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efficiency?**

A cross-country comparison

by

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Does the shadow economy raise observed aggregate efficiency? A cross-country comparison

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Abstract: We analyze how adding the shadow economy to official output figures affects technical efficiency. We find that this only slightly affects the ranking of efficiency scores, but increases average efficiency. Our results are robust to the functional form of the production technology and the adjustment of labor to account for years of schooling.

Keywords: shadow economy, income, aggregate productivity, efficiency.

JEL Classification: O11, O17, O47, O5.

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1. Introduction

Most studies of economic development rest on official output figures. However, in so doing they neglect a sizeable part of economic activity, which takes place in the informal sector and therefore goes unrecorded in official statistics. According to Schneider (2005), the “shadow economy”, defined as currently unregistered economic activities that contribute to the officially calculated (or observed) Gross National Product, amounted to 16 percent of official output in OECD countries, 39 percent in developing countries, and up to 40 percent in transition countries, in 2002/2003 (Schneider, 2005 p.599). Those daunting figures call into question the results of every empirical study ignoring this phenomenon. In particular, assessments of productivity at the aggregate country level, like e.g. Caselli (2005) or Kneller and Stevens (2003), are likely to be flawed when ignoring the shadow economy. This is particularly important for efficiency frontier methods such as stochastic frontier analysis (SFA), which estimates the world’s production frontier and assesses countries’ aggregate efficiency relative to that frontier (see e.g. Adkins et al., 2002, or Kneller and Stevens, 2003). Ignoring a substantial share of output is likely to result in biased estimates of the production frontier and a mis-measurement of inefficiencies. Most likely, efficiency is underestimated in countries with big shadow economies. The extent of the bias, however, is an empirical matter.

In what follows, we therefore check the robustness of the SFA to the inclusion of the shadow economy in official output figures. We follow Kneller and Stevens (2003) and estimate the world production frontier based on official output figures first. We then add the shadow output to gauge the bias of existing studies.

2. Empirical model and results

In order to estimate the production frontier, we need to specify its functional form. For sake of brevity, we only consider the most common production functions analyzed in the literature, the Cobb-Douglas and the translog functions. Those specifications respectively read:

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(K_i) + \beta_2 \ln(L_i) + u_i + v_i \quad (1)$$

$$\ln(Y_i) = \beta_0 + \beta_1 \ln(K_i) + \beta_2 \ln(L_i) + \beta_3 \ln(K_i)^2 + \beta_4 \ln(L_i)^2 + \beta_5 \ln(K_i) \ln(L_i) + u_i + v_i \quad (2)$$

where Y_i measures country i 's output, K_i its capital stock, and L_i its labor force. u_i is white noise accounting for measurement errors or unpredictable events that make the frontier random. v_i is the efficiency term.

As test for robustness, we use two different measures of the labor force. First, we define L_i as the absolute number of workers. Second, following Kneller and Stevens (2003) and Caselli (2005), we replace it by a measure of human capital-adjusted labor supply $L_i^* = H_i L_i$, where H_i is the mean years of schooling of the labor force.

Table 1: description of untransformed variables

Variable	Definition	Mean	S.D.
Y	Official output (billions of US\$)	331.93	939.63
K	Capital stock (billions of US\$)	721.77	2136.38
L	Number of workers (millions)	23349428.26	13.73
H	Average years of schooling	5.74	2.96
S	Shadow economy (percentage of Y)	33.65	8.60

We use Caselli's (2005) database, which provides the most comprehensive and up to date figures for aggregate capital stocks. Those figures are computed from the Penn World Tables mark 6.1, and are available for 1996.

Data for the shadow economy are taken from Schneider (2006). He calculates the size and development of the shadow economy of 145 countries, including developing, transition, and highly developed OECD countries over the period 1999 to 2003 employing the dymimic and currency demand estimation technique. In our sample, the average size of the shadow economy is 34 percent. Merging our data leaves us with 87 observations when human capital is taken into account and 97 otherwise. The sample includes both developed and developing countries. Summary statistics are presented in table 1 below.

Table 2: Stochastic frontier results

	Cobb-Douglas				Translog			
	Model 1		Model 2		Model 3		Model 4	
	official output (1a)	corrected output (1b)	official output (2a)	corrected output (2b)	official output (3a)	corrected output (3b)	official output (4a)	corrected output (4b)
β_0	2.874 (6.93)	3.702 (8.72)	4.306 (8.88)	5.084 (10.70)	2.266 (0.54)	0.322 (0.08)	6.112 (1.44)	5.398 (1.20)
β_1	0.694 (34.44)	0.657 (32.82)	0.544 (13.52)	0.516 (13.81)	0.511 (1.55)	0.720 (2.16)	0.161 (0.37)	0.286 (0.62)
β_2	0.299 (10.24)	0.323 (11.13)	0.416 (8.52)	0.427 (8.95)	0.664 (1.94)	0.645 (1.88)	0.769 (1.73)	0.727 (1.53)
β_3					0.012 (1.06)	-0.002 (0.18)	0.001 (0.05)	-0.016 (0.67)
β_4					0.008 (0.40)	-0.012 (0.56)	-0.024 (0.64)	-0.051 (1.28)
β_5					-0.025 (0.95)	0.002 (0.09)	0.019 (0.36)	0.058 (1.03)
σ	0.132 (3.42)	0.119 (3.05)	0.195 (3.46)	0.172 (3.23)	0.132 (3.53)	0.118 (3.10)	0.194 (3.54)	0.169 (3.20)
γ	0.622 (2.86)	0.536 (1.88)	0.833 (6.11)	0.711 (3.57)	0.640 (3.15)	0.543 (1.95)	0.838 (6.46)	0.711 (3.56)
<i>log-likelihood</i>	-14.39	-13.78	-17.47	-19.86	-13.55	-13.16	-16.89	-18.93
<i>N</i>	97	97	87	87	97	97	87	87

Absolute *t*-statistics in parentheses. The sigma statistics is defined as $\sigma = (\sigma_u^2 + \sigma_v^2)^{1/2}$. The gamma statistics is defined as $\gamma = \sigma_v^2 / (\sigma_u^2 + \sigma_v^2)$. Coefficients significant at least at the ten percent level are in bold.

To assess the impact of the shadow economy on measured aggregate efficiency, we estimate each model twice: once with raw output figures, once with output figures corrected for the shadow economy (that is, the sum of official and shadow output such that $Y_i^* = (I+S_i)Y_i$, where S_i is the ratio of unofficial to official output). Estimations 1a, 2a, 3a, 4a use official output and estimations 1b, 2b, 3b, 4b add the shadow economy to these output figures. The first four estimations refer to the Cobb-Douglas specification, while the last four refer to the translog function. Finally, models 1 and 3 use raw labor figures, while models 2 and 4 use human capital-adjusted labor supply. We thus end up estimating eight specifications whose results are displayed in table 2.

Not surprisingly, adding the shadow economy to official output produces different results across the two specifications of the production function. With the Cobb-Douglas specification, adding the shadow results in an increase of the production frontier's intercept. As corrected output is greater than official output by construction, the production frontier shifts upwards. However, the other coefficients remain similar in magnitude. Note that the goodness of fit of the production frontier marginally improves with the inclusion of the

shadow economy (as the increase of the log-likelihood ratio suggests). This remains true when human capital-corrected labor supply is used instead of the raw data.

The table also shows that – contrary to the results of Kneller and Stevens (2003) – the translog specification does not outperform the Cobb-Douglas in our sample. Moreover, the results obtained with the translog specification are less consistent. Namely, only the coefficient on labor is consistently significant, whereas other coefficients are insignificant, with the exception of the coefficient on physical capital in model 3, which turns significant when the shadow economy is added to official output. In addition, model 4 is the only specification whose goodness of fit deteriorates when the shadow economy is taken into account.

What is more interesting though is the evolution of inefficiency scores when output is corrected for the shadow economy. Their summary statistics are displayed in table 3. It appears that correcting output figures for the shadow economy results in an increase of the average and median efficiency scores. Thus, average and median distance to the frontier diminishes. The decrease in the gamma statistics displayed in table 2, indicating a decreasing share of inefficiency in the estimations’ total residuals, points to the same conclusion.

Table 3: Descriptive statistics and correlation of efficiency scores with uncorrected efficiency scores

	Cobb-Douglas				Translog			
	Model 1		Model 2		Model 3		Model 4	
	official output (1a)	corrected output (1b)	official output (2a)	corrected output (2b)	official output (3a)	corrected output (3b)	official output (4a)	corrected output (4b)
Min.	0.444	0.539	0.355	0.41	0.431	0.527	0.351	0.407
Max.	0.934	0.937	0.933	0.927	0.934	0.937	0.936	0.93
Mean	0.808	0.828	0.748	0.774	0.806	0.827	0.748	0.776
Median	0.826	0.835	0.787	0.800	0.822	0.836	0.786	0.797
Std. dev.	0.0802	0.0655	0.131	0.103	0.0828	0.0663	0.132	0.102
Pearson	1	0.964	1	0.959	1	0.974	1	0.965
Spearman	1	0.945	1	0.958	1	0.955	1	0.963

All correlations are significant at the one percent level.

This result is not trivial since the efficiency frontier shifts upwards with the inclusion of the shadow economy. As efficiency is a relative measure, one could as well have witnessed a decrease in efficiency. The observed evolution of efficiency scores therefore implies that the

distribution of output figures changes due to the inclusion of the shadow economy. More precisely, countries that were initially farther from the frontier benefited relatively more from the addition of unofficial production than the rest of the sample. Accordingly, minimum efficiency scores increase more than maximum scores, and the standard deviation of efficiency scores decreases. Thus, neglecting the size of the shadow economy results in overestimating inefficiencies in less efficient countries, and, in terms of traditional development accounting, this amounts to overestimating the residual. This is in line with our a priori expectation.

However, the last two lines of table 3 also show that the ranking of countries in terms of efficiency is rarely affected when average efficiency rises. To be more specific, the coefficient of correlation between efficiency scores computed with or without the shadow economy is always greater than 95 percent and is significant at the one-percent level. Similarly, the Spearman rank correlation coefficient (measuring the similarity in country rankings) exceeds 94 percent in all specifications and is also significant at the one percent level. One can therefore conclude that the ranking of countries in terms of efficiency does not dramatically depend on the inclusion of the shadow economy in output figures.

3. Conclusion

We analyzed the impact of adding the shadow economy to official output figures on technical efficiency across up to 97 countries. Including the shadow economy hardly affects the ranking of countries in terms of efficiency. However, it results in a reduction of observed efficiency scores, and thus decreases the residual. Adding the shadow economy to official output figures thus allows a more precise estimate of countries' outputs. Our results are important in several respects. First, they show that ignoring the shadow economy results in biased estimates of the production function. Second, they therefore imply that ignoring the shadow economy leads to mistakes in measured efficiency. Finally, our results provide guidance to the empirical literature on economic output and productivity at large. Given that official output figures as measure of total output are flawed, future research on the determinants and effects of a country's production may clearly benefit from taking a broader view and including the shadow economy in its analysis.

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