

## 5. INNOVATION AND LABOUR PRODUCTIVITY GROWTH IN SWITZERLAND

### An Analysis Based on Firm Level Data

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#### Introduction

This study investigates the determinants of labour productivity growth of Swiss firms in the period 1994–2002 particularly emphasizing the role of innovation activities. Thus, the main research question pursued is: to what extent do different types of firm-level innovations affect labour productivity of firms in Switzerland? This is a question of particular interest for Swiss policy-makers in the light of the unsatisfactory growth performance of the Swiss economy in the 1990s (see Federal Department for Economic Affairs 2002). Most observers consider the low growth of labour productivity as the main single factor for explaining this unfavourable performance as measured by GDP growth. Labour productivity depends on physical and human capital as main production factors as well as on new knowledge and innovation. Economies that develop more and more in the direction of a “knowledge-based economy” are relying increasingly on technological innovation. Hence, it is important to gain some insights with respect to the (quantitative) relationship between innovation and economic performance. A better understanding of the relative importance of the factors determining productivity growth could contribute to an explanation of the low productivity growth of the Swiss economy in the 1990s.

The data used in this study come from the KOF panel database and were collected in 1996, 1999 and 2002 respectively based on a questionnaire quite similar to that used in the Community Innovation Surveys (CIS). We use an (unbalanced) panel of in total 793 firms covering the manufacturing sector, a large portion of service industries and the construction sector.

In this study, we specify and estimate econometrically a *labour productivity growth equation* (growth of value added per employee) containing a variable for human capital (share of employees with tertiary-level education), a variable for physical capital (value added share of non-labour firm income) and, alternatively, a series of simple innovation indicators (introduction of innovations yes/no; introduction of product / process innovations yes/no; existence of R&D activities yes/no; at least 1 patent application yes/no; introduction of products new for the world market yes/no).

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The new elements that this paper adds to the empirical literature are, first, the consideration of several innovation indicators, thus allowing to test the robustness of the relationship between innovation and economic performance; second, the use of panel data for the period 1994–2002, since only few studies until now could dispose of a panel. It is the first study on the determinants of productivity growth based on Swiss firm data.

The set-up of the study is as follows: the second section gives information on the conceptual framework and a short summary of related empirical literature. In the third section we present the specification of the productivity growth equation. The fourth section deals with the data used in the study and the method applied in the econometric estimations. In the fifth section we discuss the empirical results. The last section contains a summary and some conclusions.

### **Conceptual framework and literature review**

Since the mid-1980s the study of macroeconomic growth and its policy implications vigorously re-entered the research agenda (Romer, 1986; Baumol, 1986). A diverse body of literature appeared trying to explain, both theoretically and empirically, why differences in income over time and across countries did not disappear as the neo-classical models of growth of the 1950s and 1960s developed by Solow (1956) and Swan (1956) predicted. The idea that emerged from this literature is that economic growth is endogenous. That is, economic growth is influenced by decisions made by economic agents, and is not merely the outcome of an exogenous process. Endogenous growth assigns a central role to capital formation, where capital is not just confined to physical capital, but includes human capital and knowledge.

The econometric work on growth is dominated by cross-country regressions (Barro, 1991; Mankiw et al. 1992). In these studies the model of growth collapses to a single growth equation by log-linearizing the model around the steady state. Following the same procedure in our set-up, results in an equation explaining labour productivity growth by a catch-up variable, human capital and the capital-labour ratio. Innovation efforts might be a relevant factor in this kind of models.

The relationship between productivity and innovations can be analyzed on different levels: economy, sector, industry, and firm. The present study is based on firm data. Thus, the reference studies to be considered here are characterized by the fact that they concentrate on productivity at the firm level and use micro data from Community Innovation Surveys (CIS).

Crépon et al. (1998) studied the links between productivity, innovation and research based on a three-equation structural model that explained productivity by innovation output, and innovation output by research investment based on a cross-section of French firm data. They found that firm productivity correlates positively with a higher innovation output, after controlling for labour skill and physical capital intensity. In a further study with French data Duguet (2006) distinguished two types of innovation, namely incremental and radical innovations. He found for a cross-section of French firm data that radical innovations are the only significant contributors to TFP growth.

Lööf et al. (2001), Janz et al. (2003) and Griffith et al. (2006) conducted comparative studies for many countries using the framework of analysis developed by Crépon et al. (1998). All three studies are cross-section investigations based on CIS data. Lööf et al. found that

the estimated elasticity of productivity with respect to innovation output is higher in Norway than in the other two countries in their sample, i.e. Finland and Sweden. Rather surprisingly, no significant relationship was found between innovation and productivity in Finland. The authors are reluctant to draw definite conclusions from these findings because of data errors, differences in model specification or unobserved country-specific effects.

Janz et al. analyzed the relationship between productivity, innovation output and R&D expenditure for a pooled sample of German and Swedish firms. The analysis showed that the two main parameter estimates, the elasticity of labour productivity with respect to innovation output and the elasticity of innovation output with respect to innovation input, are not significantly different between the two countries.

Finally, using different innovation output measures, Griffith et al. found that the innovation output is significantly determined by the innovation effort in all four countries of investigation, France, Germany, Spain and the UK. In contrast to that, productivity effects of innovation did not show up for Germany.

Wieser (2005) provides a survey of empirical studies on the impact of R&D on productivity. Despite considerable variation of the estimated returns to R&D from one study to another, the results clearly suggest a positive and strong relationship between R&D expenditures and growth of output or total factor productivity. The studies reviewed indicate that the rates of return vary sometimes significantly between industries, but it is unclear as to which industries generate higher returns. The results of a meta-analysis indicate, first, a significantly higher elasticity of R&D in the 1980s and consistently higher estimates for the 1990s, as compared with the 1970s. Second, the meta-results show that the elasticities of R&D are significantly lower in Europe than in the US.

On the whole, the comparability of existing studies is rather limited due not only to data problems but also to differences with respect to model specification and applied econometric methodology.

### Model specification

We assume a production function in which we include labour, human capital and physical capital. Besides firm-, sector- and time-specific dummies, we allow previous innovation activities to explain multifactor productivity ( $A$ ).

$$Y_{it} = A(S_j, T_t, P_t, I_{it-1}) f(L_{it}, H_{it}, K_{it}) \quad (1)$$

where  $Y_{it}$  is the output of firm  $i$  in period  $t$ ,  $L_{it}$  is the number of employees in firm  $i$  at time  $t$ ,  $H_{it}$  is human capital, and  $K_{it}$  is the fixed capital stock of firm  $i$  in period  $t$ . The term  $S_j$  and  $P_t$  stand for respectively sector- and time-specific dummies.  $I_{it-1}$  represent innovation efforts (per employee) by firm  $i$  in the period preceding period  $t$ . In the empirical analysis we assume an aggregated Cobb-Douglas production function. We then divide both sides by the number of employees and take natural logarithms, assuming constant returns to scale. In line with the macroeconomic growth literature, we specify the resulting equation in growth rates (which allows us to interpret it as the result of log-linearizing a more fully-specified growth model around its steady state) and arrive at the following equation explaining labour productivity growth:

$$\Delta(y_{it} - l_{it}) = \delta y_{it-1} + \gamma \Delta a_{ij} + \varepsilon \Delta(h_{it} - l_{it}) + \phi \Delta(k_{it} - l_{it}), \quad (2)$$

Lower cases indicate the natural logarithm of the original variables,  $y_{it-1}$  serves as a catch-up variable and  $a_{it}$  is a linear combination of the dummies for  $S_j, T_t, P_t, I_{it-1}$ . Our dependent variable is the change in the natural logarithm of value added (i.e. sales minus material and service intermediates) per employee. The natural logarithm of the human capital-labour ratio we proxy by the natural logarithm of the share of the employees with tertiary-level education and for the natural logarithm of fixed capital-labour ratio we use the natural logarithm share of capital income (value added minus labour costs) per employee.

Our main hypothesis is that innovation activities, via the multifactor productivity term  $a$ , contribute to an improvement of labour productivity growth. As we will use binary innovation indicators to proxy for innovation, we basically compare labour productivity growth between firms that are and are not involved in such innovation activities.

## Data and method

The data used in this study were collected in the course of three surveys among Swiss enterprises in the years 1996, 1999 and 2002 using a questionnaire which included besides questions on some basic firm characteristics (sales, employment, labour costs and employees' vocational education) also several innovation indicators quite similar to those in the Innovation Surveys of the European Community (CIS). The survey was based on a (with respect to firm size) disproportionately stratified random sample of firms with at least 5 employees covering all relevant industries of the manufacturing sector, the construction sector and selected service industries (18 manufacturing industries, 9 service industries and the construction industry, on the whole 28 industries) and within each industry three industry-specific firm size classes with full coverage of the upper class of large firms). Quantitative variables (e.g. value added) are referring to the years 1995, 1998 and 2001 respectively, while the innovation variables are referring to the three-year periods 1994–1996, 1997–1999 and 2000–2002 respectively.

To circumvent that the results are driven by outlying observations, we removed potential outlying observations before starting our empirical analysis. As both the mean and the standard deviation are highly sensible to the presence of outlying observations, we used robust counterparts – namely the median and the median absolute deviation – to identify extreme observations. In each cross-section those observations which in absolute sense deviated more than three times the median absolute deviation from the median itself were removed from the sample.

As already mentioned the data cover in total 18 manufacturing sectors, 9 services sectors and the construction sector. The three largest industries with each an approximate share of 10 percent in our final sample are the construction sector, metal-working industry and machinery. Close to 40 percent of the observations stem from the survey conducted in 2002. The two surveys in 1996 and 1999 each represent approximately 30 percent of the observations. This means that our panel is of an unbalanced nature. Our final dataset contained 793 observations. Due to missing values for single variables the sample fluctuates between 768 and 793 observations at maximum in the econometric estimations.

**T5–1 Summary statistics**

	Obs.	Mean	St.dev.
Labour productivity growth	793	3.8%	24.2%
Log(initial labour productivity)	793	11.73%	0.34%
Lagged foreign ownership (y/n)	793	10.1%	30.1%
Growth in share tertiary education	793	0.1%	49.2%
Growth in capital-labour ratio	793	-1.1%	55.3%
Innovation activity (y/n)	793	69.6%	46.0%
Product innovation (y/n)	793	57.3%	49.5%
Process innovation (y/n)	793	50.7%	50.0%
R&D Activities (y/n)	792	53.2%	49.9%
Patent applications (y/n)	789	20.2%	40.1%
Introduction of new products (y/n)	768	20.3%	40.3%

**T5–2 Correlation matrix of the model variables**

Obs.\Corr.	Log (initial labour productivity)	Lagged foreign ownership (y/n)	Growth in share tertiary education	Growth in capital-labour ratio	Innovation activity	Product innovation	Process innovation	R&D activities	Patent applications	New products
<b>Labour prod. growth</b>	<b>0.09</b>	<b>-0.26</b>	<b>0.03</b>	<b>0.52</b>	<b>0.05</b>	<b>0.05</b>	<b>0.01</b>	<b>0.05</b>	<b>0.04</b>	<b>0.07</b>
Log(initial labour productivity)	793	0.15	0.07	0.09	0.07	0.12	-0.04	0.08	0.04	0.08
Lagged foreign ownership (y/n)	793	793	0.03	-0.13	0.15	0.19	0.14	0.19	0.12	0.12
Growth in share tertiary education	793	793	793	-0.01	0.08	0.10	0.10	0.07	0.03	0.02
Growth in capital-labour ratio	793	793	793	793	0.04	0.03	0.00	0.07	0.00	0.02
Innovation activity (y/n)	793	793	793	793	793	0.77	0.67	0.71	0.33	0.34
Product innovation (y/n)	793	793	793	793	793	793	0.38	0.73	0.41	0.41
Process innovation (y/n)	793	793	793	793	793	793	793	0.46	0.24	0.31
R&D Activities (y/n)	792	792	792	792	792	792	792	792	0.43	0.40
Patent applications (y/n)	789	789	789	789	789	789	789	788	789	0.51
Introduction of new products (y/n)	768	768	768	768	768	768	768	768	765	768

We estimate equation (2) containing besides the first differences of the two basic variables log of share of employees with tertiary-level education and log of capital income per employee alternatively with each one of six different dichotomous innovation indicators (innovation activities yes/no; introduction of product / process innovations; R&D activities yes/no; at least one patent application yes/no; introduction of products new for the (world) market yes/no) (see table 5–1 for some descriptive statistics of the variables used, also table 5–2 for the correlation matrix of the model variables). These indicators cover both the input- and the output-side of

the innovation process as well as the two most important kinds of innovation, product and process innovation. Further our estimation equation contains 28 industry dummies, two time dummies and a dummy for a firm being domestic- or foreign-owned (see also table 5–3).<sup>79</sup>

We estimate one OLS version of equation (2) containing contemporaneous innovation indicators and a second Instrumental Variable version where the lagged innovation indicators are used as instruments. In this way, we take the possibility of the innovation variable being endogenous into account.

### Empirical results

Table 5–3 shows the results of the econometric estimations of equation (2) with six alternative innovation variables. Column (1) presents the baseline regression without any innovation dummy. The coefficients of both variables for resource endowment are, as expected, positive but only the parameters for the capital-labour ratio are statistically significant at the usual significance level. However, there is a strong positive correlation of the variable for human capital with the *level* of labour productivity, as was found in other studies (Arvanitis 2007). Further, the coefficient of the foreign ownership dummy is also positive and highly significant, which can be interpreted as a clear hint that, after controlling for all other factors, productivity growth is higher in foreign than in domestic firms. The estimated coefficient implies that, when keeping the other attributes in the model constant, foreign firms on average report a  $(100 \cdot \ln(1+0.06)) = 5.8$  percentage points higher labour productivity growth rate than domestically-owned firms. Given an average labour productivity growth of 3.8 percent in our sample (see Table 5–1), this means that foreign firms on average grow 2.5 times faster than domestic firms. The effect of productivity growth lagged by a period on current productivity growth is, as expected, significantly negative across all estimations and in absolute terms as high as the capital-labour ratio effect.

The next columns of Table 5–3 report the results in case our innovation variables are added one at a time.<sup>80</sup> Unless mentioned otherwise, we focus on the results for the instrumental variables specification.<sup>81</sup> In column (2) we first start by including our broadest defined innovation variable, overall innovation activities. This dummy equals one in case the firm reports to have carried out product or process innovations or both of them during the past three years and is significant. An economic interpretation of this coefficient is that on average a switch from a firm without innovations to a firm that has introduced innovations, is associated with an increase of productivity growth by somewhat more than 10 percentage points. When splitting up these innovation activities into product and process innovations (columns (3) and (4)), it becomes clear that largely product innovations are driving this result.

<sup>79</sup> We also experimented with including six dummies for firm size. However, in these growth regressions these dummies did not turn out to be significant and are therefore removed from the regression. The qualitative results are not affected by this.

<sup>80</sup> The high correlation (as reported in Table 5–2) between the different innovation dummies refrain us from reporting the results including all innovation dummies at once.

<sup>81</sup> We also estimated the same set of equations using only the lagged innovation dummies. The results are qualitatively identical to those of the instrumental variable approach.

T 5–3 Estimates of the productivity equation

	(1)		(2)		(3)		(4)		(5)		(6)		(7)	
			OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Number of observations	793	793	793	793	793	793	793	793	792	783	789	775	768	753
Adjusted R2	0.322	0.324	0.304	0.321	0.325	0.321	0.324	0.322	0.323	0.303	0.325	0.320	0.321	0.304
Lagged foreign ownership (y/n)	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.06
	(2.31)	(2.33)	(2.34)	(2.20)	(2.26)	(2.20)	(2.46)	(2.47)	(2.35)	(2.42)	(2.37)	(2.15)	(2.41)	(2.27)
Log(initial labour productivity)	-0.20	-0.21	-0.22	-0.22	-0.21	-0.22	-0.21	-0.21	-0.20	-0.23	-0.21	-0.21	-0.20	-0.21
	(-7.63)	(-7.84)	(-7.91)	(-8.01)	(-7.92)	(-8.01)	(-7.91)	(-7.19)	(-7.78)	(-7.80)	(-8.00)	(-7.92)	(-7.85)	(-7.74)
Growth in share tertiary education	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	(1.29)	(1.19)	(0.91)	(0.95)	(1.13)	(0.95)	(1.15)	(1.01)	(1.21)	(1.16)	(1.32)	(1.22)	(1.32)	(1.33)
Growth in capital-labour ratio	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.21	0.21	0.21	0.20
	(14.05)	(13.86)	(13.22)	(13.88)	(13.88)	(13.61)	(13.97)	(14.14)	(13.75)	(12.62)	(14.03)	(13.81)	(13.43)	(12.86)
Innovation activity (y/n)		0.03	0.11											
		(1.69)	(2.16)											
Product innovation (y/n)				0.03	0.07									
				(1.99)	(1.71)									
Process innovation (y/n)				0.02	0.04									
				(1.65)	(0.78)									
R&D Activities (y/n)									0.02	0.11				
									(1.40)	(2.36)				
Patent applications (y/n)											0.04	0.06		
											(2.15)	(1.54)		
Introduction of new products (y/n)													0.05	0.11
													(2.59)	(2.30)

Note: All equations include sector and time dummies. Heteroscedasticity robust t-values are reported in brackets.

There is some indication that process innovation is positively correlated to labour productivity growth when looking at the OLS results. However, the instrumental variables regression suggests that this is due to an endogeneity problem (column (4)). To a somewhat lesser extent, the same conclusion holds for our patent application dummy (column (6)). Hence, we cannot find significant effects for process innovation and the dummy variable for at least one patent application when we correct for potential endogeneity in these variables.

Depending on the market environment, firms pass on cost reductions to output prices. If value added is not (appropriately) deflated, mostly due to lack of price data at the firm level, a problem of identifying productivity effects of process innovations could emerge. This could explain the ambiguous results with respect to process innovation.

Besides product innovations (i.e. products new either to the firm or to market), the variable for R&D activities (column (5)) is significantly positively correlated to productivity growth. Concentrating on those product innovations and products which are new for the worldwide market (column (7)) shows that especially this type of product innovation has a strong and significant impact on subsequent labour productivity growth.

Overall, especially those innovation variables which are related to some form of product innovation are statistically significant. Their coefficients vary between 0.06 (product innovations) and 0.11 (R&D activities; new products). Hence, in the case of R&D activities and new products, a respective shift of a firm from an inactive to an active state leads to an increase of productivity growth by over 10 percentage points.

A comparison of our results for product and process innovations, which are the most frequently used binary innovation indicators, with the results for other countries (available only for a cross-section of firms), shows the following picture: a significant positive effect of process innovations was found only for France (Griffith et al. 2006) and Italy (Parisi et al. 2006); for Finland, Spain, the UK and for Sweden (in one of two studies) no effect could be identified (Griffith et al. 2006; Janz et al. 2003); for Germany and Sweden (in the second study) showed even significant negative effects. Thus, also in accordance with the Swiss panel results, process innovation does not seem to be a driver of productivity growth.

Product innovations were taken into consideration in the studies for France, Germany, Spain, the UK and Italy: significant positive effects were found for France, Spain and the UK but not for the other two countries (Griffith et al. 2006; Parisi et al. 2006). Similarly to Switzerland, also in these three countries product innovation contributes considerably to productivity growth.

### **Concluding remarks**

The results for the productivity equations can be summarized as follows: physical capital (but not human capital) growth and foreign ownership definitely matter for labour productivity growth. Besides evidence that less productive firms catch up to those who are more productive, we also find that innovation activities stimulate labour productivity growth.

With respect to latter, we found significantly positive coefficients for four out of six innovation variables; we could not find a significant effect for process innovation and patent applications. Especially product innovations seem to matter for labour productivity growth.



The magnitude of the impact effect on productivity growth varies between 7% and 10%. This means that dependent on the innovation indicator the shift from a firm without innovation activities to the one with such activities correlates with an increase of productivity growth of 7 to 10 percentage points on average over the next three years. With an average growth rate of 3.8 percent in our sample, this effect can be considered to be quite substantial. This result confirms the widespread view that the performance of the Swiss economy crucially depends on innovation. Innovation activities decreased continuously in manufacturing (for which we have more data) between 1993 and 2002 (see Arvanitis et al. 2007). Taking into consideration that manufacturing has been the most productive part of the economy, it is not astonishing that overall productivity growth has stagnated in this period. The negative development of innovation activities offers a (partial) explanation besides the decrease of capital-labour ratio (see table 5–2) for the low growth of productivity of the Swiss economy in the 1990s.

Future research has to take care of some problems that we could not handle in this study. Price deflators were not available neither at firm level nor at a disaggregated industry level, e.g. 3- or 4-digit industries. Further, the problem of double counting (expenditures on labour and physical capital used in R&D should be removed from the measures of labour and physical capital used in production) has to be encountered, especially when using some measure of R&D capital. Schankerman (1981) clearly demonstrated that the failure to remove this double counting has a downward bias on the estimated R&D coefficients. Finally, a future study has to deal with the fact that innovations are to some extent public goods, thus leading to external effects (spillovers), both positive and negative, which have to be taken explicitly into consideration.

## References

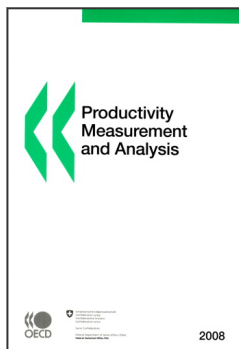
- Arvanitis, S. (2006): Innovation and Labour Productivity in the Swiss Manufacturing Sector: An Analysis Based on Firm Panel Data, *KOF Working Papers No. 149*, October, Zurich.
- Arvanitis, S., Hollenstein, H., Kubli, U., Sydow, N. and M. Wörter (2007): Innovationsaktivitäten in der Schweizer Wirtschaft – Eine Analyse der Ergebnisse der Innovationserhebung 2005, Strukturberichterstattung des Staatssekretariats für Wirtschaft (seco), Bern (in German with an extended French summary).
- Barro, R.J. (1991): Economic growth in a cross section of countries, *Quarterly Journal of Economics*, 106, 407–443.
- Baumol, W.J. (1986): Productivity growth, convergence and welfare: what the long-run data show, *American Economic Review*, 76, 1072–1085.
- Crépon, B., Duguet, E. and J. Mairesse (1998): Research, Innovation and Productivity: An Econometric Analysis
- Duguet, E. (2006): Innovation Height, Spillovers and TFP Growth at the Firm Level: Evidence from French Manufacturing, *Economics of Innovation and New Technology*, 15(4/5), 415–442.
- Federal Department for Economic Affairs (2002): Determinants of Economic Growth in Switzerland and Some Starting Points for a Growth-oriented Economic Policy, Bern (in German and French).
- Griffith, R., Huergo, E., Mairesse, J. and B. Peters (2006): Innovation and Productivity across Four European Countries, *NBER Working Papers Series No. 12722*, Cambridge, Mass.
- Janz, N., Lööf, H. and B. Peters (2003): Firm Level Innovation and Productivity – Is There a Common Story Across Countries? *ZEW Discussion Paper No. 03/26*, Mannheim.
- Lööf, H., Hesmati, A., Asplund, R. and S.-O. Naas (2001): Innovation and Performance in Manufacturing Industries: A Comparison of the Nordic Countries, *SSE/EFI Working Paper Series in Economics and Finance No. 457*, Stockholm.
- Mankiw, N.G., D. Romer and D.N. Weil (1992): A contribution to the empirics of economic growth, *Quarterly Journal of Economics*, 107, 407–437.
- Parisi, M.L., Schiantarelli, F. and A. Sembenelli (2006): Productivity, Innovation and R&D: Micro Evidence for Italy, *European Economic Review*, 50, 2037–2061.
- Romer, P.M. (1986): Increasing Returns and Log-Run Growth, *Journal of Political Economy*, 94, 1002–1037.
- Schankerman, M. (1981): The Effects of Double-Counting and Expensing on the Measured Returns to R&D, *Review of Economics and Statistics*, 63, 454–458.
- Solow, R. (1957): Technical Change and the Aggregate Production Function, *Review of Economics and Statistics*, 39, 312–320.

Swan, T. (1956): Economic growth and capital accumulation, *Economic Record*, 32, 334–361.

Wieser, R. (2005): Research and Development, Productivity and Spillovers: Empirical Evidence at the Firm level, *Journal of Economic Surveys*, 19(4), 587–621.

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