and hardware expenditures. We investigate how returns to these different types of investment vary according to ownership (state-owned vs. domestic private vs. foreign) and origin (new private vs. state and former state firms). Variation in returns by firm origin has previously been unexplored.

Ukraine provides an interesting setting for studying how firm origin matters for technology investment. Soviet technological progress proceeded at a much lower rate than in the U.S., Western Europe, or Japan post-World War II. This was not due to insufficient resources being allocated to R&D. To the contrary, R&D outlays as a proportion of GNP were estimated to be 68% higher than in the U.S. in 1975 (Bergson, 1983). The main problem was the low effectiveness of the R&D. Several features of central planning contributed to the low effectiveness (Bergson, 1983; Berliner, 1976). Integration between R&D and production was poor. R&D departments had little incentive to produce innovations that would actually be useful to enterprises, and development work needed to move an idea from the drawing board to the production process was underemphasized. To adopt new technologies, clearances from the bureaucracy and cooperation from suppliers and distributors were required. Managers were reluctant to use new, higher-technology machinery, because the adoption process could disrupt production, risking failure to meet output targets. Managers could be severely punished for missing output targets, but the reward for increasing productivity was small, leading through the "ratchet effect" to tougher plan targets in the future. Unlike in the West, enterprises were not penalized (e.g., by being forced to exit the market by more efficient producers) for not innovating. Adoption was thus not worth the risk and hassle.

Soviet technological progress relied heavily on technology transfers from the West (Sutton, 1973). Lead times were much longer, manning levels were much higher, and output produced was lower than in comparable transfers to developed market economies (Hanson, 1982). Half or more of the R&D was directed toward the defense and the space industries, so there was little difference in civilian R&D outlays as a proportion of GNP with the rates in developed market economies. Taking into account the low effectiveness of R&D generally, civilian technological progress may have lagged even further behind that of the West than did technological progress for the economy as a whole.

This legacy leads to the question whether firms originating under central planning continue to experience low returns to technology investment, or if instead market liberalization and privatization have encouraged them to invest more efficiently. Brown et al. (2007) report much higher multifactor productivity in new than old firms, in foreign compared to domestic private firms, and in domestic private firms compared to state firms using some of the same Ukrainian data as in this study, which may reflect continued weak investment performance in the old state sector. Here we investigate that possibility directly.

We find that foreign firms invest more in IT than domestic private firms, which in turn invest more than state firms. Domestic private firms invest the most in R&D, while foreign and state firms invest at similar rates. New private firms invest more in non-technological capital and IT, but less in R&D compared to initially state firms. Productivity gains from non-technology and R&D investment are insignificantly different across ownership types. Foreign firms distinguish themselves via higher IT investment returns, consistent with there being complementarities between IT and organizational capital. In contrast, new firms are not more efficient with any investment type – they simply invest at higher rates than old firms.

The next section describes our data, and Section 3 explains the estimation procedures. Section 4 presents the results, and conclusions are summarized in Section 5.

2. Data

The main data source is the State Committee for Statistics in Ukraine (*Derzhkomstat* in Ukrainian), which supplies balance sheets, financial results statements, foreign investment, industry codes, and region codes for 2000–2007. These data are supplemented by ownership information from the State Property Committee, the State Commission on Securities and Stock Market (the Commission), and the Fenix database. The data cover all firms in Ukraine outside of public and financial services.

The sample is restricted to industrial firms (NACE 10-41) and divided into 25 sectors according to the NACE 2-digit classification (except that 10, 11, and 12, 13 and 14, 15 and 16, and 23 and 24 are combined due to small numbers of firms). Firm-years are retained in the sample only when they contain complete information (nonmissing values for output, capital, employment, materials, ownership and various types of capital investment).

We remove observations on variables showing highly volatile fluctuations from one year to the next. They are excluded if they meet any of the following criteria: continuing firm increase (decrease) by a factor greater than five, continuing firm decline (rise) by a factor greater than five, increase (decrease) by a factor greater than 10 in the year after entry, or decrease (increase) by a factor greater than 10 in the final year of observation[6]. We exclude observations of firms operating less than 6 months in the year. We also scale the output, employment, and materials of observations of firms with 6 and more months of work to make them comparable to the firms operating a full year.

The total number of firms in the productivity growth regression sample is 43,402. On average, each firm is observed for about 4 years, and the total number of firm-year observations

[6] Outliers defined on the basis of output, capital, labor and materials are excluded from productivity regressions. Excluded observations constitute about 6.7% of the sample.

is 159,876. Summary statistics for the basic variables used for both determinants of investment regressions and productivity growth regressions are provided in Tables 1-3.

Output is defined as value of gross sales in thousands of year 2000 Ukrainian hryvnias[7]; capital is defined as pre-existing tangible assets at the end of the year (calculated as depreciated value of tangible assets at the end of the year minus gross investment during the year); employment is defined as the average number of registered industrial production personnel, which includes non-production workers and part-time employees; and materials are defined as materials cost in thousands of year 2000 hryvnias[8]. The data imply declining average output, employment, capital, and materials in the sample which in part reflects entry of small firms. Changes in output, capital, and materials may also partly reflect imperfect deflators that fail to distinguish true price and quantity changes. We address this issue by controlling for a full set of industry-year interactions in the econometric analysis.

Our data allow us to decompose the total capital investment into non-technological investment expenditures, R&D expenditures, and IT expenditures. IT expenditure in turn can be decomposed into IT software and IT hardware expenditures. Following the literature we divide each type of capital expenditure by output in order to construct corresponding intensity measures, determinants and effects of which we investigate in this paper. We consider the cases of intensity larger than one as implausibly large and eliminate such observations from the productivity growth regression sample. Thus, our measures of intensity of various types of capital expenditures vary in between zero and one. We take this into account when using a Tobit estimator in determinants of investment regressions by censoring the intensity variables from two sides: from the left at the limit of zero and from the right at the limit of one.

To investigate the impact of firm ownership and origin on capital investment and its relationship with productivity, we construct four firm type variables defined as follows. First, we distinguish state and private firms. State firms are those that have a private share less than 50%. Among private firms, we define foreign-owned companies (FO) as those with foreign share larger than domestic private share, and domestic-owned companies (DO) as the remaining private companies. The private ownership codes are constructed from State Property Committee private share information, while the foreign codes are constructed from the Commission and Fenix databases on shareholdings and trading dates as well as 10-zez statistical form. New firm (NEW) is defined as a private firm that was created after the collapse of Soviet Union; formally, new is defined as a firm that does not exist in 1989 industrial registry data, was never owned by the state, and was not in the State Property Fund database. Ownership is measured as of the reporting date, the beginning of the calendar year.

Tables 1 and 2 contain the mean values of the domestic and foreign ownership and new private dummy variables. Eighty-six percent represent domestic private owned firms, four percent are owned by foreign investors, and the rest are state-owned during the observation

---

[7] Official and street exchange rates were almost the same over the period 2000-2007, fluctuating between 5.05 and 5.45 UAH per 1USD.

[8] Output and materials are deflated with 2-digit industry-specific implicit deflators, with a base period of 2000.

period. The number of switches from domestic private ownership to foreign ownership is 400, from foreign ownership to private domestic ownership is 246, from state ownership to foreign ownership is 13, and from state ownership to private domestic ownership is 198. Seventy-four percent of firms are new private.

Firms in our dataset come from all regions of Ukraine, and for the empirical investigation of the determinants of capital investment we mark out 27 regions, which include 25 Ukrainian 'oblasts' and two cities, Kyiv, the capital of Ukraine, and Simferopol, the capital of Crimea. Presumably, regional specifics might be important predictors of capital expenditures. For example, most metallurgical, by-product-coking and other heavy industry plants are concentrated in the eastern oblasts that in fact significantly predetermine the levels of various types of capital expenditures across Ukrainian regions. Besides the factor of natural resources, oblast dummies are included to capture the effects of variations in local economic policies at the oblast level.

Domadenik, Prasnikar and Svejnar (2007) find also that export orientation is an important factor in explaining the R&D expenditures for a sample of Slovenian firms. Thus, we also include a dummy variable indicating the firms that had export operations in the previous year in our determinants of capital expenditures regressions. Domadenik, Prasnikar and Svejnar (2007) also document that other factors, such as financial constraints, public subsidies and heading a business group are important in explaining the capital expenditures. Even though we are not able to take into account the effects of these factors at present, we hope to add some of them to our empirical investigation in the future.

3. Methodology

We first estimate Tobit regressions to explore how ownership and firm origins are related to the intensity of different investment types. We include domestic and foreign ownership measured in the previous year and NEW. Control variables include NACE 3-digit industry market share in the previous year and its square, a dummy for exporting in the previous year, log of capital stock in the previous year, industry-year dummies, and region (oblast) dummies.

We use data on the universe of firms to calculate the market share of each firm in its business sector based on a 3-digit NACE industry classification. In a related study, Girma, Gong and Gorg (2008) also use the firm's market share based on 3-digit industry classification and find it positive and statistically significant in predicting innovation.

Domadenik, Prasnikar and Svejnar (2007) find that export orientation is an important factor in explaining the R&D expenditures for a sample of Slovenian firms. Thus, we also include a dummy variable indicating the firms that had export operations in the previous year in our determinants of capital expenditures regressions.

Firms in our dataset come from all regions of Ukraine, and for the empirical investigation of the determinants of capital investment we mark out 27 regions, which include 25 Ukrainian 'oblasts' and two cities, Kyiv, the capital of Ukraine, and Simferopol, the capital of Crimea. Presumably, regional specifics might be important predictors of capital expenditures. For example, most metallurgical, by-product-coking and other heavy industry plants are concentrated in the eastern oblasts that in fact significantly predetermine the levels of various types of capital

expenditures across Ukrainian regions. Besides the factor of natural resources location, oblast dummies are also supposed to capture historical and cultural prerequisites as well as the effect from variation in local economic policies at the oblast level.

The second set of regressions calculates the productivity growth returns to different investment types. We start with a standard neoclassical production function:

$$Y_{it} = A_{it} L_{it}^{\beta_1} K_{it}^{\beta_2} M_{it}^{\beta_3} \quad \textbf{eq. 1}$$

where Y_{it} is gross sales, while L_{it}, K_{it}, and M_{it} denote firm's major inputs, i.e., labor, physical capital stock and material costs. A_{it} is the total factor productivity, which is driven by R&D stock (RDS), informatization level (ITS) as well as other factors (jointly summarized here by α_{it}):

$$A_{it} = a_{it} RDS_{it}^{\gamma_1} ITS_{it}^{\gamma_2} \quad \textbf{eq. 2}$$

Taking logarithms of both sides yields the following production function:

$$\ln Y_{it} = \alpha_{it} + \gamma_1 \ln RDS_{it} + \gamma_2 \ln ITS_{it} + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 \ln M_{it} \quad \textbf{eq. 3}$$

In general, R&D stock is not observable and can only be evaluated with some assumptions using information about past R&D expenditures.

$$RDS_{it} = \sum_{k=1}^{t} \mu_k RD_{it-k} + (1-\delta) RDS_{it-1} \quad \textbf{eq. 4}$$

The impact of previous R&D expenditures depends on two factors. One is the distributed lag structure of R&D expenditures, described by μ_k, which reflects the potential delay and transformation rate of R&D expenditures for R&D stock. Another factor is δ, a rate of obsolescence, which reflects knowledge diffusion and depreciation rates.

Since μ_k and δ are unobservable as well, one approach is to assume some values for μ_k and δ to evaluate the R&D stock. Instead, similar to Griliches and Mairesse (1984), Griffith et al. (2000), Kinoshita (2000), and Bloom et al. (2007), we consider an alternative approach: differentiate eq. 3 with respect to time to obtain the growth specification:

$$\Delta \ln Y_{it} = \Delta\alpha_{it} + \gamma_1 \Delta \ln RDS_{it} + \gamma_2 \Delta \ln ITS_{it} + \beta_1 \Delta \ln L_{it} + \beta_2 \Delta \ln K_{it} + \beta_3 \Delta \ln M_{it} \quad \textbf{eq. 5}$$

Notice that

$$\Delta \ln RDS_{it} \approx RD_{it-1} / RDS_{it-1}$$

$$\gamma_1 = \frac{\Delta Y}{\Delta RDS} \frac{RDS}{Y} \quad \textbf{eq. 6}$$

$$MP_{RDS} = \rho_1 = \frac{\Delta Y}{\Delta RDS}$$

where γ and ρ are elasticity and marginal productivity of R&D stock respectively. As a result,

$$\gamma_1 \Delta \ln RDS_{it} = \rho_1 RD_{t-1} / Y_{it-1} \quad \textbf{eq. 7}$$

A similar story applies to IT expenditures and investment. To compare returns to R&D and IT stocks to returns to non-technological investment (NT), we disaggregate capital into the existing stock (so that $d \ln K'_{it} / dt = \log(K_{it} - NT_{it}) - \log K'_{it-1} = \Delta \ln K'_{it}$) and new investment NT_{it}. We get

$$\Delta \ln Y_{it} = \Delta\alpha_{it} + \beta_1 \Delta \ln L_{it} + \beta_2 \Delta \ln K'_{it} + \beta_3 \Delta \ln M_{it} + \rho_1 NT_{it-1} / Y_{it-1} + \rho_2 RD_{it-1} / Y_{it-1} + \rho_3 IT_{it-1} / Y_{it-1} \qquad \textbf{eq. 8}$$

Eq.6 implicitly assumes that time of delay is one year, that \$1 of R&D expenditures transfers next year into \$1 of R&D stock, and that the annual rate of obsolescence is negligibly small. While the first two assumptions are quite reasonable for IT expenditures and non-technological capital, for R&D stock this assumption is quite strong, which may bias downward the return to R&D stock.

Next, we parameterize returns to non-technological capital stock, R&D stock, and informatization level (ITS), ρ_j in eq.7, to allow different responses by ownership and firm origin.

$$\rho_j = \varphi^j_{1,it} + \varphi^j_{2,it} DO_{it-1} + \varphi^j_{3,it} FO_{it-1} + \varphi^j_{4,it} NEW_i \qquad \textbf{eq. 9}$$

where *j* varies from 1 to 3 and indicates the stock of non-technological capital, R&D stock, and informatization level (ITS).

In a similar way, we allow returns to major inputs varying by 25 two-digit industries and include industry-year interactions. Firm fixed effects are also included in some specifications. NT, R&D, and IT intensities are allowed to vary across industries in one set of regressions. Combining this all together we come up with the following estimation equations:

$$y_{it} = \varphi_{0,it} + (\varphi^j_{1,it} + \varphi^j_{2,it} DO_{it-1} + \varphi^j_{3,it} FO_{it-1} + \varphi^j_{4,it} NEW_i) * * (NT_{it-1} / Y_{it-1} + RD_{it-1} / Y_{it-1} + IT_{it-1} / Y_{it-1}) + + \sum_{s,p} IND_s YEAR_p (\beta^{sp}_l l_{it} + \beta^{sp}_k k'_{it} + \beta^{sp}_m m_{it}) + \sum_{s,p} \eta_{sp} IND_s YEAR_p + \tau_i \qquad \textbf{eq. 10}$$

where y, l, k, and m are growth variables, index *j* refers to a corresponding type of stock for the components of total factor productivity, and τ_i is the firm fixed effect.

4. Results

Table 3 presents the incidence and intensity of investment behavior of firms of various types, defined according to ownership – state, domestic, or foreign – and according to origin – old firms inherited from the Soviet period versus new ones started up (or spun off) afterward. For all types of investment, the incidence is by far the highest among firms owned by foreign investors. State-owned firms have the second highest incidence, but the differences compared with domestic firms are slight relative to the large gap with foreign firms. Three-quarters of foreign firms undertake non-technological investment expenditures, compared to only half for state and domestic. Although the incidence of technological expenditures are lower for all ownership categories, the foreign gap is proportionately even larger, particularly for IT, where 41 percent of foreign firms invest, compared to only 20 percent of state and 17 percent of domestic. Within IT, the incidence of both types of expenditures (software and hardware) is much higher in foreign firms. The incidence of R&D is only 10 percent among foreign firms, but it is 6 percent among state and 4 percent among domestic. On the other hand, the conditional rates of investment (defined as the ratio to output among investing firms) are more similar across ownership types and for total IT and both types is significantly higher among both state and domestic than foreign firms.

Perhaps more surprising is that the incidence of all types of investment is also higher for old than for new firms. The proportional gap is less marked for non-technological assets – 60 versus 46 percent – but it is 10 versus 2 percent for R&D and 25 versus 16 percent for IT. One might have expected to find the highest incidence of investment among new firms, consistent with the common view of start-up firms as the most dynamic, investing sector, and particularly so in a transition economy like Ukraine. But the data contradict this notion, showing that investment is more commonly found in the old sector. Conditional on investing, however, the mean level of investment (as a ratio to output) tends to be higher in new firms. As a consequence, the unconditional rates (including noninvestors) tend to be rather similar between old and new. The data imply that new firms are more heterogeneous in the sense that they may be less likely to invest but when they do invest, their expenditures are higher.

None of these calculations, of course, take into account the possibility of differences in the industries within which these types of firms operate. New firms may locate in sectors with few capital requirements, while foreigners' access to finance may give them a comparative advantage in capital-intensive industries. Moreover, even within industries firms with some characteristics – larger market share, export, and larger – may be more likely to invest. Finally, access to finance and technology may vary over time and across regions. To assess investment behavior taking into account such possibilities, Table 4 presents Tobit estimates of investment rates as functions of ownership and new/old type, while controlling for a full set of industry-year dummy interactions, region (oblast) effects, market share in the firm's 3-digit industry and its square, a dummy for exporting, and log of the tangible capital stock.[9]

Contrary to the results in Table 3, the multivariate estimates imply almost uniformly higher levels of investment of each type not only for foreign but also for domestic firms relative to state-owned enterprises. Foreign ownership is associated with the highest rates in every case but R&D, when the coefficients imply the reverse ordering given by Table 3, with domestic now highest and foreign lowest (although statistically indistinguishable from state). A qualitatively similar reversal occurs for the results with respect to new/old, as the Table 4 results imply higher rates for new firms; again, the only exception is R&D, where the estimated coefficient on new private is negative and statistically significant, consistent with the pattern in Table 3. In general, these results show the importance of taking other characteristics into account, particularly industry and firm performance.

---

[9] Market share, size (capital), and exporting behavior are generally highly correlated in any data set, so the estimated partial effects of these variables should be interpreted cautiously. The region controls (27 oblast dummies) are less clearly justified than industry, as most arguments concerning the former (e.g., location of heavy manufacturing in Eastern Ukraine) are captured by the latter. Because our data cleaning procedure censored observations with investment/output > 1, these are double-limit Tobits. Future revisions might therefore emphasize or refer to more parsimonious specifications, and perhaps should report single-limit Tobits (without censoring values exceeding 1) as well.

The results also imply that both foreign and new firms engage in less R&D but more IT and non-technological investment – already an interesting, perhaps surprising result in the data.[10] The higher levels of investment in foreign firms might stem from easier access to finance, for instance through multinational parents. The lower level of R&D in foreign firms is consistent with R&D functioning less to derive innovations that push out the technological frontier but rather to absorb and adapt technologies from abroad. Firms dominated by foreign owners may face less of an absorption problem than domestic firms having to purchase or reverse engineer technologies at arms length from the original source. In this sense, FDI and R&D may be substitutes as methods of acquiring new technologies.

The same qualitative pattern for new firms – less R&D but more of all other kinds of investments relative to state firms – is more puzzling. New firms are likely to be the most financially constrained and to have less developed channels for acquiring technologies.

What impact do these various types of investment have on measured productivity growth? Table 5 reports on non-technological investment, R&D, and IT, and Table 6 disaggregates IT into software and hardware. Both OLS and FE specifications are presented. The first two columns contain estimates of equations without interactions, and thus only main investment and firm-type effects are presented. Interactions are added in the third and fourth columns. To control for differences in industry composition by firm type, interactions of investment types with industries are included in the last two columns.

The first two columns of Table 5 show positive, statistically significant returns to non-technological and IT investments in both the OLS and FE specifications, but the R&D coefficient is statistically significant only in the OLS. The estimated IT return is equal to nearly one, implying that IT investments are repaid in the year immediately following (of course, IT also depreciates rapidly when IT technology improves rapidly). The ownership effects imply similar productivity growth rates in all three ownership types, except for a slight edge for domestic firms (0.046 relative to state, 0.023 relative to foreign) in the FE specification. Because these are growth rather than level equations, they are not necessarily inconsistent with typical findings of higher productivity level among foreign than domestic firms.

The analysis of the heterogeneity of the investment returns in the 3rd-6th columns of Table 5 shows much higher point estimates of the returns to all types of investment among foreign firms. The coefficients on the interactions of investments with the foreign dummy are sizable, especially for IT, and the IT interaction is highly statistically significant. These results seem inconsistent with the view that FDI improves productivity through facilitating access to finance, as in this case the returns should not be higher among foreign firms. Instead, we find both higher levels and higher returns among foreign firms, which suggest a higher marginal productivity of capital schedule compared to both domestic and state firms. For non-technological investments and R&D, on the other hand, the return estimates are always imprecisely estimated.

[10] It bears emphasis that these statements concern overlapping categories, and the foreign result concerns a comparison to state and domestic while new firms are compared to old, regardless of ownership. Clearly, while state firms are by definition (assumption) old in our data, domestic and foreign firms may be either old or new.

The results for the new firm dummy imply no difference in non-technological and R&D investment returns in Table 5, but lower returns to IT. Thus, new firms invest more in IT but gain less in productivity growth from this expenditure, compared to their older counterparts.

Finally, Tables 6 disaggregates IT spending into the categories of hardware and software. As hardware is tangible and software intangible, so if ownership types and origins distinguish themselves via monitoring, they should have different returns to software but not hardware investment. Columns 1-2 show that the estimated returns to software are insignificantly different from zero in the sample as a whole, while returns to hardware are positive, very large, and highly significant. Differences across ownership types in these returns are revealed in columns 3-6. Returns to software are estimated to be negative among state firms. The returns to both hardware and software are estimated to be much higher in domestic firms, and still higher in foreign firms, with all coefficients highly statistically significant. The results for new versus old firms imply lower returns to both hardware and software among the former, although the differences are not always statistically significant. The differences in ownership types and origins are similar for hardware and software, inconsistent with the monitoring hypothesis. The insignificant differences in R&D investment returns are also inconsistent with this hypothesis (R&D is intangible).

5. Conclusion

Using a large panel of Ukrainian industrial firms, this paper finds significant differences in investment volume and returns across ownership types and by firm origin. The differences are most stark for IT investment, where foreign firms invest more and have higher returns than domestic private firms and state firms, and new firms invest more than old firms.

The fact that foreign firms invest manage to achieve higher returns both larger amounts along with higher returns are inconsistent with a story that foreign firms outperform mainly by having greater access to financing, as that would predict higher volume but lower returns.[11] Instead they appear to have a higher marginal productivity of IT capital schedule.

The results suggest that new firms' performance outpaces that of old firms not because of superior monitoring or organizational capital, but from higher non-technological and IT investment rates.

The results do not support the hypothesis that foreign firms provide better monitoring. Under this hypothesis, one would expect foreign firms to achieve significantly higher returns to intangible investments like R&D and IT software, as intangible investments should be more difficult to monitor. We find that foreign firms do not achieve significantly higher returns to R&D investment, and their advantage in IT software investment is similar to their advantage with IT hardware investment.

The foreign firm edge in IT as opposed to other investment types points to the possibility of superior organizational capital, as suggested by Bloom et al. (2007) and Crespi et al.'s (2007)

[11] This assumes decreasing returns to investment. A regression including a squared term for IT investment shows a negative (though insignificant) coefficient for it.

results on foreign vs. domestic firms in the United Kingdom. Foreign investors bring managers who are experienced in using IT, and they introduce business models that more fully exploit the technology.

In future research it would be desirable to collect data on organizational capital and estimate more directly its role in foreign firms' superior performance, following the work of Crespi et al. (2007) in the United Kingdom.

References

Bergson, Abram, "Technological Progress," in *The Soviet Economy, Toward the Year 2000*. Abram Bergson and Herbert S. Levine (eds.), London: George Allen and Unwin Ltd., 1983.

Berliner, Joseph, *The Innovation Decision in Soviet Industry*. Cambridge: MIT Press, 1976.

Bloom, Nick, Raffaela Sadun, and John Van Reenen, "Americans Do I.T. Better: US Multinationals and the Productivity Miracle," CEP Discussion Paper No. 788, April 2007.

Boycko, M., Shleifer, A. and Vishny, R.W. (1996). 'A theory of privatization', *Economic Journal*, vol. 106(435), pp. 306–19.

Bresnahan, Timothy F., Erik Brynjolfsson, and Loren Hitt, "Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-level Evidence," *Quarterly Journal of Economics*, 117:1, 338-376, 2002.

Brown, J. David, John S. Earle, and Almos Telegdy, "What Makes ECA Firms Productive? Ownership, Age, Market Structure, and Import Penetration in Georgia, Hungary, Romania, Russia, and Ukraine," mimeo, 2007.

Brynjolfsson, Erik, and Loren Hitt, "Beyond Computation: Information Technology, Organizational Transformation and Business Performance," *Journal of Economic Perspectives*, 14:4, 23-48, 2000.

Burkart, Mike, Denis Gromb, and Fausto Panunzi, "Large Shareholders, Monitoring, and the Value of the Firm," *Quarterly Journal of Economics*, 112, 693-728, 1997.

Chen, Victor Z, Jing Li, Lisa Papania, and Daniel M. Shapiro, "Effects of Ownership Structure on Innovation Performance of Firms in an Emerging Market", mimeo, Dec. 7, 2008.

Chung, Kee H., Peter Wright, and Ben Kedia, "Corporate governance and market valuation of capital and R&D investment", Review of Financial Economics, 12, 2003, pp. 161-172.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen, "Boards: does one size fit all?" *Journal of Financial Economics*, 87, 329-356, 2008.

Crespi, Gustavo, Chiara Criscuolo, and Jonathan Haskel, "Information Technology, Organizational Change and Productivity Growth: Evidence from UK Firms," CEP Discussion Paper No. 783, March 2007.

Devaraj, S., and R. Kohli, "Performance Impacts of Information Technology: Is Actual Usage the Missing Link?" *Management Science*, 49(3), pp. 273-289, 2003.

Domadenik, Polona, Janez Prasnikar, and Jan Svejnar, "How to Increase R&D in Transition Economies? Evidence from Slovenia, IZA DP No 2801, May 2007.Eklund, Johan E., Johanna

Palmberg, and Daniel Wiberg, “Ownership Structure, Board Composition and Investment Performance,” Ratio Institute Working Paper No. 129, February 2009.

Girma, Sourafel, Yundan Gong and Holger Gorg, “Foreign direct investment, access to finance, and innovation activity in Chinese enterprises”, Kiel Working Paper No. 1400, February 2008.

Griliches, Zvi, and Jacques Mairesse, “Productivity and Research and Development at the Firm Level,” pp. 271-297 in *Research and Development, Patents and Productivity,* Griliches ed., Chicago University Press, 1984.

Hanson, Philip, “The Soviet System as a Recipient of Foreign Technology,” in Industrial Innovation in the Soviet Union, Ronald Amann and Julian M. Cooper (eds.), New Haven: Yale University Press, 1982.

Ho, Joanna L. Y., Anne Wu, and Sean Xin Xu, “Corporate Governance and Returns on Information Technology Investment: Evidence from an Emerging Market”, mimeo, June 2007.

Hunter, Larry W., Annette Bernhardt, Katherine L. Hughes, and Eva Skuratowicz, “It’s Not Just the ATMs: Technology, Firm Strategies, Jobs, and Earnings in Retail Banking,” Wharton Financial Institutions Center Working Paper 00-31, 2000.

Megginson, W.L. and Netter, J.M. (2001). ‘From state to market: a survey of empirical studies on privatization’, *Journal of Economic Literature*, vol. 39(2), pp. 321–89.

Ortega-Argiles, Raquel, Rosina Moreno-Serrano, and Jordi Surinach Caralt, “Ownership structure and innovation: is there a real link”, The Annals of Regional Science, Vol. 39(4), pp. 637-662, December 2005.

Sutton, Anthony C., Western Technology and Soviet Economic Development 1945 to 1965, Vol. 3, Stanford, CA: Hoover, 1973.

Sveikauskas, Leo, “R&D and Productivity Growth: A Review of the Literature,” BLS Working Paper No. 408, September 2007.

Table 1

Means and Standard Deviations for Determinants of Investment Regressions

	Mean	Std. Dev.
Log Capital	4.5328	2.8000
Non-Technology Invest./Output	0.0482	0.1184
R&D Expenditures/Output	0.0009	0.0108
IT Expenditures/Output	0.0010	0.0089
IT Software Expenditures/Output	0.0002	0.0034
IT Hardware Expenditures/Output	0.0008	0.0098
3-digit-industry market share	0.0037	0.0221
3-digit-industry market share squared	0.0006	0.0119
Exporting firm	0.1544	
Domestic Ownership	0.8570	
Foreign Ownership	0.0368	
New firm	0.7431	

Notes: All variables are calculated on the regression sample for Table 4, using 182,860 annual observations. Non-technology investment is total investment – (R&D + IT Expenditures). IT Investment is IT Software + IT Hardware. Exporting firm is a dummy variable equalling 1 if a firm had exports in year *t*-1 and 0 otherwise.

Table 2

Means and Standard Deviations for Productivity Growth Regressions

	Mean	Std. Dev.
Change in Log Output	-0.0004	0.6109
Change in Log Employment	-0.0649	0.4058
Change in Pre-Existing Tangible Assets	-0.1427	0.6980
Change in Log Materials	-0.0128	0.7926
Non-Technology Invest./Output	0.0423	0.1041
R&D Expenditures/Output	0.0016	0.0199
IT Expenditures/Output	0.0014	0.0117
IT Software Expenditures/Output	0.0002	0.0037
IT Hardware Expenditures/Output	0.0011	0.0109
Domestic Private	0.8447	
State	0.1168	
Foreign	0.0385	
New Private	0.7199	

Notes: All variables are calculated on the regression sample for Tables 5 and 6.

Table 3

Incidence and Magnitude of Investment Expenditures by Ownership Type

	All	State	Domestic	Foreign	Old	New
Any Non-Tech.	49.9%	51.7%	48.5%	75.1%	59.6%	46.1%
Mean >0	0.085	0.074	0.085	0.112	0.071	0.092
Any R&D	4.2%	6.3%	3.7%	10.2%	9.9%	2.0%
Mean >0	0.038	0.036	0.037	0.048	0.036	0.043
Any IT	18.6%	20.2%	17.3%	40.5%	25.3%	15.9%
Mean >0	0.007	0.009	0.007	0.005	0.005	0.009
Any IT Software	8.6%	9.4%	7.8%	24.8%	12.8%	7.0%
Mean >0	0.0025	0.0029	0.0024	0.0020	0.0019	0.0029
Any IT Hardware	15.7%	17.4%	14.6%	34.8%	21.9%	13.3%
Mean >0	0.0073	0.0085	0.0075	0.0039	0.0046	0.0090

Notes: These are calculated on the regression sample for Table 5, with the exception of New, which uses the Table 6 sample. The numbers in the "Mean >0" rows are mean intensities (investment expenditures divided by output) among observations with positive values.

Table 4

Determinants of Firm Non-Tech, R&D, and IT Investment: Ownership, Market Share, Export Orientation, and Size

	Non-Tech	R&D	IT	IT Software	IT Hardware
Domestic	0.013***	0.005**	0.001**	0.002***	0.001
	(0.002)	(0.002)	(0.000)	(0.000)	(0.000)
Foreign	0.017***	-0.001	0.002***	0.003***	0.002***
	(0.003)	(0.003)	(0.001)	(0.000)	(0.001)
New Private	0.047***	-0.016***	0.003***	0.002***	0.003***
	(0.002)	(0.002)	(0.000)	(0.000)	(0.000)
3-digit-industry market share	-0.364***	0.209***	0.034***	0.033***	0.037***
	(0.036)	(0.025)	(0.006)	(0.003)	(0.006)
3-digit-industry market share squared	0.433***	-0.215***	-0.060***	-0.046***	-0.062***
	(0.064)	(0.041)	(0.010)	(0.006)	(0.011)
Exporting firm	0.026***	0.030***	0.007***	0.003***	0.007***
	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)
Log Capital	0.034***	0.019***	0.004***	0.002***	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: These are Tobit regressions run on 182,860 annual observations. Each of the investment variables is scaled by output. Other regressors include industry-year dummies and region (oblast) dummies. Standard errors are shown in parentheses. Foreign = 1 if the firm is majority private and the majority of private shares are foreign-owned in the beginning of year *t*-1. Domestic = 1 if majority private, but the majority of private shares are not owned by foreigners, in the beginning of year *t*-1. New Private = 1 if the firm entered as a private firm. Market share, exporting firm, and log capital are measured in year *t*-1. * = significant at 10-percent level. ** = significant at 5-percent level. *** = significant at 1-percent level.

Table 5

Returns to Non-Tech, R&D, and IT Investment

	OLS	FE	OLS	FE	OLS	FE
Non-Tech Invest.	0.149***	0.168***	0.078***	0.161***		
	(0.013)	(0.017)	(0.032)	(0.041)		
R&D	0.106***	0.086	0.030	0.031		
	(0.044)	(0.054)	(0.137)	(0.151)		
IT	0.942***	0.977***	0.092	-0.001		
	(0.191)	(0.244)	(0.247)	(0.285)		
Domestic	-0.004	0.046**	-0.012***	0.040*	-0.010**	0.042*
	(0.004)	(0.022)	(0.005)	(0.023)	(0.005)	(0.023)
Foreign	0.001	0.023	-0.015*	0.010	-0.011	0.016
	(0.006)	(0.026)	(0.008)	(0.026)	(0.008)	(0.027)
New Private	0.008***		0.012***		0.012***	
	(0.003)		(0.003)		(0.003)	
Non-Tech*Domestic			0.114**	0.050	0.047	-0.017
			(0.047)	(0.062)	(0.064)	(0.081)
Non-Tech*Foreign			0.136**	0.083	0.083	0.026
			(0.065)	(0.081)	(0.079)	(0.097)
Non-Tech*New			-0.048	-0.058	-0.048	-0.054
			(0.038)	(0.050)	(0.038)	(0.050)
R&D*Domestic			0.086	0.046	0.111	0.084
			(0.153)	(0.177)	(0.179)	(0.261)
R&D*Foreign			0.272	0.135	0.287	0.172
			(0.178)	(0.200)	(0.205)	(0.282)
R&D*New			-0.075	-0.007	-0.035	0.014
			(0.088)	(0.114)	(0.095)	(0.112)
IT*Domestic			2.594***	2.858***	2.322**	2.613***
			(0.947)	(1.080)	(0.983)	(1.035)
IT*Foreign			5.084***	5.424***	3.364***	3.004**
			(1.723)	(2.104)	(1.263)	(1.321)
IT*New			-1.786*	-1.946*	-1.684*	-1.894*
			(0.930)	(1.058)	(0.950)	(0.992)

Notes: These are productivity growth regressions run on 159,876 annual observations for 43,402 firms. The dependent variable is change in log output. Other regressors include industry-year dummies and changes in log employment and log materials interacted with 25 industry dummies. In columns 5 and 6, each investment variable is interacted with 25 industry dummies. Standard errors (corrected for firm clustering) are shown in parentheses. Foreign = 1 if the firm is majority private and the majority of private shares are foreign-owned in the beginning of year *t*-1. Domestic = 1 if majority private, but the majority of private shares are not owned by foreigners, in the beginning of year *t*-1. * = significant at 10-percent level. ** = significant at 5-percent level. *** = significant at 1-percent level.

Table 6
Returns to Disaggregated IT Investment

	OLS	FE	OLS	FE	OLS	FE
Non-Tech Invest.	0.149***	0.169***	0.081***	0.164***		
	(0.013)	(0.017)	(0.032)	(0.041)		
R&D	0.110***	0.088*	0.030	0.029		
	(0.043)	(0.054)	(0.137)	(0.151)		
IT Software	0.102	0.233	-1.217**	-1.111**		
	(0.584)	(0.519)	(0.503)	(0.498)		
IT Hardware	1.052***	1.072***	0.329	0.204		
	(0.202)	(0.267)	(0.250)	(0.297)		
Domestic	-0.004	0.046**	-0.012	0.040*	-0.010**	0.042*
	(0.004)	(0.022)	(0.004)	(0.023)	(0.005)	(0.023)
Foreign	0.001	0.023	-0.015**	0.010	-0.012	0.016
	(0.006)	(0.026)	(0.008)	(0.026)	(0.008)	(0.027)
New Private	0.008***		0.012***		0.012***	
	(0.003)		(0.003)		(0.003)	
Non-Tech*Domestic			0.110**	0.047	0.044	-0.019
			(0.047)	(0.062)	(0.064)	(0.081)
Non-Tech*Foreign			0.132**	0.083	0.079	0.025
			(0.065)	(0.080)	(0.079)	(0.097)
Non-Tech*New			-0.046	-0.057	-0.048	-0.054
			(0.037)	(0.050)	(0.038)	(0.049)
R&D*Domestic			0.087	0.050	0.096	0.067
			(0.152)	(0.177)	(0.165)	(0.246)
R&D*Foreign			0.267	0.132	0.272	0.151
			(0.179)	(0.200)	(0.195)	(0.271)
R&D*New			-0.067	-0.001	-0.024	0.026
			(0.088)	(0.114)	(0.096)	(0.113)
IT Software*Domestic			5.744***	5.199***	3.827**	3.397*
			(1.234)	(1.392)	(1.779)	(1.882)
IT Software*Foreign			6.598***	5.879***	6.174***	5.400***
			(1.513)	(1.644)	(1.817)	(1.966)
IT Software*New			-4.471***	-3.907***	-3.135*	-2.172
			(1.341)	(1.430)	(1.668)	(1.870)
IT Hardware*Domestic			2.024*	2.450**	1.891*	2.209**
			(1.060)	(1.182)	(1.054)	(1.085)
IT Hardware*Foreign			5.328**	5.909**	2.985	2.084
			(2.219)	(2.696)	(2.021)	(1.938)
IT Hardware*New			-1.370	-1.682	-1.422	-1.724*
			(1.045)	(1.163)	(1.025)	(1.938)

Notes: These are productivity growth regressions run on 159,876 annual observations for 43,402 firms. The dependent variable is change in log output. Other regressors include industry-year dummies and changes in log employment and log materials interacted with 25 industry dummies. In columns 5 and 6, each investment variable is interacted with 25 industry dummies. Standard errors (corrected for firm clustering) are shown in parentheses. * = significant at 10-percent level. ** = significant at 5-percent level. *** = significant at 1-percent level.