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The efficiency of postal services in the age of market liberalization and the internet: Evidence from Central and Eastern Europe

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ABSTRACT

The rise in electronic communications and the recent liberalization of the postal market in the European Union have put national postal-service providers in Central and Eastern Europe (CEE) under pressure to restructure and optimize their operations. The paper employs non-parametric methods to measure the relative technical and cost efficiency of CEE postal operators in terms of quantity-based and quality-based output indicators. The results indicate that inefficiency varies between 20% and 30%. Regression analysis attributes efficiency gains to increased competition, institutional reforms, less burdensome customs procedures, and population density, while use of electronic mail was negatively related to postal-service efficiency.

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1. Introduction

Rapid expansion of electronic communications over the past two decades has caused a dramatic decline in the demand for postal services, and letter mail in particular. Faced with dwindling mail volume and mounting financial losses, postal operators have attempted to improve efficiency by cutting costs, whereby post offices have been closed and mail boxes dismantled, mail delivery has been cut back, and the workforce has been reduced. But these cost-saving measures have been constrained, as most national postal-service providers are state-owned or government-controlled entities that operate under the universal service obligation, which stipulates national coverage at affordable rates. Furthermore, the monopolistic protection enjoyed by most postal operators in their function as universal-service providers has been gradually eroded as governments have liberalized postal and telecommunication markets. As a result, national postal operators have encountered competition in the most profitable service segments, such as parcel delivery and express mail, while letter mail has mostly remained part of the reserved area of the universal-service provider. Lastly, the additional drop in mail volume and revenues due to the recent global economic and financial crisis has further increased the pressure on postal operators to improve their efficiency.

This paper focuses on the performance and efficiency of postal operators in Central and Eastern Europe (CEE), a region that has been marked by the transition from a centrally-administered to a market-based economic system. Unlike most other state monopolies in the industrial and service sectors that were broken up and privatized in the 1990s, national postal operators in CEE have remained in state ownership and retained their monopolistic position. The lack of restructuring and competition combined with an inadequate legal framework and weak regulatory oversight have prevented postal operators from overcoming their reputation as providers of an inefficient and unreliable mail service.

The accession of 10 CEE countries to the European Union (EU) in 2004 and 2007 instigated major changes as the new member states had to comply with the directives governing the EU postal market. These directives were aimed at improving the efficiency and service quality of deficit-running national postal operators through gradual market liberalization. The first postal directive in 1997 defined maximum weight and price thresholds for letter services reserved for the universal-service provider, while the second directive in 2002 reduced these thresholds, further limiting the scope of the postal monopoly (ITA-Consulting and WIK-Consult, 2009). The third directive in 2008 mandated that the reserved area should be abolished and all postal markets fully opened to competition by December 2010. Although a few CEE countries acted ahead of schedule (including Estonia which liberalized its postal sector in

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2009), most other EU member states in CEE chose to delay the implementation of the directive until the end of 2012. This provides the ideal opportunity to investigate the efficiency of postal operators in CEE as they are now exposed to competition from private firms in all segments of their operations.

The goals of the paper are twofold. First, the performance of 17 postal operators in CEE is evaluated over the period 1994–2009. In particular, technical and cost efficiency are measured with regard to various combinations of quantitative and qualitative outputs of postal operations. For this purpose, non-parametric methodology is employed to assess the extent by which CEE postal operators minimize labor and capital costs in the process of collecting and delivering letter mail, parcels, and financial services. The efficiency of each operator in terms of mail volume as well as the speed and reliance of delivery is ranked relative to the best performers in CEE. Second, the paper identifies the determinants of relative efficiency using second-stage regression analysis. The effects of the rise in electronic communication and institutional factors as well financial indicators and the extent of competition are taken into account.

The existing literature has focused largely on the efficiency of postal offices within a single country. Previous studies have examined the performance of postal offices in the United States (Christensen et al., 1993; Grifell-Tatje and Lovell, 2008; Register, 1988), Canada (Clark and Bickerton, 2002), UK (Cazals et al., 2008; Doble, 1995), Japan (Mizutani and Uranishi, 2003), and Switzerland (Filippini and Zola, 2005). Only two papers have compared postal efficiency across a sample of countries. Perelman and Pestieau (1994) estimated the technical efficiency of national postal operators in Western Europe, Japan, and Australia over the period 1975–1989. Iturralde and Quiros (2008) measured technical efficiency and productivity change for 17 postal operators in the EU over the years 1999–2003. Their sample included four CEE postal operators, which were found to be among the most efficient performers. A more recent study examined the effects of privatization on the universal service obligation of postal operators in 21 OECD countries over the period 1980–2007 and reported an overall decrease in service quality (Schuster, 2013).

In contrast to previous papers that have focused exclusively on developed countries, the present study examines postal services in transition economies, where state-owned enterprises tend to be highly inefficient and postal reforms have been initiated only after accession to the EU. In particular, the sample includes advanced CEE countries that have joined the EU as well as countries from the former Soviet Union and the Western Balkans, where the market transition has been more sluggish. Another advantage of this paper is using input prices to calculate cost efficiency, which provides a more suitable measure of overall performance. With few exceptions (e.g., Filippini and Zola, 2005), existing works are limited to the estimation of technical efficiency, which disregards prices and costs. Furthermore, the literature has focused exclusively on the quantitative aspects of postal efficiency, whereas this paper incorporates quality indicators, such as speed and reliability of mail delivery, in the model.[1] Lastly, the present analysis goes a step further than previous studies to identify the factors responsible for cross-country disparities in postal efficiency.[2]

The rest of the paper is organized as follows. The next section describes the methodology and the data. Section 3 presents the results of the analysis and Section 4 concludes.

2. Methodology and data

2.1. Efficiency measurement

According to Farrell's (1957) seminal work, firms can achieve technical efficiency by minimizing the quantities of inputs used in producing a given level of output.[3] Furthermore, firms could achieve cost efficiency if they found a combination of inputs and corresponding input prices that would minimize overall cost. Cost efficiency is thus a more comprehensive measure than technical efficiency. In practice, the efficiency of a firm is evaluated relative to a reference point on a benchmark production frontier. The efficiency measure is a radial measure of the distance between the firm and the best-practice frontier calculated as the ratio of actual to potential firm performance. Accordingly, a firm is considered efficient if its performance corresponds to a point on the best-practice frontier. In this case actual and potential performances are identical resulting in an efficiency score of 1. In contrast, a score of less than 1 is associated with inefficient firms located below the frontier due to poor performance relative to potential.

The radial measure of efficiency relies on the existence of a benchmark production frontier, which is not observed in practice. Two main approaches have been developed in the literature to deal with this issue. Parametric methods, such as the Stochastic Frontier Approach (SFA), use econometric techniques to estimate a frontier and decompose the stochastic term of the regression model into an inefficiency component and a random error. Non-parametric methods, such as Data Envelopment Analysis (DEA), use mathematical programming to construct a piecewise linear production frontier that envelopes the observed data points and treats all deviations from the frontier as inefficiency. In the literature on postal efficiency, Filippini and Zola (2005), Perelman and Pestieau (1994), and Quiros (2011) have used SFA, whereas Doble (1995), Cazals et al. (2008), and Iturralde and Quiros (2008) have opted for DEA.

The present study adopted the DEA methodology to estimate the efficiency of postal operators in CEE because the non-parametric approach allows the data to determine the form of the frontier without imposing any restriction that might misspecify the production technology. Although SFA has the advantage of taking into account random error, it requires *a priori* specification of the functional form of the frontier and makes assumptions about the distributional properties of the components of the stochastic term which are often violated (Greene, 1999). The major drawback of the DEA approach is the sensitivity of efficiency measures to outliers and sampling variation. For this reason, this paper uses the bootstrapping method by Simar and Wilson (1998) to test the robustness of our DEA estimates. The bootstrapping produces bias estimates, which are then used to correct for the bias of the original DEA estimates.[4]

The technical efficiency of postal operators is estimated by solving the following input-oriented linear programming model developed by Banker et al. (1984):

[1] A notable exception is Doble (1995), who included the average waiting time of customers at UK post offices as an output measuring the quality of service. Moreover, Schuster (2013) measures quality in terms of post office and letter box density.

[2] Copenhagen-Economics (2010) and ECORYS (2008) used regression analysis to explore the determinants of postal employment and mail volumes, respectively, but not postal efficiency.

[3] Alternatively, firms can maximize their output given a certain level of inputs. However, this approach is unsuitable in the context of postal services because the outputs, defined as letter-post mail and parcels, are beyond the control of the postal operator and thus have to be treated as given.

[4] For a detailed discussion of the advantages and disadvantages of the two methods, see Badunenko et al. (2012).

$$\begin{aligned} \theta^* &= \min_{\theta,\lambda} \theta \\ s.t. \quad \theta x_{io} &\geq \sum_{j=1}^{n} \lambda_j x_{ij} \quad i = 1,\ldots,m \\ y_{ro} &\leq \sum_{j=1}^{n} \lambda_j y_{rj} \quad r = 1,\ldots,s \\ \sum_{j=1}^{n} \lambda_j &= 1 \\ \lambda_j &\geq 0 \quad \forall j \end{aligned} \tag{1}$$

where x_{ij} and y_{rj} denote the levels of the ith input and rth output of the jth postal operator, $j = 1,\ldots,n$. The first two constraints require that the performance of a given postal operator o in terms of its inputs x_{io} and outputs y_{ro} is located within a production possibility set defined by the envelopment of all data points. The last two constraints, where λ is an $N \times 1$ vector, allow for variable returns to scale by imposing a convexity restriction which generates a frontier in the form of a convex hull of intersecting planes. The scalar θ^* is the optimal solution of the maximization problem in Eq. (1) and represents the efficiency score of a given postal operator. If $\theta^* = 1$, the operator is located on the best-practice frontier and is thus efficient, whereas $0 < \theta^* < 1$ indicates inefficiency.

Using data on input prices, cost efficiency is estimated by solving the following linear programming model based on Farrell (1957):

$$\begin{aligned} c_{io}x^*_{io} &= \min_{x,\lambda} \sum_{i=1}^{m} \sum c_{io}x_{io} \\ s.t. \; x_{io} &\geq \sum_{j=1}^{n} \lambda_j x_{ij} \quad i = 1,\ldots,m \\ y_{ro} &\leq \sum_{j=1}^{n} \lambda_j y_{rj} \quad r = 1,\ldots,s \\ \sum_{j=1}^{n} \lambda_j &= 1 \\ \lambda_j &\geq 0 \end{aligned} \tag{2}$$

where the constraints, including variable returns to scale, are identical to the model in Eq. (1), but the goal is to minimize the production cost represented by the product of the input x_{io} and its corresponding price c_{io}. The optimal solution is the input vector x^* that when multiplied with the input-price vector c determines the minimal cost. The cost efficiency (CE) score for each postal operator is then obtained by evaluating the minimal cost cx^* relative to the observed cost cx as follows:

$$CE = \frac{cx^*}{cx} \tag{3}$$

where $0 < CE \leq 1$ and the postal operator is cost efficient only if $CE = 1$. Technical efficiency is a necessary condition for cost efficiency on the best-practice frontier, but not vice versa.

Labor and capital employed to collect, process, and deliver mail and to provide postal and financial services were selected as input variables. The outputs were defined as the total amount of letter-post mail, parcels, and financial transactions processed by the postal operator. Moreover, an alternative specification included the speed and reliability of letter delivery as additional outputs. There is no need to explicitly control for the country's size or population in the model because the DEA relates each country's inputs to its outputs and evaluates the resulting proportions across countries relative to the benchmark.[5]

2.2. Data

The data for most input and output variables were obtained from the Universal Postal Union, an international organization that collects and publishes annual statistics from the postal operators of its member countries based on universal standards. The data set includes national postal-service providers from 17 CEE countries over the period 1994–2009.[6]

Labor input is measured as the number of staff working full-time for the postal operator.[7] In view of data availability, two proxies for capital input are used, namely the number of post offices and letter boxes. The sample includes permanent post offices that are open to the public and are staffed either by representatives of the postal operator or by contractual personnel. Mobile post offices were excluded because they include mainly rural delivery staff already represented by the labor input. Letter boxes are a component of fixed capital and relevant because one of the first cost-saving measures often adopted by postal operators is the dismantling of rarely-used letter boxes. Furthermore, letter boxes are usually located around town and must be serviced at regular intervals, making them a proxy for transport equipment, for which no complete data exists.

Postal offices and letter boxes are not ideal measures. The optimal approach would be to use the value of capital derived from investment flows by applying the perpetual inventory method. However, very few studies have been able to collect the necessary data (Grifell-Tatje and Lovell, 2008). Most previous works on postal efficiency have also struggled to find appropriate proxies for the capital inputs. For instance, Perelman and Pestieau (1994) use the number of post offices and the number of motor vehicles employed by the post, which are similar to the measures used in this investigation. Furthermore, using an available quantitative measure of capital input is a standard technique in the efficiency literature. For example, studies on the efficiency of hospitals and nursing homes use as a rule the number of beds as a proxy for capital (Chilingerian and Sherman, 2011). Similarly, the number of cows has been employed as a proxy for capital in papers on the efficiency of dairy farms (Kelly et al., 2013; Tauer, 1993). Using the number of post offices and letter boxes is in line with this literature.

Obviously, post offices and letter boxes are major components but do not represent the entire capital stock of postal operators, which could produce biased results. Therefore, a robustness test was conducted using data for 11 postal operators over the period 2006–09 to compare a model using the value of fixed capital as an input variable and an alternative one employing post offices and letter boxes instead. The results (not reported here but available upon request) yielded a Spearman rank-order correlation coefficient of 0.62 in the estimation with quantity-based outputs, and 0.90 when quality-based outputs were added. The difference in the average efficiency levels between the original and new

[5] As a robustness check, the two capital inputs described in the next section were weighted by the share of a country's population in the overall population of the sample for each year. The efficiency levels were very similar and are thus not reported here but are available from the author upon request.

[6] The sample consists of Albania, Belarus, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Serbia, Slovakia, Slovenia, and Ukraine. Bosnia and Herzegovina was excluded from the sample due to data limitations, while Montenegro, which became independent in 2006, was counted as part of Serbia.

[7] Although the number of posts in full-time equivalent would be preferable, these data are available only since the early 2000s. Robustness checks using full-time equivalents over the period 2001–2009 produced very similar results, which are available upon request. This indicates that part-time staff played a relatively minor role over the sample period.

specifications was only 0.02 in both the quantity- and quality-based output models. These findings suggests that the estimation using post offices and letter boxes as proxies for capital produces an efficiency ranking that is relatively robust given the data limitations.[8]

Input prices for the cost efficiency model were constructed only for 12 of the 17 postal operators over the years 2007–08, because the availability of financial statements, from which the relevant data were collected, was very limited.[9] In this specification, capital was measured as the value of fixed capital in Euros, whereas the price of capital was defined as the ratio of non-wage operating costs to fixed capital. The non-wage operating costs reflect the expenditure on employing, renting, and maintaining buildings, land, and equipment. Accordingly, these costs expressed per unit of fixed capital are a more suitable proxy for the price of capital than the rental price per square meter (Filippini and Zola, 2005) or the value of amortization allowances (Iturralde and Quiros, 2008) used in previous research on postal efficiency. The price of the labor input was calculated as the ratio of the total annual wage and salary costs in euros to the number of full-time staff.[10]

The output variables consist of letter-post mail, parcels, and financial transactions. Letter-post items are letters, post cards, small packages with a weight of up to 2 kg, and advertising materials sent as standard, registered, or insured mail.[11] Express items and newspapers delivered by mail are not included due to data limitations. Parcels are limited to a weight of 20 kg and cover both ordinary and insured items. Letter-post items and parcels take into account the domestic collection and delivery of items, the dispatch of domestic mail destined abroad, and the delivery of mail received from abroad. Postal operators are also engaged in providing financial services, which is introduced in the model in the form of money orders. The number of ordinary money order transactions counts the domestic service as well as the dispatch and receipt of international money orders.

In addition, service-quality indicators were taken into account in an alternative specification of the model. The data were obtained from the International Post Corporation, which measures the service performance of European postal operators with regard to cross-border mail flows. The first indicator (denoted by J+3) concerns the speed of delivery, calculated as the percentage of letters that are delivered to addressees in a foreign country within 3 days of mailing. The second indicator (denoted by J+5) assesses reliability, measured as the percentage of letters that are delivered to addressees within 5 days of mailing. Each of the two indicators was measured as the average performance level for letters sent from a given CEE country to France and the UK.[12] Annual data on the two quality indicators are available for 9 of the CEE countries[13] in the sample over the years 2005–09, while data for Bulgaria, Croatia, and Macedonia are reported only for 2008–09.

The descriptive statistics shown in Table 1 suggest that postal-service characteristics vary widely among CEE countries. In general, Central European and Baltic countries have between 2 and 3 postal workers per 1000 people, while Balkan countries and former Soviet republics employ less than half of that number. There is less variation in the number of permanent post offices, with reported values between 0.2 and 0.3 per 1000 people in most cases. Large disparities are also apparent in the output variables. For instance, while an average Albanian has only 1.5 letter-post items in a given year, his Hungarian counterpart has 120 items. Slovenia is ranked at the top with 308 letter-post items per person, largely because advertising mail has grown rapidly reaching levels observed in Western Europe but not among CEE countries (ITA-Consulting and WIK-Consult, 2009).

With regard to the speed of delivery, none of the postal operators in the Balkans exceeds the 50% mark, whereas Central European postal services deliver between 80 and 90% of the cross-border letter mail within 3 days. The gap in performance with regard to reliability is less pronounced, but the pattern is similar. In terms of price of the labor, average annual wages of postal workers in Bulgaria and Macedonia amount to between 5000 and 6000 Euros, while in Slovenia, Slovakia, the Czech Republic they are more than twice as high. The price of capital does not exhibit clear geographical patterns. At their lowest level, operating costs amount to about a third of the value of fixed capital, while in the extreme case of Estonia this ratio is almost 1.

3. Results

3.1. Efficiency estimates

The results of the DEA analysis, presented in Table 2, indicate that the inefficiency of CEE postal operators averages between 15% and 30% across the different model specifications. The first model covering the entire period 1994–2009 and all 17 countries in the sample employs the quantity of letter-post items, parcels, and money orders as outputs. The estimates of technical efficiency, shown in the first column of Table 2, vary widely across countries. In general, postal operators in the former Soviet republics and the Balkan countries exhibit the lowest average efficiency levels, while their counterparts in Central Europe emerge as efficiency benchmarks located on the frontier. With its focus on output quantities, this model disregards the importance of speedy and reliable delivery of postal items. A second model is estimated using the quantity of letter-post items as well as the quality of delivery as outputs. The two quality outputs measure speed and reliability of delivering mail from a given CEE country to France and the UK. Due to data limitations, the model is estimated for two shorter periods (2005–09 and 2008–09) and a smaller number of postal services. As evident from the results in columns 3 and 4, Balkan countries are again at the bottom of the efficiency scale, whereas the postal operators in the Baltics rank significantly higher when quality is taken into account.

Although postal operators can be efficient in quantity and quality terms, they do not necessarily deliver services at optimal cost. Accordingly, a third model involving the input prices of labor and capital is estimated for 12 operators over the years 2007–08. The corresponding results are reported in columns 5 and 7 of Table 2. Technical efficiency, with an average of 85%, is relatively high.[14] In addition, the geographical pattern found in the previous

[8] The main reason for the Spearman rank-order correlation coefficient in the model with quantitative outputs to be just 0.62 is the change in the efficiency ranking of postal operators in Bulgaria, Croatia, and Serbia. This is most likely due to the unreliable measurement of fixed capital in these countries.

[9] Albania, Belarus, Moldova, Romania, and Ukraine were excluded from the cost efficiency estimation.

[10] Badunenko et al. (2008) have suggested an alternative method of estimating allocative efficiency scores without input prices. We opt for the traditional approach because we do not estimate allocative efficiency separately.

[11] Standard, registered, and insured mail are combined as a single output to ensure that parcels and money orders could be included in the model as well. More than 3 outputs resulted in almost all postal operators being identified as efficient, which precludes a meaningful analysis.

[12] These two countries were chosen based on data availability and the fact that they do not share borders with any CEE countries.

[13] These include the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.

[14] The results for technical efficiency cannot be compared to the estimates of the previous two models due to a different definition of capital. As described in the method section, the models with quantity- and quality-based indicators use postal offices and letter boxes as capital inputs, while the cost efficiency specifications employ the value of fixed capital.

Table 1
Descriptive statistics of the input and output variables.

	Input variables			Output variables			Quality outputs		Input prices	
	Staff	Post offices	Letter boxes	Letter post	Parcels	Money orders	J+3	J+5	Labor	Capital
Albania	0.54 (0.09)	0.17 (0.01)	0.17 (0.01)	1479 (942)	8.1 (2.2)	8.4 (5.8)	–	–	–	–
Belarus	1.61 (0.29)	0.38 (0.02)	2.24 (0.25)	62,452 (6613)	145.2 (88.4)	517.6 (214.8)	–	–	–	–
Bulgaria	1.38 (0.25)	0.38 (0.02)	0.74 (0.08)	10,313 (1576)	140.6 (49.3)	425.7 (123.0)	32.6 (5.1)	76.1 (8.5)	4752 (476)	0.84 (0.13)
Croatia	2.58 (0.39)	0.26 (0.00)	1.15 (0.05)	63,014 (8105)	418.9 (85.9)	297.4 (47.1)	44.1 (13.7)	83.5 (6.2)	9659 (1497)	0.84 (0.03)
Czech Rep.	3.20 (0.43)	0.33 (0.01)	2.37 (0.06)	78,199 (5665)	1681 (308)	8978 (590)	83.5 (3.3)	97.5 (0.8)	11,834 (2859)	0.66 (0.01)
Estonia	2.59 (0.38)	0.39 (0.04)	2.59 (0.17)	44,846 (7563)	1074 (223)	181.9 (82.6)	72.2 (6.1)	93.8 (2.8)	10,622 (110)	0.98 (0.02)
Hungary	3.38 (0.25)	0.30 (0.02)	1.55 (0.31)	120,523 (12,581)	862.6 (397.9)	602.8 (137.0)	91.2 (3.5)	98.0 (1.3)	8782 (604)	0.70 (0.08)
Latvia	2.40 (0.52)	0.40 (0.04)	1.00 (0.10)	21,246 (7281)	68.7 (48.9)	166.9 (66.0)	74.1 (9.6)	93.2 (4.2)	6628 (754)	0.89 (0.16)
Lithuania	1.19 (0.13)	0.27 (0.01)	1.25 (0.24)	14,472 (2579)	68.2 (48.9)	119.8 (51.8)	68.7 (12.7)	93.3 (4.2)	9111 (769)	0.31 (0.07)
Macedonia	1.38 (0.62)	0.15 (0.01)	0.43 (0.19)	15,309 (2248)	106.8 (16.5)	84.1 (12.1)	7.13 (2.7)	33.8 (2.0)	6062 (59)	0.37 (0.02)
Moldova	0.71 (0.16)	0.31 (0.01)	0.93 (0.18)	6628 (2522)	13.2 (4.4)	62.9 (22.6)	–	–	–	–
Poland	2.30 (0.10)	0.22 (0.02)	1.45 (0.08)	48,936 (11,412)	591.7 (89.3)	2769 (566)	79.9 (3.0)	96.8 (0.8)	6186 (518)	0.36 (0.01)
Romania	1.53 (0.05)	0.34 (0.08)	0.66 (0.09)	16,999 (6257)	279.9 (32.7)	510.7 (44.9)	49.2 (11.6)	83.4 (6.3)	–	–
Serbia	2.76 (0.85)	0.22 (0.03)	0.69 (0.15)	26,852 (5370)	212.3 (111.5)	336.9 (68.6)	–	–	7807 (37)	0.36 (0.02)
Slovakia	2.49 (0.43)	0.31 (0.01)	1.35 (0.07)	88,298 (13,916)	1140 (145)	6891 (2178)	72.5 (4.6)	94.9 (2.7)	14,489 (2132)	0.47 (0.00)
Slovenia	2.86 (0.35)	0.27 (0.01)	1.52 (0.17)	307,545 (144,344)	1946 (1306)	284.0 (65.3)	77.8 (5.1)	95.3 (2.0)	15,650 (405)	0.37 (0.05)
Ukraine	1.58 (0.28)	0.32 (0.01)	1.13 (0.30)	8465 (1848)	165.2 (128.9)	384.5 (110.5)	–	–	–	–

Note: The reported numbers are averages with standard deviations in parenthesis. Inputs and outputs (in per 1000 people) are period averages over 1994–2009, input prices over 2007–08, and quality outputs (in percent) over 2005–09.

Table 2
Technical and cost efficiency levels of postal operators in CEE.

	Quantity indicators		Quality indicators		Input costs			
	1994–09		2005–09	2008–09	Technical efficiency		Cost efficiency	
	(1)	(2)	(1)	(1)	(1)	(2)	(1)	(2)
Albania	1.00 (0.00)	1.00 (0.00)	–	–	–	–	–	–
Belarus	0.66 (0.24)	0.72 (0.24)	–	–	–	–	–	–
Bulgaria	0.32 (0.06)	0.44*** (0.07)	–	0.35 (0.02)	0.96 (0.06)	1.00 (0.00)	0.33 (0.02)	0.61*** (0.03)
Croatia	0.46 (0.12)	0.55** (0.10)	–	0.45 (0.03)	1.00 (0.00)	1.00 (0.00)	0.32 (0.00)	0.34 (0.02)
Czech Republic	1.00 (0.00)	1.00 (0.00)	0.66 (0.36)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Estonia	0.95 (0.06)	1.00 (0.00)	0.97 (0.08)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	0.88 (0.08)	0.93 (0.10)
Hungary	0.93 (0.20)	0.93 (0.19)	1.00 (0.00)	1.00 (0.00)	0.68 (0.07)	0.74 (0.07)	0.50 (0.30)	0.56 (0.36)
Latvia	0.44 (0.07)	0.75*** (0.14)	1.00 (0.00)	1.00 (0.00)	0.66 (0.02)	0.87*** (0.02)	0.51 (0.04)	0.84** (0.07)
Lithuania	0.53 (0.03)	0.91*** (0.07)	0.96 (0.06)	0.95 (0.08)	0.57 (0.06)	0.78* (0.06)	0.57 (0.06)	0.84** (0.03)
Macedonia	1.00 (0.00)	1.00 (0.00)	–	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Moldova	0.69 (0.17)	0.98*** (0.05)	–	–	–	–	–	–
Poland	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Romania	0.42 (0.10)	0.43 (0.11)	0.32 (0.32)	0.16 (0.00)	–	–	–	–
Serbia	0.41 (0.13)	0.49 (0.14)	–	–	0.38 (0.04)	0.44 (0.04)	0.22 (0.01)	0.46 (0.32)
Slovakia	1.00 (0.00)	1.00 (0.00)	0.68 (0.29)	0.74 (0.37)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Slovenia	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Ukraine	0.25 (0.19)	0.30 (0.26)	–	–	–	–	–	–
Average	0.71 (0.29)	0.79 (0.25)	0.84 (0.24)	0.80 (0.31)	0.85 (0.22)	0.90 (0.17)	0.69 (0.32)	0.80 (0.24)

Note: (1) reports the average raw score; (2) shows the average bias-corrected estimate from the bootstrapping procedure. Standard deviation is in parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

models is less pronounced. For instance, the Bulgarian and Croatian postal services are now located on the best-practice frontier, while the Hungarian Post is among the less efficient enterprises. The most important estimates are for cost efficiency, because they combine technical and allocative aspects to produce an indicator of overall efficiency. In this respect, 40% of the operators in the sample score the highest levels of efficiency, with most of them being from Central Europe. The average cost efficiency of less than 70% for the entire sample is dragged down by the performance of postal operators from the Balkans, which does not exceed 35%.

To test the robustness of the efficiency estimates, the bootstrapping procedure by Simar and Wilson (1998) is performed and the estimated bias is used to adjust the raw efficiency scores. The resulting bias-corrected estimates along with the statistical significance of the difference between them and the raw scores are displayed in columns denoted by (2) in Table 2.[15] It is evident that the bootstrap values are generally higher than the raw score but in most cases not statistically significantly so with the exception of the postal services of Latvia, Lithuania, and Moldova.

3.2. Determinants of postal efficiency

To explain the variation in relative performance of postal operators across CEE, the bias-corrected DEA scores from Section 3.1 are regressed on a number of firm-specific and institutional variables using the following specification

[15] The bias-corrected estimates for the model involving quality indicators are not reported because they are almost identical to the raw scores. These estimates are available upon request.

$$EFF_{it} = \beta_0 + \beta_1 INT_{it} + \beta_2 MOB_{it} + \beta_3 TEL_{it} + \beta_4 COM_{it} + \beta_5 CUS_{it} + \beta_6 DEN_{it} + \beta_7 PRO_{it} + \beta_8 PRI_{it} + u_{it} \quad (4)$$

where EFF_{it} stands for the technical or cost efficiency level of postal operator i in year t. Since efficiency scores are limited to values between 0 and 1, a censored regression specification is employed as it captures the lower and upper censoring of the dependent variable and produces consistent maximum likelihood estimates. In the DEA literature, a censored regression specification is preferred over a truncated regression model because the latter excludes observations greater than 1, while the DEA simply constrains the values of the efficiency levels between 0 and 1 (Chilingerian, 1995; Chilingerian and Sherman, 2011).

The number of internet users per 100 people (*INT*) and the number of mobile-phone subscriptions per 100 people (*MOB*) serve as proxies for the impact of new information and communication technologies on postal efficiency. Both indicators have recorded a rapid increase over the sample period; however the variation of internet usage across CEE countries is more pronounced than for mobile phones. For instance, in 2009 less than 35% of Ukrainians and Romanians used the internet, whereas in Estonia and Slovakia the number of internet users was twice as high.

Customs procedures can have an adverse effect on the speedy and reliable delivery of letters and parcels across borders. For this reason, the burden of customs procedure (*CUS*) is included in the regression as a number ranging from 1 to 7, with a higher score indicating greater efficiency.[16] According to this scale, Estonia's customs is the most efficient in CEE with an average score of 5.4, while Ukraine's is at the bottom with a score of 2.8. Another important variable that could affect the performance of postal operators is population density (*DEN*). Data on all independent variables discussed so far were obtained from the World Bank's World Development Indicators database.

Another group of variables evaluates the effects of institutional factors on postal efficiency. Competition policy (*COM*) assesses the introduction, effectiveness, and enforcement of competition legislation and institutions, while the telecoms indicator (*TEL*) surveys the reform progress in the postal and telecommunication sector of transition economies.[17] Both variables, obtained for the years 1996–2009 from the European Bank of Reconstruction and Development's annual Transition Report, are measured on a scale from 1 to 4 with higher numbers indicating progress in promoting competition, commercialization, and regulation of the postal and telecommunication sector.

Lastly, two firm-specific variables enter the right-hand side of the regression equation. These include profits as a share of revenue (*PRO*) and the price of a standard letter (*PRI*), expressed in euros and adjusted for differences in purchasing power and labor costs. Data on profits and revenue were collected from the Universal Postal Union's database and cover the period 1996–2009, while price statistics for the years 2007–09 were taken from the German postal operator's annual publication, entitled “Letter prices in Europe”. In nominal terms, the price of a standard letter in CEE countries is below EU's average price, however once purchasing-power and labor-cost differences are taken into account, letter prices in CEE turn out to be the highest in Europe.

The results of the regression are presented in Table 3. Internet usage is found to have a significantly negative effect on technical and cost efficiency in the models with quantity-based outputs. Due to rapid growth in internet access and usage, physical mail, particularly between households, has been increasingly replaced by electronic communication. Moreover, demand for subscribed newspapers and magazines sent through the mail has dropped with the advent of on-line news media, while governments have started offering electronic services, such as the e-filing of taxes.[18] Previous studies have shown that letter volumes per capita are negatively related to broadband penetration for EU member countries (including CEE) in the years 2002–07 (Copenhagen-Economics, 2010). Despite the declining volumes of letter post, which accounts for a large share of revenue, postal operators in CEE have been slow to adjust the number of employees and postal offices accordingly, contributing to the deterioration in technical and cost efficiency.

Efforts by postal operators to lower costs by adopting electronic communication in the delivery of letters, such as hybrid mail, have not had a significant impact on efficiency either because the volumes of hybrid mail are still negligible or because in some CEE countries (such as Bulgaria and Slovakia) hybrid mail is not part of the universal service and is thus open to competition. However, the results presented in Table 3 suggest that internet usage was positively associated with efficiency in terms of the quality of delivery, and significantly so for the last two years of the sample period. In this context, hybrid mail and other technological innovations, such as online shipping and web-based tracking, seem to have contributed to increases in efficiency by improving the speed and reliability of delivery, especially in cross-border mail.

In general, mobile-phone subscriptions do not have a significant effect on postal efficiency. The only exception is technical efficiency of quantity-based outputs over the entire sample period, which improved with an increase in mobile-phone usage. This is probably due to the fact that in the earlier years of the sample period, postal and telecommunication services in CEE were still combined in single entities that monopolized their telecommunications markets. Once the two services were separated and commercialized, and the market for mobile-phone services was liberalized, the positive effects on postal efficiency disappeared. This line of reasoning is further supported by the fact that the coefficient for the telecommunications indicator is not statistically significant in the technical efficiency models without input prices. The telecommunications indicator measures, among others, the progress in separating postal and telecommunication services and the commercialization of the two new entities. As these processes advanced in the later years of the sample period, they enhanced technical and cost efficiency where input costs matter.

Competition in the postal sector has become more relevant in the 2000s as some areas were opened to private companies. Therefore, it is not surprising that the competition policy variable is not significant across the entire sample period. However, private competition seems to have beneficial effects on technical and cost efficiency when input prices are taken into account. This is in line with previous studies based on samples of European countries (Quiros, 2011). In fact, some postal operators in CEE face fierce competition from private companies, compelling them to improve their performance. In Hungary and Latvia, the national postal

[16] Data on the burden of customs procedure are available only for the years 2007–09.

[17] Unfortunately, the lack of data precludes the calculation of a Herfindahl-Hirschman index to account for market concentration on the market for postal services in CEE.

[18] In the period 2004–08, less than 10% of households in CEE sent back filled-out government forms, with the exception of Estonia where this share reached 25% in 2008. In contrast, more than 50% of companies in Central Europe and the Baltics communicated electronically with the government in 2008 (ITA-Consulting and WIK-Consult, 2009).

Table 3
Regression results for the determinants of technical and cost efficiency.

	Quantity indicators		Quality indicators		Input costs	
	1996–09	2007–09	2005–09	2008–09	TE	CE
Internet	−0.004*** (0.001)	−0.010*** (0.004)	0.003 (0.006)	0.060*** (0.008)	−0.006*** (0.002)	−0.022*** (0.004)
Mobile phones	0.001** (0.000)	0.002* (0.001)	−0.002 (0.002)	−0.008* (0.004)	−0.000 (0.001)	0.001 (0.001)
Telecoms	0.024 (0.016)	0.196 (0.130)	−0.087 (0.325)	−0.752 (0.491)	0.173*** (0.056)	0.613*** (0.136)
Competition	0.025 (0.032)	0.188 (0.173)	0.331 (0.409)	−1.522*** (0.246)	0.336*** (0.092)	0.419* (0.224)
Customs	–	0.243** (0.113)	–	–	0.081 (0.070)	0.624*** (0.165)
Density	−0.013*** (0.003)	0.009 (0.026)	0.071 (0.045)	0.106*** (0.040)	0.017 (0.019)	0.167*** (0.047)
Profit margin	−0.000 (0.000)	−0.002** (0.001)	0.002 (0.002)	0.003*** (0.001)	−0.001*** (0.000)	−0.004*** (0.001)
Letter price	–	–	–	0.643*** (0.138)	−0.037 (0.065)	−0.245 (0.136)
Countries	17	15	9	12	12	12
Log likelihood	211.47	57.95	17.81	44.02	66.19	44.57

Note: Standard error is in parenthesis. ***p < 0.01, **p < 0.05, *p < 0.10.

operator has less than 20% market share in the express mail and parcel segments, while in Bulgaria, Lithuania, Poland, and Romania this share is less than 10%. Notably, increased competition has had an adverse impact on technical efficiency in terms of quality of delivery. Apparently, national operators have not been able to match the speed and reliability of private competitors, likely contributing to loss of market share.

Onerous customs procedures impose additional costs on postal operators. The regression results support this argument by showing that technical and cost efficiency benefit from smooth customs processing.[19] Population density, which is associated with urbanization, is also found to enhance efficiency, especially in the relevant areas of quality and costs. More densely populated areas are favorable for postal operators because they allow faster and more reliable delivery at lower cost.

Growing profits as a share of revenue could reflect improved efficiency. In turn, profits could also affect the performance of postal operators. The results of the regression overall indicate a significantly negative relationship between the two variables in the later years of the sample period. Given that many of the CEE postal operators incurred a financial loss in these years, the negative coefficient suggests that losses encouraged postal operators to improve technical and cost efficiency. In contrast, the estimate from the model with quality-based indicators implies that efficiency and profits tend to move together.

Prices of postal services in CEE increased dramatically over the sample period. For instance, the price of a standard letter in Slovakia and Slovenia (adjusted for inflation) rose by more than 115% between 1999 and 2009, while in the Czech Republic, Poland and, Hungary, the increase ranged from 70% to 96% (DeutschePost, 2011). Only in Estonia letter prices remained constant over the same period. The price hikes were largely the result of artificially low prices in the 1990s that did not reflect costs. Another reason is that some postal operators (such as those in Slovenia, Hungary, Poland) phased out cheaper second-class letter service. The regression results suggest that price increases contributed to improvements in technical efficiency in terms of the quality of delivery. However, letter prices did not have a significant effect on efficiency in the model including input costs.

4. Conclusions

Similar to their counterparts in the developed world, postal operators in the transition economies of CEE face a myriad of challenges in the age of market liberalization and the internet. In addition, they must overcome a legacy of low service quality and inefficiency inherent to deficit-incurring state-owned enterprises from the era of centrally-administered economic systems. EU accession proved decisive in forcing member states from CEE to restructure and optimize their national universal-service providers before the postal market was completely liberalized in 2012. This paper evaluated the performance of postal operators in CEE with regard to their ability to minimize input quantities and costs in providing speedy and reliable delivery of postal services. The results indicate that the average level of inefficiency among CEE postal operators varied between 20 and 30% depending on the model specification. In general, providers from Central Europe formed the efficiency frontier followed by their counterparts in the Balkans and with operators from the former Soviet republics a distant third. Regression analysis attributed efficiency gains in the postal sector to increased competition, institutional reforms aimed at commercialization of universal-service providers, less burdensome customs procedures, and population density. Internet usage was found to have a negative effect on efficiency, while financial losses seem to have compelled postal operators to improve their performance. Future research needs to explore whether the efficiency of postal operators in CEE improved as a result of the liberalization of postal markets across Europe. Another important topic worth exploring is a comparison of postal-service efficiency in CEE and Western Europe that would also test for convergence in a dynamic framework.

The complete liberalization of the postal markets will be a crucial test for postal operators in CEE to prove that they can withstand competition from smaller private companies as well as from privatized national operators, such as Germany's Deutsche Post and the Dutch postal company TNT, that operate worldwide. Some CEE countries, such as Estonia, were sufficiently confident to liberalize their postal-service markets ahead of the EU deadline, consistent with the evidence in this paper showing the Estonian operator to be among the most efficient in the region. But the relative performance of others, most notably those in Romania and Bulgaria, suggests that they will face tough choices, which in a time of fiscal austerity and debt worries also include the possibility of privatization and takeover by larger and more efficient competitors from Western Europe.

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[19] The customs variable was excluded from the model with quality outputs because data were available only for 12 countries, 10 of which are EU members. Given that mail within the EU is not subject to customs inspections, the estimated coefficient would have been misleading.

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