JOURNAL OF COMPARATIVE ECONOMICS **26,** 446–464 (1998)
ARTICLE NO. JE981529

Productive Efficiency during Transition: Evidence from Bulgarian Panel Data[1]

Derek Jones,* Mark Klinedinst,† and Charles Rock‡

**Hamilton College, Clinton, New York 13323; †University of Southern Mississippi, Southern Station Box 5072, Hattiesburg, Mississippi 39406; and ‡Rollins College, Winter Park, Florida 32789*

Received December 26, 1996; revised April 2, 1998

Jones, Derek, Klinedinst, Mark, and Rock, Charles—Productive Efficiency during Transition: Evidence from Bulgarian Panel Data

New and unusually rich panel data for Bulgarian companies during late communism and early transition were used to investigate the determinants of productive efficiency. Compared to conventional production functions, stochastic frontier models were found to be the preferred specifications. Typically, enterprise performance was found to be unaffected by several factors, including the extent of exports, joint venture status, labor management relations and unionization. However, business efficiency was enhanced by incentive compensation arrangements. Compared to fading communism, the determinants of productive efficiency were found not to have changed much during early transition. Average firm efficiency was also investigated and found to be quite low—between 0.603 and 0.720. This dispersion has grown during early transition. *J. Comp. Econom.,* September 1998, **26**(3), pp. 446–464. Hamilton College, Clinton, New York 13323; University of Southern Mississippi, Hattiesburg, Mississippi 39406; Rollins College, Winter Park, Florida 32789. © 1998 Academic Press

Journal of Economic Literature Classification Numbers: P210, P310, J540.

1. INTRODUCTION

While the determinants of productive efficiency have been identified as a key issue concerning "efficiency" for firms in transition economies, the matter is also quite controversial. Differences are reflected in the development of diverse hypotheses concerning the impact of structural and policy variables, including

[1] The authors acknowledge support from NSF 9010591 and the research staff in Bulgaria, headed by Dr. Yuri Arroyo, who played a crucial role in the development of the data used here. Rock's work benefited from an IREX research grant and the paper was completed while Jones was a visiting professor at The London Business School. The authors are grateful to comments from participants at those meetings, especially John Bonin, Alan Gelb, Jeffrey Pliskin, and an anonymous referee.

0147-5967/98 $25.00

Copyright © 1998 by Academic Press
All rights of reproduction in any form reserved.

the extent to which firms are export-oriented, whether firms participate in joint ventures, the impact of different forms of ownership, and whether the effect of these variables might be expected to vary in the change from plan to market (Blanchard *et al.*, 1993; World Bank, 1996). Disagreement also results from the limited nature of the empirical work that has begun to appear on this issue.[2] Frequently this reflects severe data restrictions—for example, small sample sizes (Estrin *et al.*, 1995) or a narrow range of available variables—which precludes researchers from using multivariate methods to test a broad range of hypotheses.

By contrast, in this study, we are fortunate to be able to use new and unusually rich panel data for a large random sample of Bulgarian manufacturing companies. Moreover, data are from both before and after the start of the transition process. In providing some of the first rigorous evidence on the determinants of organizational efficiency, we follow the dominant econometric approach (Prasnikar *et al.*, 1992) and estimate diverse specifications, including conventional production functions. Reflecting the influence of another stream of literature (Brada, 1989), some of the first stochastic frontier estimates for a transition economy are also reported. In fact, in both our panel and our cross-sectional estimates, frontier estimates prove to be the preferred specifications. Our findings provide varying support for influential hypotheses on the determinants of productive efficiency and also point to substantial inertia in these determinants during early transition.

Another issue that has attracted considerable attention is the extent of inter-enterprise variation in technical efficiency during transition. Most previous work in this area has been for command economies and has concluded that variation in technical efficiency is quite limited (Danilin *et al.*, 1985). However, preliminary work for transitional economies suggests that there are great differences across firms in enterprise performance (World Bank, 1996). By using our stochastic frontier estimates, another contribution of this paper is to investigate whether or not differences in firm performance is a key concern when examining efficiency losses during early transition.

2. THEORY, PREVIOUS STUDIES, AND EMPIRICAL STRATEGY

Often the conventional wisdom is clear concerning the effect on firm performance of various structural and policy variables, such as the number of competitors, exports, joint ventures, forms of ownership, and union membership. For example, frequently it is hypothesized that joint ventures may lead to transfers of technology and managerial expertise and that, in turn, this may result in improvements in organizational performance (Goldfeld and Quandt, 1992). Similar

[2] For example, see Pinto *et al.* (1993) for a review. While Prasnikar *et al.* (1992) use a larger data set, they study the special case of the Former Republic of Yugoslavia and use data that are somewhat dated.

arguments have been made concerning the allegedly beneficial effects of exports (Smith and Svejnar, 1984). Since many former centrally planned countries had high levels of industrial concentration, many argue that substantial benefits to business performance will result from exposure to the rigors of a more competitive context (Blanchard *et al.*, 1993). Concerning ownership and institutions that influence the organization of work, most economists are antipathetic toward state forms of ownership and strong trade unions, expecting that these institutional forms will result in profound allocative as well as technical inefficiencies. Also, in firms in which employee influence is strong or employees' compensation is contingent on firm performance, many hypothesize that performance will be lower. Often this reflects an agency or transaction cost approach, with predictions of reduced managerial incentives, higher costs of monitoring and the possibility that decision-making will be inconsistent or poor.[3]

However, on closer inspection, often it turns out that formal theory is less clear-cut and that the expected impact on enterprise performance of many of these structural and policy variables is ambiguous. For example, under planning, long-term relations between firms were the norm and organizational effectiveness was crucially dependent on "network capital" (Ickes and Ryterman, 1995). By eroding such interfirm links, competition may harm firm performance. Also, many have challenged the mainstream view of the necessarily harmful effects of trade unions on organizational performance (Brown and Medoff, 1978). Alternative hypotheses emerge from the literature on the economics of participation. For some, in firms with high levels of employee involvement and/or provision for performance-related compensation, higher morale will translate into greater effort or less workplace conflict and thus result in a positive association between employee involvement and/or financial participation and performance.

Predictions concerning the dispersion of technical efficiency during fading communism and early transition are also ambivalent. In a perfectly planned economy, one might argue that information on best practices would be quickly shared and implemented so that interfirm variation in technical efficiency would be expected to be low. However, the existence of rigidities and pathologies in the operation of actual planning might lead one to predict that, in practice, the dispersion in firm performance would be large. Moreover, during early transition, factors such as the heterogeneity across firms in the quality of input endowments might be anticipated to lead to an increase in variation in interenterprise performance. At the same time, as transition continues, the budget constraints facing firms harden, and the possibility of firm entry and exit increases; therefore it is reasonable to envisage that the dispersion in technical efficiency might fall.[4]

Empirical investigations of the determinants of productive efficiency have

[3] For reviews, see Blinder (1990) and Bonin *et al.* (1993).

[4] While it is beyond the scope of this paper to discuss developments in the Bulgarian economy during the period of this study, see Bristow (1996) and the essays in Jones and Miller (1997).

used two basic approaches, each with its own strengths.[5] The main approach is the estimation of conventional production functions (Balassa, 1985). Letting Q = output, L = labor, and K = capital, the production function can be seen in a general form as

$$Q = f(t, Z)g(L,K), \tag{1}$$

where g is an input function and, following common practice, productive efficiency varies across time and institutional settings and is captured by $f(.)$. When we implement this approach, the main distinguishing features of our study flow from the nature of the available data. Few production function studies have been able to examine as broad a range of structural and policy variables as we are able to examine, nor have they been able to use panel data.

The second approach is the estimation of stochastic frontiers. By assuming a nonnormal asymmetric disturbance, the strength of the stochastic frontier specification is that it allows the error in standard production functions to be partitioned into an inefficiency component and an error which may represent a number of random effects beyond the control of the firm. The proponents of the frontier approach claim that, since frontier estimates are based on the best practice production processes, this is a preferable and theoretically sounder approach.[6] While a few frontier studies have appeared in the comparative economic systems literature (Danilin *et al.*, 1985; Brada, 1989), there do not appear to be any published studies that estimate frontier functions for transition economies in Eastern and Central Europe.[7]

In pursuing this second approach the general stochastic frontier production model estimated is

$$Q_{\mathrm{it}} = (\mathbf{X}_{\mathrm{it}}, \beta)e^{\epsilon_{\mathrm{it}}}, \tag{2}$$

where Q is value-added, and $\mathbf{X}$ is a vector of inputs, β is a vector of parameters to be estimated, and e captures the random disturbance. The random component can be decomposed as

$$\epsilon_{\mathrm{it}} = v_{\mathrm{it}} - u_{\mathrm{it}}. \tag{3}$$

In the above the v_{it} are assumed to be normally and identically distributed (NID) with mean equal to zero and variance equal to σ_v^2. The u_{it}, which are nonnegative random variables, are obtained by truncation of random variables that are NID

[5] Other techniques include case studies and partial productivity indicators. For example, see Jefferson and Xu (1991) for China and, for transitional economies in Eastern Europe, Estrin *et al.* (1995) and the studies reviewed by Carlin *et al.* (1995).

[6] By contrast, production functions estimate *average* practice production function processes. However, critics of frontier techniques argue that such methods are potentially unduly sensitive to outliers.

[7] However, there has been some recent work for China. See Liu and Liu (1996).

$[\mu_{it}, \sigma_u^2]$, and are independent of v_{it}. The mean of the inefficiency effects (μ_{it}) is determined by a number of factors that impact on the firm. Hence,

$$\mu_{it} = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \cdots + \delta_K Z_K. \tag{4}$$

While this decomposition of the error term follows the method developed by Battese and Coelli (1992), in contrast to procedures used to capture efficiency in earlier studies (Brada *et al.*, 1995), this method allows for the simultaneous estimation of the production function in Eq. (2) and the inefficiency function in Eq. (4).[8] Hence, by estimating the production function simultaneously with an inefficiency function, in our frontier estimates we progress beyond other empirical work in this area.[9]

The technical efficiency then of the *i*th firm in the *t*th year can be written as

$$\mathrm{TE}_{it} = \exp(-u_{it}). \tag{5}$$

Thus the technical efficiency for a firm is inversely related to the inefficiency effect measured in Eq. (4) and ranges from zero to one.[10]

In sum, in examining the determinants of productive efficiency, our empirical strategy is to draw on both frontier and conventional production function approaches and to estimate diverse specifications. Model selection tests are used to choose between estimates based on comparable specifications for the two approaches, e.g., for specifications with similar Z vector variables. In particular, the asymmetry of the error term is a key test of this model. This asymmetry can be shown in the parameter $\lambda = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$, with skewness varying directly with λ. On the other hand, if there is no measured inefficiency ($\sigma_u^2 = 0$), then λ is zero. Large values for λ imply that, in analyzing the data, the inefficiency function is an important complement to the production function. In choosing between the production function and frontier estimates, we note that one of the main advantages in using maximum-likelihood estimates of the frontier model is an expected gain in efficiency, since the properties of the error term are at least partially assumed in advance.

In addition, we estimate both models that use the complete panel as well as cross sections for 1989 (fading communism) and 1992 (early transition). In all cases, we estimate with and without industry-specific fixed effects and we also examine if the coefficients on the input variables are industry-specific. In the panel estimates, these procedures will help to capture key features of the time-invariant heterogeneity of firms in different industries. By contrast, in the

[8] This function was estimated using the program *Frontier 4.1* written by Tim Coelli (1994).

[9] In order to gauge the effect of market power on value-added, market share was included in the production function rather than in the inefficiency function. However, this approach means that it is not possible to discern whether a positive relationship would be caused by firms with large market share being capable of increasing their prices or whether this was a sign of past and present superior performance (Ickes and Ryterman, 1992).

[10] The calculation of this conditional expectation can be found in Battese and Coelli (1993).

estimated cross sections, we explore the potentially changing importance of factors influencing productive efficiency during late plan and early market and whether parameters of included variables are unchanging.

While these matters are the chief considerations that frame our empirical approach, a number of other econometric issues also influence our strategy. For both frontier and conventional production function estimates, we do not impose a particular form of technology on the production process but instead estimate several specifications including Cobb–Douglas and translog. Model selection tests are used to choose the specifications which best fit the data and only those results are reported. To test whether different sets of variables within the Z vector—for example, the different forms of enterprise governance and forms of compensation—have a statistically significant effect on performance, F and likelihood ratio tests are used to examine whether their joint exclusion leads to a rejection of the null hypothesis. Finally, we sometimes experiment by using specifications that include different measures of key variables such as the degree of export-orientedness and the extent of employee involvement.

3. THE DATA

An important strength of our study is the use of rich new panel data, details of which are contained in the Appendix. It is important to stress that these data enable us not only to estimate diverse specifications, but also to construct measures of key variables that often are closer to theoretical ideals than those used in previous studies. For example, whereas many studies have been required to use sales as a proxy for enterprise performance, in our case the dependent variable is the theoretically preferable value-added. Importantly, we are also able to measure production-worker-equivalents, i.e., the number of workers corrected for skill and education levels. However, as is the norm in the literature, our measure of capital services is total physical capital.

A variety of institutional and other factors (basic definitions of variables are in Table 1 and are further defined in the Appendix) were included in various specifications. In view of the theoretical attention given to new patterns of control that are believed to be emerging in transition economies, the measures we construct to represent distinct types of labor–management relations may be worthy of special note. Firms are classified as being either managerially controlled (MCF), labor-managed (LMF), or codetermined (COD) or as having a moderate degree of worker influence (WIF). To capture the degree of product market concentration facing enterprises, we constructed alternative measures. Some of these measures used information on the number of competitors that each firm perceived it had, while others used a market share approach. Since experimentation showed that estimates were essentially insensitive to the use of alternative measures, in the reported estimates, we adopt a measure where market share for each firm is expressed as a percentage of total industrial output.

TABLE 1

Definitions of Variables

Variable	Variable description
Q = value-added	Total revenue minus material costs. In thousands of 1989 leva.
L = labor	Number of production-worker equivalents.
K = capital	Total physical assets at the start of the year in thousands of 1989 leva.
State	Dummy for firms controlled by central or municipal government measured by percentage of firms.
Nonstate Firms	Firms that have at least some independence from the state. Total of the following three variables measured by percentage of firms.
State joint stock	Dummy for firms controlled by central or municipal government, but also corporatized measured by percentage of firms.
Independent cooperatives	Dummy for co-ops that were independent from state or central control measured by percentage of firms.
Private firms	Dummy for firms that were sole proprietorships, partnerships or privately owned measured by percentage of firms.
External orientation	Firms that may have either formed a joint venture or export measured by percentage of firms.
Joint ventures	Dummy variable for firms with joint ventures measured by percentage of firms.
Exports	Dummy variable for firms that export measured by percentage of firms.
Market share	The firm's percentage of total industry value added.
Managerially controlled	According to a survey of management, workers had little or no influence on decisions concerning wages, benefits, and employment measured by percentage of firms.
Codetermined and LMF	Codetermined and labor-managed firms. Total of the following two variables measured by percentage of firms.
Codetermined	According to a survey of management, workers and managers jointly decide measured by percentage of firms.
Labor-managed	According to a survey of management, workers primarily decide measured by percentage of firms.
Unionization	Percentage of employees who were union members.
Profit-sharing	Dummy for firms that had plans for nonmanagerial workers to profit share measured by percentage of firms.
Incentive pay	Dummy for firms that had a monetary incentive pay plan for nonmanagerial workers. Strongly resembles gain-sharing plans measured by percentage of firms.

Before turning to our findings, it is instructive to examine the summary statistics (Table 2). These show a dramatic decline in real value-added, capital, and labor from 1989 to 1992.[11] While these declines are somewhat higher than other estimates

[11] The decline in production-worker-equivalents used in Table 2 mirrors the drop in actual average labor used from 1989 to 1992, i.e., 815 to 499.

TABLE 2

Summary Statistics

Variable	Mean	Variable	Mean	Variable	Mean
Value-added		Incentive pay		Independent cooperatives	
Overall	6,263	Overall	27.5%	Overall	5.8%
1989	10,392	1989	38%	1989	4.9%
1991	4,897	1991	28%	1991	6.0%
1992	3,498	1992	17%	1992	6.5%
Capital		Labor-managed		Private firms	
Overall	9,384	Overall	1.2%	Overall	0.4%
1989	18,344	1989	0.4%	1989	0
1991	7,361	1991	1.6%	1991	0.4%
1992	2,447	1992	1.6%	1992	0.8%
Labor		Codetermined		Market share	
Overall	690	Overall	21.6%	Overall	2.3%
1989	884	1989	15.8%	1989	2.6%
1991	645	1991	22.7%	1991	2.3%
1992	541	1992	26.3%	1992	2.0%
Joint ventures		Managerially controlled		Unionization	
Overall	1.9%	Overall	37.5%	Overall	64.8%
1989	0.8%	1989	42.9%	1989	100%
1991	2.8%	1991	35.7%	1991	50.0%
1992	2.0%	1992	34.0%	1992	44.4%
Exports		State		Region	
Overall	45.6%	Overall	89.1%	Sofia	41.5%
1989	41.7%	1989	93.1%	Plovdiv	11%
1991	44.9%	1991	91.6%	Pleven	28.5%
1992	50.2%	1992	82.6%	Pernik	4.1%
Profit-sharing		State joint stock		Bourgas	15%
Overall	3.2%	Overall	4.7%	Industry	
1989	4.9%	1989	2.0%	Food	15.8%
1991	2.0%	1991	2.0%	Textiles	15.4%
1992	2.8%	1992	10.1%	Wood/paper	9.3%
				Engineering	24.3%
				Electronics	11.3%
				Chemicals	8.9%
				Nonmetal	2.8%
				Mining	2.4%
				Other	9.7%

(compare, for example, with Borensztein *et al.*, 1993), recall that some of our measures are preferable to those normally used in other estimates, e.g., production is value-added and labor is quality-adjusted. At the same time, the difficulty of properly pricing outputs and inputs should not be underestimated.

The number of companies that have joint ventures with foreign firms, although averaging only 1.9% over the whole period, more than tripled during the first 3

years of the transition, but actually declined in 1992. Firms that exported went up by about 20% over the 4-year period. The use of profit-sharing declined abruptly in the first 2 years of the transition (by 59%) but rebounded somewhat by 1992. The use of incentive pay continued to decline into 1992. By 1992, in almost 28% of the firms, labor had significant input into decision making (firms were classified as labor-managed or codetermined), representing a 72% increase in a 4-year period. Managerially controlled firms experienced a decline during the same time frame of 21%.

Potentially important changes occurred in the ownership and legal form of many sample firms during 1989–1992. Thus the proportion of firms that were state controlled and owned dropped by 11% over this period. However, at 82.6%, this still represented a large part of industrial production. In addition, while the development of state joint stock (corporatized) companies got off to a slow start, by 1992 the number of such firms had jumped to 10% of the sample. Other changes concern the cooperative form of ownership, which historically has been a strong sector in Bulgaria (Meurs and Rock, 1993). The restitution of cooperative ownership is evident from the 33% increase in cooperatives over the period. Finally, and consistent with our sampling strategy, there were no private firms initially. Moreover, reflecting the slow progress made by privatization in the manufacturing and industrial sectors in Bulgaria, private firms never amount to even 1% (only two firms) of our sample.[12]

The stiffening of the competitive environment is reflected in the steady decline of market share over the period.[13] Trade union density shows a decline of 56% over 4 years. While this would normally reveal a marked weakening of labor unions in a stable Western context, this may not be the case in the context of a transforming system of industrial relations. For example, while in the past membership levels were higher (approaching 100%), this was in the context of a system of single official unions that were dominated by the communist party and where trade unions' functions did not extend to influencing wages (Jones, 1992). However, during early transition, with multiple and often rival unions existing independently of the state, and where collective bargaining was beginning, the effects of an apparent fall in union density for business performance are difficult to predict.

4. RESULTS

Our key findings concerning hypotheses on the determinants of productive efficiency are contained in Table 3. There we report preferred specifications that

[12] Small scale privatization has proceeded much faster (see Jones and Rock, 1994).

[13] Recall that our preferred measure of market share, which averaged about 2% in 1992, is constructed for firm value-added as a ratio of total industry value-added. In other estimates, we use alternative measures including the number of competitors that a firm faced, which increased steadily during the period. Results using all measures of market share are qualitatively similar.

TABLE 3

Stochastic Production Frontier Models: ML Estimates

Production	1989 Translog	1992 Translog	Panel translog	Panel translog
Time dummy coefficients				
1991	—	—	−0.567	−0.569
			(−7.895)	(−8.018)
1992	—	—	−0.771	−0.773
			(−10.839)	(−11.052)
Market share	31.067	35.910	25.684	26.251
	(30.621)	(29.448)	(23.136)	(22.261)
Variance parameters				
$\lambda = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$	0.993	0.999	0.991	0.992
	(154.433)	(7082.498)	(431.535)	(472.474)
Ln(Likelihood)	−89.614	−128.666	−581.774	−580.449
Inefficiency function				
Constant	−2.181	−3.845	−9.400	−9.443
	(−5.211)	(−7.409)	(−6.154)	(−6.003)
Nonstate firms	0.323	−0.427	0.790	
	(0.330)	(−0.703)	(1.510)	
State joint stock				1.777
				(1.918)
Independent cooperatives				−0.160
				(−0.241)
Private				−10.142
				(−5.094)
External orientation	0.192	1.532	0.682	
	(0.559)	(5.475)	(3.276)	
Joint venture				2.562
				(0.025)
Exports				0.447
				(1.760)
Codetermined and LMF	−0.440	0.556	0.264	
	(−0.500)	(1.638)	(0.587)	
Managerial control				−0.598
				(−1.55)
Codetermined				0.157
				(0.357)
Labor-managed				0.359
				(0.365)
Unionization				0.124
				(0.294)
Profit-sharing	−0.087	−4.894	−4.644	−4.527
	(−0.091)	(−5.118)	(−4.792)	(−4.632)
Incentive pay	−0.189	−1.422	−3.354	−3.456
	(−0.399)	(−2.455)	(−5.667)	(−5.528)

TABLE 3—*Continued*

Production	1989 Translog	1992 Translog	Panel translog	Panel translog
Region				
Plovdiv	0.982	0.087	−1.215	−0.976
	(1.185)	(0.133)	(−2.084)	(−1.632)
Pleven	1.037	1.238	1.914	1.952
	(2.621)	(4.030)	(5.099)	(4.662)
Pernik	0.766	−1.361	5.395	5.726
	(0.976)	(−1.492)	(5.443)	(5.203)
Bourgas	0.832	1.315	1.479	1.503
	(1.333)	(3.238)	(3.457)	(2.976)
Time dummy coefficients				
1991	—	—	3.263	3.423
			(7.196)	(6.967)
1992	—	—	0.888	0.858
			(2.883)	(1.988)
Mean efficiency	0.720	0.633	0.625	0.603

Note. Figures in parentheses are asymptotic t ratios. All reported estimates include coefficients on $\ln L$, $\ln K$, $(\ln L)^2$, $(\ln K)^2$, $\ln L \times \ln K$.

emerge after consideration of the econometric tests previously discussed, notably the choice of technology and whether frontier estimates are preferred to conventional production functions. To try to disentangle some of the dramatic changes that led to the implosion of Bulgarian industry, cross-sectional estimates are reported for 1989 (column 1) and 1992 (column 2). Estimates for the entire panel of data are reported in columns 3 and 4, where the models differ in how export-orientedness, worker influence, and ownership are measured.

In all cases, we find that specifications that include industry specific parameters on the input variables are preferred. So far as the form of technology is concerned, generalized likelihood ratio tests led us to select translog over Cobb–Douglas.[14] Also we find that models with fewer components in the inefficiency function, i.e., estimates in the first three columns, are favored over the more general estimates in the fourth column.[15]

[14] For example, the χ^2 result for comparing the Cobb–Douglas to the translog counterpart in column 3 was calculated at 157.096 versus the critical value for the 1% significance level at 27 degrees of freedom of 47.

[15] Concerning the potential problem of endogeneity of inputs, while calculations based on the test statistics developed by Wu (1973) indicated that some simultaneity bias was at times present, we also find that the value of the simultaneous estimates and their significance are similar to the other specifications and typically fall in the middle of alternative estimates. Given the similar estimates and the theoretical expectation of possibly small simultaneity bias (Zellner *et al.*, 1966), the discussion of the results concerning the determinants of productive efficiency will focus on the more parsimonious nonsimultaneous estimates.

In choosing between the production function and frontier estimate approaches, as previously noted, the asymmetry of the error term is a key test of the frontier model. Our estimates indicate that λ is 0.991 (column 3 of Table 3). This implies that the random element of the inefficiency effect contributes significantly in the study of these industrial firms. We will focus on the translog estimates in the third column of Table 3, since the appropriate tests mentioned above suggest their approval compared to other panel estimates.

While for ease of presentation we do not report labor and capital coefficients, usually these are estimated at plausible levels. For example, they show that the elasticities of output with respect to labor and capital are positive.[16] The time dummies in the production function estimates in Table 3 reflect the dramatic decline in value-added over time, which was also cited in Table 2. The biggest drop occurred in the initial transition year of 1991, although the drop continued into 1992. This negative effect over time is also seen in the time dummy estimates that are part of the inefficiency function. It needs to be kept in mind when looking at the coefficient of the explanatory variables in the inefficiency function that a positive coefficient implies an increase in technical inefficiency. These dummies may be capturing some of the other events going on during this dramatic period, such as the collapse of historic markets and fluctuations in government macroeconomic policies.

Turning to evidence for specific hypotheses, the coefficients on market share consistently were found to be positive and very significant. Comparing the magnitude and significance of the coefficients on market share in Table 3, it is clear that market share has a strong impact on value-added, both during the central planning regime and in the initial years of transition. However, it is not possible to discern whether the large positive coefficient on market share that we obtain is due to firms with large market share being capable of increasing their prices or whether this is a sign of past and present superior performance.

The estimated parameters of the inefficiency function show a number of interesting results. Concerning the effect of different forms of ownership and enterprise organization, the effect of private ownership is almost always calculated to be significant and negative (hence, a positive effect on efficiency). By contrast, in these and other unreported estimates, the effect of cooperative ownership (independent cooperatives) is always insignificant. The impact of the process of corporatization in state-owned firms is less clear-cut. In the panel estimates reported in column 4, the coefficient for state joint stock companies is found to be significant. However, in most alternative specifications, i.e., besides those reported in Table 3, the result is not even marginally significant. Hence, on balance, it appears that the transformation of state-owned firms into joint-stock firms did not lead to appreciable effects on enterprise performance. During early

[16] Cobb–Douglas estimates also show decreasing returns to scale. These are not reported here but, as with other unreported regressions, are available from the authors.

transition, this is possibly attributable to a persistent soft budget constraint in state firms that had access to the national treasury and may still have been using markets that originated under central planning (Calvo and Coricelli, 1993). In later years, when state subsidies began to be reduced, this might also reflect the mushrooming of interenterprise debt in firms with strong ties to banks.

The estimated coefficients for firms with some kind of external orientation, either through a joint venture or by exporting, indicate that this results in a considerable negative impact on efficiency in 1992. Tested separately from exports, joint ventures with foreign firms are found to have an insignificant impact on productive efficiency. In accounting for this finding, we conjecture that at least a few of the joint ventures established by sample firms in fact may be little more than a way of siphoning money out of the country into personal bank accounts. If so, this may be the reason why no evidence of a beneficial effect of managerial and technical know-how being transferred is found.

Firms that exported a portion of their sales had an increasingly rough time during this period. Again, this result is not illustrative of the efficiency gains that might be expected as firms restructure to meet world-class competition. Instead, this might reflect the tremendous loss of markets in the East and the boycott on the former Republic of Yugoslavia (Bristow, 1996). It might also possibly indicate an effort to export by firms which have lost their domestic markets (hence, self-selection of the worst firms).

In many cases, F and likelihood ratio tests on the joint exclusion of the proxies for corporate governance and the different forms of compensation lead to rejection of the hypothesis that these variables do not affect productivity. In addition, when one examines the productivity effects of the individual forms of compensation and corporate governance, several interesting patterns emerge. Usually, the different types of performance-related compensation are found to influence significantly business performance. Thus the coefficients on profit-sharing in the inefficiency function are almost always estimated to be negative and significant. As such, this finding of the beneficical effects of profit-sharing resembles that for profit-sharing firms in the West (Kruse, 1993). Also, incentive pay is estimated to have a positive and quite significant effect on enterprise performance. Moreover, the effect is quite sizable and similar to the result for profit-sharing in that it gains strength in the transition period. Again, this finding is comparable to findings from studies of Western firms.[17] Hence, our findings contradict the entirely pessimistic propositions of, for example, Jensen and Meckling (1979) and suggest that some forms of financial participation by employees tend to improve performance.

Turning to the impact of individual forms of corporate governance, in contrast to firms in which employees have moderate influence (the base case), the three types of firm management are found to have no effect on productive efficiency.

[17] For a review of the evidence on gain sharing in the West, see Jones *et al.* (1997).

In other words, productive efficiency was unaffected not only when there was a situation of "worker control," but also when the firm was perceived as being "managerially controlled." Equally, in instances where managers and employees were viewed as "codetermining" policy, no appreciable effect on enterprise performance was detected, other things being equal. Similar findings emerge when different base cases were used. Hence, our findings are at odds with both those who predict the deleterious effects of worker control in transition economies (Boycko *et al.*, 1996) and much other empirical work that often finds employee participation alone enhancing business performance (Doucouliagos, 1995).

In the panel results, we find that union membership typically has an insignificant effect on enterprise performance. Many factors might explain this result, including the awakening of new unions as an independent force from the government, the existence of political battles between rival unions, and the embryonic nature of collective bargaining (Thirkell and Tseneva, 1992).

Usually the coefficients on the regional dummies are positive and significant (the capital city area, Sofia, is the excluded case). Only the region of Plovdiv showed any positive effect (negative coefficient), due possibly to factors such as training (Plovdiv has a major university) and a solid infrastructure. The regional disparities measured could also reflect the lack of mobility during the central planning period (Liu and Liu, 1996).

Concerning the other area of interest, i.e., the dispersion in firm performance, we note that in the panel estimates, average firm efficiency in the half-normal error is estimated at slightly more than 60%. This indicates that there are firms that fall significantly behind their counterparts. The cross-section values provide additional information on this point. These estimates suggest that the dispersion in firm efficiency levels was increasing during early transition. Using firm specific estimates of technical efficiency from column 3 of Table 3, we find a number of interesting results. The good firms (top 25, or about 10% of the sample) shed labor much more quickly over this period than the poor firms (bottom 25).[18] Somewhat surprisingly, even though in 1989 the market share for good firms was higher than for the average firm, by 1992 it was well below the average. Unlike good firms in 1992 (average efficiency of 90%), poor firms (average efficiency of 19%) were much less likely to have incentive pay or high levels of unionism and, perhaps unsurprisingly, profit-sharing. Also, poor firms were less likely to be either active exporters or an independent cooperative.

These estimates of inefficiency are typically higher than those observed in previous studies (Danilin *et al.*, 1985).[19] Several factors may help to account for

[18] This finding is similar to that in Jones and Nikolov (1997).

[19] However, by using data for a large sample of Czechoslovakian and Hungarian firms, Brada *et al.* (1995) are able to estimate frontiers. They also find evidence of substantial dispersion in technical efficiency.

this apparent discrepancy. One consideration is probably that best-practice firms now have a much higher comparison benchmark, i.e., world standard production methods. Additional reasons include a rapidly changing macroeconomic environment during the period under study, widely varying degrees of institutional rigidities, and variation in the ability to quickly adapt to the new circumstances. Moreover, our sample is more representative than samples that were available during the planning era and these data are apt to be more reliable than the possibly politically biased figures used in the past. In addition, reassuringly, the findings from the first studies for firms in transitional economies are comparable to our findings for Bulgarian firms. For example, Pinto *et al.* (1993) find that there are good and bad Polish firms in all sectors. However, whereas other studies for transition economies typically use small samples and do not employ multivariate analysis, our findings are derived from data for a large sample of firms that is representative of all Bulgarian industrial firms.

5. CONCLUSIONS AND IMPLICATIONS

An unusually rich and large panel data set gathered from Bulgarian industrial companies was used to provide one of the first econometric studies of various dimensions of efficiency during the fading years of a command economy and the early transition. By estimating diverse specifications for both production function and stochastic frontier models, we compare findings that emerge from these two distinct approaches. In the main our preferred specifications are frontier models.

In examining the determinants of productive efficiency during this early stage, we typically find that: (i) several factors stressed in the literature, including the extent of exports, joint venture status, labor management relations, and unionization, had *no* effect on enterprise performance; (ii) having an external orientation in the early years of transition had a *negative* effect on efficiency; (iii) enterprise performance is *enhanced* by private ownership, a larger market share, and compensation systems that provide for profit-sharing and incentive systems. In addition, we find that the average firm efficiency is fairly low—between 0.603 and 0.720.

Our findings have a number of implications. The frontier function estimates indicate that some policies advocated during early transition have been accompanied by efficiency gains for Bulgarian firms. This is most clearly the case for compensation policies where our findings point to the benefits of adopting policies that provide for more flexible forms of compensation. Equally, our findings suggest that other policies traditionally advocated during early transition have been accompanied by losses by Bulgarian firms. This is most clear for firms that operate in more competitive markets. While elsewhere there is some evidence that increased competition forced some firms to become more efficient (World Bank, 1996), in the Bulgarian context, the rapid spread of competition has arguably been accompanied by enormous loss of network (organizational) capital. The finding of large variation in

technical efficiency suggests considerable dispersion in the ways in which Bulgarian firms were responding to the profound changes that accompanied early transition. In turn, this implies that, even absent mass privatization, some firms and managers were able to undertake restructuring activities and that interenterprise efficiency variation is an important area to investigate when examining the sources of efficiency loss during transition.

APPENDIX: DESCRIPTION OF THE DATA AND VARIABLES

This study uses data from the Bulgarian Labor Flexibility Survey (BLFS), the Bulgarian Management Survey (BMS), and the Bulgarian Economic Survey (BES). The BLFS survey was organized to assess microeconomic changes in labor practices in Bulgarian industry and was carried out by the ILO in cooperation with the National Institute of Statistics and the Institute for Social and Trade Union Research in Sofia. The survey involved 490 establishments that were randomly selected to ensure a sample that was nationally and sectorally representative. The other surveys follow these same 490 firms. Thus the BMS was an interview questionnaire collected from managers in mid-1992, while the BES gathered written surveys from economists in the same firms.

These 490 state and cooperative industrial establishments employed more than 230,000 employees in 1992, which constitutes more than 20% of the total annual workforce in all of Bulgarian industry in 1992. Data used in the study came from the last year before the fall of the Zhivkov regime, 1989, and 2 years into the reform process, 1991 and 1992. Merging these three data sets and incomplete questionnaires left 247 firms with comprehensive data for the 3 years under consideration for this paper.[20]

The key variables used in the study are defined as follows:

Q = value-added = total labor costs + total capital costs + surplus = revenue − material costs. This variable, measured in thousands of 1989 leva (in 1989 \$1 ≅ 7 leva), was deflated using inflation figures from the European Bank for Reconstruction and Development (1994).

K = capital = total physical assets at the start of the year. This variable was measured in thousands of 1989 leva.

L = number of production-worker-equivalents = skill corrected labor =

$$L_j = \sum_{i=1}^{5} (I_{ij}/I_{1j})\, L_{ij},$$

[20] We have no reason to believe that there are any systematic differences in the firms that were excluded from the original sample and those that remain. Indeed, when it was possible to conduct a t test on the means for key variables, such as labor force and sales for firms in the original sample of 490 firms and for the sample of 247 that was used in the study, there were typically no significant differences. These results are available from the authors upon request.

where

L_j = the number of production-worker-equivalents in firm j.
I_{ij} = the average income of skill i in firm j.
I_{1j} = the average income of skill one in firm j.
L_{ij} = the number of workers in the ith skill group, of five groups, in firm j.

Labor–management relations: MCF, LMF, COD, WIF

To gather data to use in constructing measures of labor–management relations, managers were asked to assess their influence versus that of workers on several issues. Influence was ranked on a scale from 1 to 6, with 1 being the case where management alone decides and six where workers alone decide. Managerially controlled firms (MCF) were defined as those with a 1 and, in a like manner, labor-managed firms (LMF) registered a 6. Firms where both labor and management shared decision making, measured by a 5 on this scale, were listed here as codetermined (COD).[21]

Market share equals a firm's percentage of total industry value-added. Typically many studies use the top four-firm sales as a percentage of industry sales to measure monopoly power in that industry. Since we use a firm specific measure of sales (firm sales as a percentage of industry), our numbers are much smaller. For example, in the United States, while there are 130 firms that sell light bulbs of one sort or another, the top four (GE, Sylvania, etc.) probably have at least 60% of the market. However, an individual firm's percentage of the market here would still average about 0.5–3 percent, as is the case in Table 2. Since all 130 firms have a combined market share of 100 and there are so many firms, the average market share is quite small. Comparing our data to the US Department of Commerce 1992 data shows that industries are, on average, about three times more concentrated in Bulgaria than in the United States.

REFERENCES

Balassa, Bela, "Exports, Policy Choices, and Economic Growth in Developing Countries after the 1973 Oil Shock." *J. Develop. Econom.* **18,** 1:23–35, May–June 1985.

Battese, George, and Coelli, Tim, "Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India." *J. Productivity Anal.* **3,** 1–2:153–169, June 1992.

Battese, George, and Coelli, Tim, "A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects." *Working Papers in Econometrics and Applied Statistics,* No. 69. Department of Econometrics, University of New England, Armidale, Australia, 1994.

Blanchard, Olivier, Dornbusch, Rudiger, and Krugman, Paul, *Reform in Eastern Europe.* Cambridge, MA: MIT, 1993.

[21] More detail on the construction of these measures is provided in Jones (1995). In that paper it is shown how these measures of management control provided by managers were not dramatically different from those provided by employees.

Blinder, Alan (ed.), *Paying for Productivity: A Look at the Evidence.* Washington, DC: Brookings Institution, 1990.

Bonin, John, Jones, Derek, and Putterman, Louis, "Theoretical and Empirical Studies of Producer Cooperatives." *J. Econom. Lit.* **31,** 3:1290–1320, Sept. 1993.

Borensztein, Eduardo, Demekas, Dimitri G., and Ostry, Jonathan D., "An Empirical Analysis of the Output Declines in Three Eastern European Countries." *Internat. Monetary Fund Staff Papers* **40,** 1:1–31, Mar. 1993.

Boycko, Maxim, Schleifer, Andrei, and Vishny, Robert W., "A Theory of Privatisation." *Econom. J.* **106,** 435:309–319, Mar. 1996.

Brada, Josef C., "Technological Progress and Factor Utilization in Eastern European Economic Growth." *Economica* **56,** 224:433–448, Nov. 1989.

Brada, Josef C., King, A. E., and Ma, Chia Ying, "Industrial Economics of the Transition: Determinants of Enterprise Efficiency in Czechoslovakia and Hungary." *Oxford Econom. Papers* **49,** 1:104–127, Jan. 1997.

Bristow, John A., *The Bulgarian Economy in Transition.* Brookfield, VT: Edward Elgar, 1996.

Brown, Charles, and James Medoff, "Trade Unions in the Production Process." *J. Polit. Economy* **86,** 3:355–378, June 1978.

Calvo, Guillermo, and Coricelli, Fabrizio, "Output Collapse in Eastern Europe: The Role of Credit." *Internat. Monetary Fund Staff Papers* **40,** 1:33–52, Mar. 1993.

Carlin, Wendy, Van Reenen, John, and Wolfe, Toby, "Enterprise Restructuring in Early Transition: The Case Study Evidence from Central and Eastern Europe." *Econom. Transition* **3,** 4:427–458, Dec. 1995.

Coelli, Tim, *A Guide to Frontier Version 4.1: A Computer Program for Stochastic Frontier Production Function and Cost Function Estimation.* Department of Econometrics, University of New England, Armidale, Australia, Oct. 1994.

Danilin, V. I., Materov, Ivan S., Rosefielde Steven, and Lovell, Knox, "Measuring Enterprise Efficiency in the Soviet Union: A Stochastic Frontier Analysis." *Economica* **52,** 26:225–233, May 1985.

Doucouliagos, Chris, "Worker Participation and Productivity in Labor-Managed and Particpatory Capitalist Firms: A Meta-analysis." *Indust. Labor Relations Rev.* **49,** 1:58–77, Oct. 1995.

Estrin, Saul, Gelb, Alan and Singh, Inderjit, "Shocks and Adjustment by Firms in Transition: A Comparative Study." *J. Comp. Econom.* **21,** 2:131–153, Oct. 1995.

European Bank for Reconstruction and Development, Transition Report for 1994. London: EBRD, 1994

Goldfeld, Stephen M., and Quandt, Richard E., "Effects of Bailouts, Taxes and Risk-Aversion on the Enterprise." *J. Comp. Econom.* **16,** 1:150–167, Mar. 1992.

Ickes, Barry, and Ryterman, Randi, *Entry without Exit: Economic Selection Under Socialism.* University Park, PA: Dept. of Economics, Pennsylvania State University, 1993.

Ickes, Barry, and Tenev, Stoyan, "On Your Marx, Get Set Go: The Role of Competition in Enterprise Adjustment." *Working Paper Series,* The Pennsylvania State University, Working Paper 11-95-9, November 1995.

Jefferson, Gary, and Xu, Wenyi, "The Impact of Reform on Socialist Enterprises in Transition: Structure, Conduct and Performance in Chinese Industry." *J. Comp. Econom.* **15,** 1:45–64, Mar. 1991.

Jensen, Michael C., and Meckling, William H., "Rights and Production Functions: An Application to Labor-Managed Firms and Codetermination." *J. Bus.* **52,** 4:469–506, Oct. 1979.

Jones, Derek C., "The Transformation of Labor Unions in Eastern Europe: The Case of Bulgaria." *Indust. Labor Relations Rev.* **45,** 3:452–470, Apr. 1992.

Jones, Derek C., and Kato, Takao, and Pliskin, Jeffrey, "Profit Sharing and Gainsharing: A Review of Theory, Incidence and Effects." In David Lewin, Daniel J. B. Mitchell, and Mahmood A.

Zaidi, eds., *The Human Resource Management Handbook*, pp. 153–174. Greenwich, CT: JAI Press, 1997.

Jones, Derek C., and Miller, Jeffrey, *The Bulgarian Economy: Lessons from Reform during Early Transition.* Brookfield, VT: Ashgate, 1997.

Jones, Derek C., and Nikolov, Stoyko, "Enterprise Adjustment During Early Transition." In Derek Jones and Jeffrey Miller, Eds., *The Bulgarian Economy: Lessons from Reform during Early Transition*, pp. 249–271. Brookfield, VT: Ashgate, 1997.

Jones, Derek C., and Rock, Charles, "Privatization in Bulgaria." In Saul Estrin, Ed., *Privatization in Central and Eastern Europe.* Harlow: Longman, 1994.

Kruse, Douglas, *Profit Sharing: Does it Make a Difference?* Kalamazoo, MI: Upjohn Institute for Employment Research, 1993.

Liu, Zinan, and Liu, Guy Shaoijia, "The Efficiency Impact of the Chinese Industrial Reforms in the 1980s." *J. Comp. Econom.* **23,** 3:237–255, Dec. 1996.

Meurs, Mieke, and Rock, Charles, "Recent Evolution of Bulgarian Cooperatives." In Yearbook of Cooperation 1993. London: Plunkett Foundation, 1993.

Pinto, Brian, Beleva, Marek, and Krajewski, Stefan, "Transforming State Enterprises in Poland." *Brookings Papers Econom. Activity* **0,** 1:213–260, 1993.

Prasnikar, Janez, Svejnar, Jan, and Klinedinst, Mark, "Structural Adjustment Policies and Productive Efficiency of Socialist Enterprises." *European Econom. Rev.* **36,** 1:179–199, Jan. 1992.

Smith, Stephen C., and Svejnar, Jan, "The Economics of Joint Ventures in Less Developed Countries." *Quart. J. Econom.* **99,** 1:149–167, Feb. 1984.

Svejnar, Jan, "Enterprises and Workers in the Transition: Econometric Evidence." *Amer. Econom. Rev.* **86,** 2:123–127, May 1996.

Thirkell, J. E. M., and Tseneva, Elena A., "Bulgarian Labour Relations in Transition: Tripartism and Collective Bargaining," *Internat. Labour Rev.* **131,** 3:355–366, 1992.

World Bank, *World Development Report 1996: From Plan to Market.* Oxford, UK: Oxford Univ. Press for the World Bank, 1996.

Wu, De-Min, "Alternative Tests of Independence Between Stochastic Regressors and Disturbances." *Econometrica* **41,** 4:733–750, July 1973.

Zellner, Arnold, Kmenta, Jan, and Drèze, Jacques, "Specification and Estimation of Cobb–Douglas Production Function Models." *Econometrica* **34,** 4:784–795, Oct. 1966.