Enterprise Efficiency in Romania Redux

K. H. McIntyre[1]

McIntyre and Martin (2013) found a significant efficiency gap between Romanian manufacturing and counterpart industries in other Central and Eastern European nations in 2005. Although disheartening from the standpoint of Romanian enterprise, the results suggest that there efficiency gains to be had. This companion paper presents updated estimates of Romanian enterprise efficiency from 2010. I find that that Romanian firms have in general made significant strides in efficiency between 2005 and 2010. Additional results show that the measurable industrial drivers of technical efficiency in Romania are consistent with firms operating in a competitive, market economy, suggesting that Romania has largely shed its Communist economic heritage.

Keywords:Romania, firm efficiency, frontier estimation
JEL Classifications: D21, O14, P27

[1] **K.H. McIntyre**, Department of Economics & Business, McDaniel College, 2 College Hill, Westminster, MD 21157 USA, e-mail: mcintyre@mcdaniel.edu.

Introduction

Romania has historically been viewed as one of the least-developed economies in Europe. Indeed, a relatively more damaging Communist experience and an unstable, painful transition period all contributed to Romania being one of Europe's least competitive nations as measured by enterprise efficiency entering the 21st century. McIntyre and Martin (2013), in particular, note an efficiency gap of approximately 10% existed between Romanian manufacturing and wholesaling and counterpart industries in other Central and Eastern European nations as late at 2005.

This paper is a companion piece to McIntyre and Martin, updating their estimates of Romanian enterprise efficiency for 2010. Although fairly short, the 2005-2010 period was an economically eventful one for the Romania: it joined the European Union (EU) in 2007, thus exposing its firms to a heretofore unseen degree of international competition; and the southeast European economy were roiled by the 2008 financial crisis and the early stages of the European sovereign debt crisis, macroeconomic episodes likely to have long term impacts on EU economy. As such, revisiting enterprise efficiency in Romania so soon is pertinent along at least two dimensions. First, is allows one to assess the early impact of Romanian EU membership on firms and industrial sectors. Second, it provides a benchmark to examine how the macroeconomic turbulence and capital market instability that have roiled Europe since 2007 will affect Romania going forward. It goes without saying that the events of the 2005-2010 period represent very strong incentives for firms to become more efficient, and quickly.

These challenges notwithstanding, Romania's outlook, however, is not so dark and its development potential is very good. Indeed, mirroring the McIntyre and Martin industrial sample and using identical estimation methods, I find that Romanian industry has in general made significant strides in efficiency between 2005 and 2010; a formal comparison of results in 2005 and 2010 finds that 14 of 19 industrial sectors surveyed show significantly higher mean efficiency in 2010. Additional results show that the measurable industrial and financial determinants of technical efficiency in Romania are consistent with firms operating in a competitive, market economy.

The remainder of the paper is organized as follows: The next section discusses possible systematic and structural factors that may have influenced Romanian enterprise efficiency since 2005. That is followed by a description of the data set and a comparison of estimates of industry-level firm efficiency in Romania in 2010 and 2005. After that, I outline the determinants of firm efficiency in Romania in 2010 with a conclusion to follow.

Romanian Enterprise Efficiency to 2010

There is ample scholarship arguing that Romania is a comparatively inefficient country. Hollanders and Esser (2007), for example, cite Romania as one of the least efficient countries in Europe. McIntyre and Martin (2013) quantify this assertion, finding that Romanian manufacturing and wholesaling sectors are on average 10% less efficient than in other Central and Eastern European countries. Zugravua and Sava (2012) likewise find a "significant deterioration" in public sector efficiency in 2008-2011, mainly as a result of decreases in Romanian government expenditures in response to the global financial crisis of 2007-2008, while Încalţărău and Maha (2010) suggest that EU membership resulted in an additional loss of industrial competitiveness.[2]

Much recent scholarship has concentrated on Romania's banking sector. Staikouras et al. (2008) suggest that the banking sector in the entire Balkan region is relatively inefficient. Bonin et al. (2004), for example, focus on the relative inefficiencies of the Romanian banking sector, a result of Romania's late start in privatizing its banking sector during its transition period in the 1990s. Similar findings of banking

[2] The results of this study dispute this finding.

inefficiency are reported by Andrieş and Cocriş (2010) for the 2000-2006 period and by Roman and Şargu (2012) for the years immediately following the global financial crisis.

Most of these studies argue that Romania's relative inefficiency is primarily the result of structural factors, including but not limited to Romania's Communist experience (Demekas and Khan, 1991), its economically volatile and politically uncertain transition experience (Budina et al., 2006), and corruption. Taken in sum, this paints a rather bleak picture of Romania. There is, however, an upside. Joining the EU in 2007 required Romania's leadership to engage in a series of public spending reforms designed to stabilize the Romanian economy, hopefully creating an environment more conducive to entrepreneurship. Moreover, EU membership also exposed Romanian firms to much higher levels of competition, creating strong incentives for Romanian firms to rapidly become more efficient.

Although far from optimal, the entrepreneurial environment in Romania is arguably as good as it has ever been. Romania is now a full member of a multinational marketplace, it has emerged from a severe recession in arguably better shape than its neighbors, and further reforms designed to increase competitiveness are likely in the offing. If the reasons underlying Romania's relative economic inefficiency were indeed structural in nature, Romania should be poised to experience efficiency gains going forward.

Efficiency Estimates

Stochastic Frontier Analysis

McIntyre and Martin (2013) and this paper endeavor to quantify enterprise efficiency via stochastic frontier analysis. First proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977), this empirical technique, formally described in the proceeding subsection, has since become a standard tool to investigate issues of technical efficiency at the firm and industry level. As applied here, this technique involves estimating a production possibilities frontier for a given industry using firm-level data, restricting firm-specific errors to be positive. By definition, production possibilities frontiers assume all inputs to production are fully and efficiently employed; as such, any unique, firm-level deviation from industry production possibilities implies technical inefficiency in that firm.

I use these measures of technical efficiency in Romanian industry to address two main issues. First, comparing industrial efficiency over time allows me to quantify changes in industry level efficiency. The degree to which firms and industries are in becoming more or less efficient in general is of obvious interest to policymakers, the investment community, and others. Second, it provides for an quantitative investigation into the determinants of technical efficiency. This touches on matters such as effective entrepreneurship and sound economic governance, again issues of great interest to policymakers, entrepreneurs, and investors.

Data

My data set consists of financial statement information for 6,930 private firms in Romania for 2010. These data were drawn from the AMADEUS pan-European micro database compiled by Bureau van Dijk. Capital input is measured using a firm's fixed assets in current (2010) Euros. Labor input is measured using a firm's workforce. Value added was directly obtained, and is also denoted in 2010 Euros. Industries were defined using 2-digit NACE rev 2.0 codes and were selected to mirror the industry sample used by McIntyre and Martin (2013), which defines nineteen broadly defined industries. Those industries are: crude petroleum and natural gas mining; food products and beverages; textiles; wood; pulp, paper; publishing and printing; chemicals and chemical products; rubber and plastic products; other non-metallic mineral products; basic metals and fabricated metal products; miscellaneous machinery; electrical and optical equipment;

motor vehicles; electricity, gas, and water supply; construction; sale, maintenance, and repair of motor vehicles; wholesale of household goods and food products; wholesale of non-agricultural intermediate products, waste, and scrap; and transportation, storage, communication. I also have access to the raw data and individual firm efficiency estimates obtained by McIntyre and Martin for comparison purposes.

Table 1 is compares sample sizes between this and the McIntyre and Martin studies. The data set used in this paper is larger by of factor of about three, and in general each industry's sample size is about 2-4 times larger here. Exceptions are found in the petroleum and textiles industries, where the Martin and McIntyre sample sizes are larger.

Table 1

Sample Sizes

			Sample Sizes	
	NACE rev 2.0	*NACE rev 1.1*	*2010*	*2005 (from McIntyre & Martin, 2013)*
Extraction of crude petroleum and natural gas	09	11	17	34
Manufacture of food products and beverages	10-11	15	444	228
Manufacture of textiles	13, 1439	17	101	116
Manufacture of wood products	16	20	113	80
Manufacture of pulp, paper; publishing and printing	17, 18, 58-59	21-22	160	46
Manufacture of chemicals and chemical products	20-121, 325	24	130	48
Manufacture of rubber and plastic products	22	25	213	53

Manufacture of other non-metallic mineral products	23, 33	26	154	81
Manufacture of basic metals and fabricated metal products	24-25	27-28	386	147
Manufacture of machinery, n.e.c.	2751, 28	29	172	109
Manufacture of electrical and optical equipment	26-27	30-33	204	97
Manufacture of motor vehicles	29-30, 33	34-35	128	91
Manufacturing, n.e.c.	31	36	159	118
Electricity, gas, and water supply	35	40	101	53
Construction	41-13	45	1408	341
Sale, maintenance and repair of motor vehicles	45, 47	50	432	76
Wholesale of household goods and food products	4634	5134	828	214
Wholesale of non-agricultural intermediate products, waste, and scrap	4677	515	284	140
Transportation, storage, and communication	49-53, 60-61, 64-65, 79	60-64	1012	88

Empirical Model

Following McIntyre and Martin (2013), I propose a stochastic frontier model of the form:

$$V_i = g(a_i, \Psi) \cdot e^{u} \cdot e^{-v_i} \qquad (1)$$

where V_i denotes firm *i*'s value added and *g* its production technology. In natural logs, this becomes:

$ln(V_i) = ln[g(a_i,\Psi)] + u + v_i$.

The firm employs a vector of inputs a with parameter vector Ψ. This specification has two error terms, u and v_i, that are assumed independent across industrial sectors. u and v_i are distributed as:

$u \sim N(0,\sigma_u^2)$ (2)

$v \sim$ half-normal $(0,\sigma_v^2)$.

u captures the random aspect of the relationship between value added and inputs to production; it is uniform across firms in a given industry. Accordingly, u measures systematic industrial shocks such as legal constraints, policy changes, and any market distortion that can affect production possibilities at the macro or industry levels.

The other error term, v_i, is unique to a given firm and is restricted to assume positive values only. v_i thus reflects the difference between firm *i*'s actual value added, V_i and its maximum possible production $[g(a_i,\Psi) + u]$ given its business environment. That is, v_i represents firm *i*'s technical inefficiency. Accordingly, a given firm's technical efficiency, E_i, is given by:

$E_i = 100 \cdot \exp(-v_i)$ (3)

As v is restricted to positive values, E is bounded by 0 and 100. A value of $E = 100$ thus corresponds to a firm that is fully (or 100%) efficient.

Following Brada et al. (1991), I assume each firm employs two inputs, capital (K) and labor (N), so $a_i = [K_i, N_i]$, and as in McIntyre and Martin, I specify g as a Cobb-Douglas production function so:

$ln[g(a_i,\Psi)] = M + z_K ln(K_i) + z_N ln(N_i)$, (4)

where M is a constant term, and the parameters z_K and z_N denote capital's and labor's share of output respectively; the parameter vector Ψ is thus $[M, z_K, z_N]$. No restrictions on were imposed on the coefficients z_K and z_N or $z_K + z_N$. The model is estimated using a two-stage maximum likelihood procedure; see Aigner et al. or Greene (2008) for more information on the MLE estimator employed here.

The results obtained from estimating (4) are reported in Table 2. I was able to able to obtain consistent estimates for all nineteen industries detailed above. The fit of each model was quite good; all input share parameters were significant at the 1% level or better; only the occasional constant term was insignificant. All parameter estimates carry the correct, positive sign and all have reasonable magnitudes. That is, there are no capital or labor share coefficients that exceed unity and like most production function estimates, one observes $z_K < z_N$. Indeed, along these dimensions, the models are remarkably robust across industries. As in McIntyre and Martin (2013), frontier estimation suggests widespread decreasing returns to scale in Romanian industry. To wit: the last two columns of Table 2 report the results of a Wald test for constant returns to scale, that is, $z_K + z_N = 1$. In every instance, the null hypothesis of constant returns to scale is soundly rejected.

Table 2

Industry Frontier Estimates

	Constant	z_K	z_N	Returns to scale χ^2	Returns to scale *p*-value
Extraction of crude petroleum and natural gas	2.53 (134.190)	0.40*** (0.037)	0.45*** (0.050)	16.09	0.00
Manufacture of food products and beverages	2.63 (0.162)	0.33*** (0.022)	0.46*** (0.024)	88.36	0.00
Manufacture of textiles	3.11 (32.298)	0.27*** (0.029)	0.42*** (0.026)	114.47	0.00
Manufacture of wood products	2.36*** (0.228)	0.39*** (0.042)	0.35*** (0.049)	71.22	0.00
Manufacture of pulp, paper; publishing and printing	2.77*** (0.171)	0.17*** (0.028)	0.54*** (0.040)	71.62	0.00
Manufacture of chemicals and chemical products	2.17*** (0.220)	0.27*** (0.038)	0.54*** (0.050)	22.92	0.00
Manufacture of rubber and plastic products	3.32*** (0.013)	0.24*** (0.002)	0.46*** (0.003)	120.81	0.00
Manufacture of other non-metallic mineral	2.7	0.25***	0.58***	35.84	0.00

products	(47.012)	(0.028)	(0.045)		
Manufacture of basic metals and fabricated metal products	3.42*** (0.058)	0.28*** (0.010)	.44*** (0.014)	477.48	0.00
Manufacture of machinery, n.e.c.	3.69*** (0.013)	0.13*** (0.002)	0.59*** (0.003)	309.49	0.00
Manufacture of electrical and optical equipment	3.41*** (0.012)	0.22*** (0.002)	0.54*** (0.003)	143.91	0.00
Manufacture of motor vehicles	3.90*** (0.377)	0.26*** (0.049)	0.52*** (0.055)	23.44	0.00
Manufacturing, n.e.c.	2.91 (28.236)	0.16*** (0.022)	0.60*** (0.027)	93.48	0.00
Electricity, gas, and water supply	3.99*** (0.030)	0.29*** (0.004)	0.46*** (0.008)	25.95	0.00
Construction	3.81*** (0.007)	0.22*** (0.001)	0.39*** (0.001)	1056.63	0.00
Sale, maintenance and repair of motor vehicles	3.46 (8.437)	0.22*** (0.007)	0.41*** (0.045)	1350.40	0.00
Wholesale of household goods and food products	4.27*** (0.026)	0.14*** (0.005)	0.40*** (0.010)	23.44	0.00
Wholesale of non-agricultural intermediate products, waste, and scrap	4.23*** (0.157)	0.14*** (0.029)	0.42*** (0.053)	175.64	0.00
Transportation, storage, and communication	3.52*** (0.952)	0.15*** (0.009)	0.56*** (0.011)	1631.71	0.00

1) Standard errors in parentheses.
2) Returns to scale are tested using a Wald test. Under the null hypothesis of constant returns to scale ($z_K + z_N = 1$), the test statistic follows a $\chi2$ distribution with one degree of freedom.
3) *** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.

Using the frontier estimates obtained from (4) and from the McIntyre and Martin data set, it is possible to formally test for differences in mean industry efficiency between 2005 and 2010. These findings are found in Table 3, which reports summary statistics on industry efficiency and the results of a series of one-tailed Samawi-Vogel (2014) t-tests for mean differences in technical efficiency. This test was developed for use on data sets that contain samples that are partially paired, which is the case here. Specifically, there is some overlap of firms in both samples; these data should obviously be treated as paired. At the same time, however, there has been considerable firm churn in the five year period ending in 2010, so each set of industry efficiency estimates also contains information for firms in 2005 that were not extant in 2010 and vice versa. This is especially relevant less concentrated industries. In addition and as previously noted, my (2010) data set has approximately three times as many observations as McIntyre and Martin's. So all else being equal, most of these data should be considered independent.

The Samawi-Vogel test follows from a data set consisting of two partially paired samples with n paired observations and n_1 and n_2 the independent observations in 2010 and 2005, respectively. From here, let D denote the mean deviation in technical efficiency among the paired data between 2010 and 2005, and let $\overline{E}_1$ denote mean technical efficiency for the independent observations in the 2010 sample and $\overline{E}_2$ likewise for 2005. The test statistic is:

$$t = \frac{\overline{D} + (\overline{E}_1 + \overline{E}_2)}{\sqrt{\theta_1 s_D^2 + \theta_2 s_P^2}},$$

where $\theta_1 = 1/n$ and $\theta_2 = 1/n_1 + 1/n_2$. s_D^2 is the sample variance of the paired deviations in technical efficiency, s_P^2 is the pooled sample variance of the independent observations:

$$s_P^2 = \frac{(n_1\text{-}1)s_{E_1}^2 + (n_2\text{-}1)s_{E_2}^2}{n_1 + n_2\text{-}2}$$

where $s_{E_1}^2$ and $s_{E_2}^2$ are the sample variances of the independent 2010 and 2005 technical efficiency samples, respectively.

Table 3

Mean Efficiency

	2010	*25*	*n paired*	*n indep. 2010*	*n indep. 2005*	*t-stat*	*df*	*1-tail p*
Extraction of crude petroleum and natural gas	99.08 (0.0116)	97.27 (0.0771)	11	23	6	131.35	36	0.000
Manufacture of food products and beverages	70.13 (7.3534)	51.19 (16.4920)	103	341	125	19.67	210	0.000
Manufacture of textiles	63.40 (13.0351)	98.96 (0.0182)	31	70	85	26.47	66	0.000
Manufacture of wood products	83.73 (7.2277)	45.12 (19.6720)	28	107	52	20.31	61	0.000
Manufacture of pulp, paper; publishing and printing	55.39 (21.8844)	51.70 (12.7285)	23	137	23	0.28	49	0.391
Manufacture of chemicals and chemical products	59.07 (17.2060)	33.06 (28.1444)	19	111	29	3.33	21	0.002
Manufacture of rubber and plastic products	86.76 (1.4015)	57.31 (14.5788)	29	185	24	20.52	37	0.000
Manufacture of other non-metallic mineral products	98.63 (0.0197)	97.21 (0.0695)	32	122	49	230.40	65	0.000
Manufacture of basic metals and fab. metal products	65.66 (14.5362)	50.33 (15.6267)	54	332	93	10.27	124	0.000
Manufacture of machinery, n.e.c.	87.13 (1.6570)	53.77 (17.8588)	39	132	70	23.05	76	0.000
Manufacture of electrical and optical equipment	85.59 (1.9496)	48.94 (17.6632)	43	155	54	26.15	82	0.000
Manufacture of motor vehicles	50.08 (13.7491)	64.75 (12.2626)	39	89	52	-8.12	120	1.000
Manufacturing, n.e.c.	98.87 (0.0185)	97.15 (0.1222)	42	117	76	162.17	77	0.000

Electricity, gas, and water supply	74.54 (3.9231)	24.61 (26.1111)	20	81	33	12.69	22	0.000
Construction	85.16 (1.8762)	98.61 (0.0192)	158	1195	207	-107.9	980	1.000
Sale, maintenance and repair of motor vehicles	99.82 (0.0005)	79.51 (2.7801)	24	250	40	72.63	26	0.000
Wholesale of household goods and food products	89.49 (0.8223)	99.61 (0.0010)	73	755	138	-145.4	133	1.000
Wholesale of non-ag. int. products, waste, and scrap	51.73 (14.0057)	91.63 (0.5841)	24	250	114	23.36	26	0.000
Transportation, storage, and communication	94.81 (0.3101)	95.00 (0.2000)	41	972	47	0.52	85	0.302

1) Standard errors in parentheses
2) *t*-statistic for the difference in mean efficiency 2005-2010 using the Samawi-Vogel (2014) partially paired test.

Under the null hypothesis of no difference in mean technical efficiency,
$t \sim t_{df}$,
where the degrees of freedom, *df*, is the closest integer value to:

$$\frac{(\theta_1 s_D^2 + \theta_2 s_P^2)^2}{\frac{(\theta_1 s_D^2)^2}{n-1} + \frac{(\theta_2 s_P^2)^2}{n_1+n_2-1}}.$$

This series of tests suggests that Romanian industry has in general achieved significant efficiency gains during the 2005-2010 period. 14 of 19 industries surveyed displayed significant increases in technical efficiency at the less than 1% level. Technical efficiency in two sectors---pulp, paper, publishing and printing; and transportation, storage and communication---we statistically equal in 2005 and 2010, while efficiency in four industries---motor vehicles; construction; and intermediate products wholesale---was significantly below 2005 levels on average. In the case of construction, my results mirror those of Liţă and Stamule (2011), who measure low levels of efficiency in many Romanian firms, notably in the construction industry. This is hardly surprising, however, given the impact global financial crisis of 2007-2009 had on the Romanian banking and real estate sectors (Morosan, 2011). As such, it is reasonable to expect that the Romanian construction sector will reverse any measured efficiency losses as the Romanian and global economies strengthen and recover going forward.

Determinants of Enterprise Efficiency

Theory

Given that, on average, Romanian industry has made significant efficiency gains in the 2005-2010 period, it is of interest to investigate those factors which explain firm efficiency in 2010. Indeed, understanding the factors that drive efficiency is of key importance to effective entrepreneurship; for firms wishing to obtain funds and for potential lenders and investors; and for public policy designed to foster and improve the business climate. Most of the candidates for determinants of efficiency are available on a firm's financial statement. I focus on five such potential determinants of efficiency.

Profitability. Profit variables have been traditionally included in efficiency studies of Central and Eastern European manufacturing since the transition period of the 1990s and early 2000s. Such measures were included to account for the possibility of residual profit leveling behavior—the reallocation of funds toward less profitable firms, usually via taxation—in post-Communist industrial policy. Evidence of such behavior was present in Romania in the mid-1990s (Everaert and Hildebrandt, 2001). McIntyre and Martin (2013), however, found no such evidence in study based on 2005 data; more profitable firms were almost always more efficient, the usual competitive market result. Given that result and the fact that Romanian firms were arguably operating in an even more open, competitive environment in 2010 than they were in 2005, one would expect to again find a strong, positive relationship between technical efficiency and profitability.

Size. Romanian heavy manufacturing is still heavily concentrated, an ongoing legacy of its Communist period. Firm size may contribute to efficiency in two contrasting ways. First, larger firms may be in a better position to exploit economies of scale. As such, larger firms in more concentrated industries should be more efficient. In contrast, basic economic theory suggests that larger firms are, unlike smaller, presumably more competitive firms, somewhat insulated from market forces. Accordingly, larger firms have fewer incentives to maximize efficiency. In short, the relationship between firm size and efficiency can be either positive or negative. To measure size, I use the share of firm *i*'s value added as a share of industry (or sample) valued added.

Payroll structure. Like size, a firm's payroll structure can impact efficiency in multiple ways. First, higher employee costs create incentives to substitute away from labor and to innovate, which would positively impact technical efficiency. Similarly, a relatively high wage bill might indicate the presence of efficiency wages, which should also lead to higher work effort and thus higher efficiency. On the other hand, a high wage bill might be reflecting an inefficient production process, excessive union power, or inefficient use of productive resources, all of which would translate into lower efficiency. Labor costs are measured by costs/employee.

Solvency. The relative health of a firm's financial balance sheet is an important indicator of technical efficiency. Relatively high debt levels, are usually viewed as signaling troubled, inefficient firms. To measure balance sheet health, I use the solvency ratio, a common financial accounting metric. The solvency ratio is defined as a firm's earnings (after tax profits) plus depreciation relative to its outstanding debt. In this context, a large solvency ratio is indicative of a healthy firm able to concentrate on maximizing profits and efficiency, that is, aggressive entrepreneurship, as opposed to focusing primarily on debt service and survival.

Liquidity. Another important balance sheet metric that impacts technical efficiency is cash flow, defined as the net amount of money being transferred into and out of a firm. Cash flows are an important determinant of overall firm health as they indicate a firm's wherewithal to pay its bills and to expand and to make investments. The last item, investments, can link to efficiency. In particular, firms with healthy cash flows are in a better position to engage in effective, efficient entrepreneurship.

To investigate the relationship between these factors and technical efficiency at the firm level, I estimate the following regression model for each of the 19 industries previously discussed:

$$E_i = \beta_1 MARGIN_i + \beta_2 SIZE_i + \beta_3 \left(\frac{COST}{EMPLOYEE}\right)_i + \beta_4 SOLVENCY_i + \beta_5 (CASH\ FLOW)_i + \epsilon_i , \quad (5)$$

where E_i is firm *i*'s estimated technical efficiency, previously defined; $MARGIN_i$ its profit margin in percent; $(COSTS/EMPLOYEE)_i$ is self-explanatory and is denoted in 2010 Euros; $SOLVENCY_i$ is firm i's solvency ratio, described above; and $(CASH\ FLOW)i$ firm *i*'s cash flow, also described above and also denoted in current Euros. Lastly, ϵ_i is an i.i.d. error term. Note that in the above model, the constant is suppressed; a firm with profit margin, size, costs, solvency and cash flow equal to zero would suggest a firm has zero output, and as such, technical efficiency would be zero as well.

Results

The results of estimating (5) are reported in Table 4. The results are generally positive and consistent across industrial sectors. Profit margins are usually positive and significant, indicating that more profitable firms are more efficient, the expected result for firms subject to competitive market forces. The paper and printing industry is only one instance of a negative, significant profit margin coefficient. When positive and significant, coefficient magnitudes are typically below 0.50; a 100 basis point increase in profit margin translates into a less than 50 basis point increase in technical efficiency.

Table 4
Determinants of Technical Efficiency

	Profit Margin	*Size*	*Costs/ Employee*	*Solvency Ratio*	*Cash Flow*	*Uncentered R^2*
Extraction of crude petroleum and natural gas	0.89 (0.600)	20.05*** (6.198)	1.67*** (0.528)	0.94*** (0.181)	-0.002*** (0.001)	0.77
Manufacture of food products and beverages	0.10 (0.156)	-0.38*** (0.045)	4.19*** (1.084)	0.81*** (0.102)	0.0002 (0.001)	0.82
Manufacture of textiles	0.73*** (0.198)	24.73*** (8.326)	6.24** (2.802)	0.66*** (0.133)	-0.01* (0.007)	0.88
Manufacture of wood products	0.69 (0.450)	-6.39*** (1.511)	10.78*** (1.133)	0.56*** (0.097)	.002** (0.001)	0.87
Manufacture of pulp, paper; publishing and printing	-0.34** (0.165)	-1.87 (6.915)	2.37*** (0.626)	0.70*** (0.090)	-0.0008 (0.003)	0.67
Manufacture of chemicals and chemical products	-0.13 (0.279)	5.61*** (1.986)	1.67*** (0.516)	0.71*** (0.086)	-0.003*** (0.001)	0.73
Manufacture of rubber and plastic products	0.41*** (0.154)	9.10** (4.634)	7.77*** (0.672)	0.54*** (0.077)	-0.003** (0.001)	0.87
Manufacture of other non-metallic mineral products	0.60*** (0.231)	-0.06*** (0.009)	6.32*** (0.744)	0.71*** (0.105)	-0.001*** (0.0002)	0.85
Manufacture of basic metals and fabricated metal products	0.26 (0.221)	-0.02 (0.021)	4.78*** (0.845)	0.45*** (0.087)	0.0004 (0.0004)	0.87
Manufacture of machinery, n.e.c.	0.43*** (0.155)	7.33 (4.666)	6.23*** (0.673)	0.53*** (0.085)	-0.002 (0.002)	0.92
Manufacture of electrical and optical equipment	0.37*** (0.100)	11.84*** (3.828)	4.82*** (0.664)	0.62*** (0.074)	-0.001* (0.0006)	0.90
Manufacture of motor vehicles	0.45*** (0.126)	-0.18*** (0.011)	0.16** (0.065)	0.64*** (0.039)	0.0004** (0.0001)	0.80
Manufacturing, n.e.c.	-0.09 (0.447)	5.41 (5.176)	9.62*** (1.944)	0.84*** (0.184)	-0.003 (0.003)	0.87

Electricity, gas, and water supply	0.42*** (0.161)	-3.55*** (0.909)	1.64*** (0.417)	0.77*** (0.095)	0.0002*** (0.0001)	0.81
Construction	0.01 (0.017)	-0.06** (0.025)	0.23* (0.122)	1.37*** (0.025)	.004*** (0.001)	0.76
Sale, maintenance and repair of motor vehicles	0.0003 (0.003)	0.07** (0.030)	3.96*** (0.549)	1.16*** (0.051)	-0.002** (0.0007)	0.83
Wholesale of household goods and food products	0.43** (0.168)	0.003*** (0.0001)	2.90*** (0.254)	1.12*** (0.048)	0.0003 (0.001)	0.78
Wholesale of non-agricultural int. products, waste, and scrap	0.43* (0.241)	-0.04 (0.027)	1.58*** (0.536)	1.15*** (0.071)	0.006*** (0.002)	0.81
Transportation, storage, and communication	0.50*** (0.089)	-0.02*** (0.001)	3.68*** (0.628)	1.05*** (0.066)	-0.0001 (0.0001)	0.73

Notes:
1) Estimation method: OLS w/ White heteroskedasticity correction.
2) Standard errors in parentheses.
3) *** = significant at 1% level; ** = significant at 5% level; * = significant at 10% level.
4) Dependent variable: efficiency estimate in %, $100 \cdot e^{-v}$

The impact of firm size on measured technical efficiency differs by sector. The coefficient on size is significant for 12 of 19 industries. In eight cases, it is positive, the remainder are negative. Interestingly, many of the significantly positive size coefficients are found in what is typically considered high value added manufacturing, specifically petroleum and natural gas; chemicals; rubber; machinery; and electric and optical equipment. Although this result bodes well for ongoing efficiency improvements in Romania, it is somewhat unusual given that these—indeed, all—industrial sectors exhibit evidence of decreasing returns to scale. In contrast, significantly negative coefficients are found in less concentrated, more competitive industries like food, construction, and transportation, storage and communication, exactly what theory would predict.

The coefficient on employee costs is positive and significant for all 19 industrial sectors. As suggested in the previous section, this indicates that Romanian firms are able to adjust their input mix so as to maximize profits. And with a naive industry average of approximately 4.25, the relatively large magnitude of these coefficients suggests firm efficiency is fairly sensitive to payroll. That is, a one Euro increase in costs/employee translates into a 425 basis point increase in technical efficiency. Likewise, solvency is positive and significant for all industries surveyed, exactly as theory would predict.

The estimated effects of cash flow, when significant, differ by sector. As discussed, one would expect firms with higher cash flows to be more efficient, all else being equal. This is exactly what is observed in five of the twelve industries when cash flow is significant. In the remaining seven industries the cash flow is significant and negative. A closer look at the industries in which this is observed---petroleum and natural gas; textiles; chemicals; rubber and plastics; non-metallic minerals; electrical and optical equipment; and motor vehicle sale and maintenance---may shed some light on this result. Specifically, these industries all tend to be mature and are generally operating at a high average level of efficiency to begin with. These industries are also ones in which firm size tends to positively impact efficiency. In these sense, firms in these industries are not able to use higher cash flows to "buy" efficiency gains like a firm in a younger, less concentrated industry might. That is, it is likely that higher cash flows in these industries are not being fully directed into efficiency-boosting, profit maximizing improvements and instead going to repurchase shares and pay down debt, that is, towards maximizing a firm's book value. It is thus possible that higher cash flows may contribute to lower efficiency. That said, this is an area identified for further study.

Analogous work by McIntyre and Martin (2013) suggests that the "decisions [Romanian] entrepreneurs make appear largely consistent with profit maximizing behavior in the environment in which they operate." I find that in toto this is also the case here; these results are congruous with firms operating in a fairly competitive market environment. Similarly, my findings are also consistent with standard management practice at both younger and more mature firms.

Conclusion

This paper has examined enterprise efficiency in Romania in the 2005-2010 period. Following the methodology of McIntyre and Martin (2013), technical efficiency is estimated for a 19 industry sample in 2010. The results of this exercise, when compared to analogous results for 2005, suggest that Romanian firms have, on average, made significant efficiency gains in a relatively short period of time. Additional investigation into the economic and financial determinants of technical efficiency loosely suggests that Romanian firms are operating in an increasingly competitive market setting.

There are two broad conclusions that follow from these findings. First, Romania's initial experience with transition to EU membership has gone fairly well from an efficiency perspective. To be sure, observing an almost uniform advance in enterprise efficiency in the face of the greater competitive pressure and a stricter regulatory environment associated with EU accession is particularly noteworthy. Second, it appears as if Romanian firms are operating in an environment mostly consistent with fellow EU member countries. That is, the economic vestiges of Romania's Communist heritage are largely a thing of the past.

Going forward, this study also serves as a benchmark for two important questions. Namely, the results obtained here should provide some firm-level understanding of how Romanian industry reacted over the longer term to the global financial and European sovereign debt crises, and to the resultant series of severe austerity measures and economic reforms enacted by the Romanian government in 2010 and beyond. Structurally, it will also be of interest to Romanian policymakers and investors to determine the extent to which Romanian firms are able to consolidate and build upon recent gains in measured industrial efficiency. Indeed, the rate at which Romanian firms are able to converge with the rest of the EU should influence further structural and fiscal reforms proposed and attempted by Romanian authorities. Ongoing investigation in this area is certainly warranted, and five years is a relatively short period in development terms, but the results of this study bode well for Romania's future growth potential..

Acknowledgements
I would like to thank Rachel Kling for helpful research assistance.

References

Aigner D., Lovell, C., and Schmidt, P. (1977). "Formulation and Estimation of Stochastic Frontier Production Functions." *Journal of Econometrics 6*, pp. 21--37.

Andrieş, A. and Cocriş, V. (2010). "A Comparative Analysis of the Efficiency of Romanian Banks." *Romanian Journal of Economic Forecasting 13*(4), pp. 54-75.

Bonin, J., Hasan, I., and Wachtel, P. (2008). "Privatization Matters: Bank Efficiency in Transition Countries." Bank of Finland--Institute for Economies in Transition Discussion Paper #8.

Brada, J., King, A. and Ma, C.Y. (1997). "The Industrial Economics of the Transition: Determinants of Enterprise Efficiency in Czechoslovakia and Hungary." *Oxford Economic Papers 49*, pp. 104-127.

Budina, N., Maliszewski, W., de Menil, G., and Turlea, G. (2006). "Money, Inflation and Output in Romania, 1992-2000." *Journal of International Money and Finance 25*, pp. 330-347.

Cojanu, V. (2006). "Optimum Competitive Area: Romania's Economic Integration in Southeastern Europe." *Transition Studies Review 13*(1), pp. 175-198.

Dardac, N. and Moinescu, B. (2009). "The Third Wave of the Financial Crisis and Its Ripple Effects on the Deterioration Risk of Romanian Banking Sector's Performance." *Economic Computation & Economic Cybernetics Studies & Research 43*(1), pp. 23-40.

Demekas, D. and Khan, M. (1991). "The Romanian Economic Reform Program." IMF Occasional Paper No. 89.

Everaert, G. and Hildebrandt, A. (2001). "On the Causes of Soft Budget Constraints: Firm-Level Evidence from Bulgaria and Romania." LICOS Centre for Transition Economics discussion paper 109/2001.

Greene, W. (2008). *Econometric Analysis*, 6th edition. Upper Saddle River, NJ: Pearson/Prentice Hall.

Hollanders, H. and Esser, F. (2007). "Measuring Innovation Efficiency." INNO-Metrics Thematic Paper, December.

Încalţărău, C. and Maha, S.S. (2010). "Romania's EU Accession Impact on the Development of [SIC] Romanian Economy." Centre for European Studies (CES) Working Paper II(1).

Liţă, I. and Stamule, T. (2011). "Stochastic Frontier Analysis of Production Function and Cost Function Estimation Methods. Study of Efficiency at Industry Level [SIC]." *Management & Marketing Challenges for the Knowledge Society 6*(1), pp. 163-176.

McIntyre, K., and Martin, C. (2013). "Estimates and Determinants of Firm Efficiency in Eastern Europe: Evidence from Romanian Microdata." *Eastern European Economics 51*(2), pp. 58-89.

Meeusen, W. and van den Broeck, J. (1977). "Efficiency Estimation From Cobb-Douglas Production Functions with Composed Error." *International Economic Review 18*(2), pp. 435-444.

Morosan, G. (2011). "Effects of the Romanian Economic Crisis upon the Banking System." *The USV Annals of Economics and Public Administration 11*, No. 1(13), pp. 245-254.

Roman, A. and Şargu, A. (2012) "Bank Efficiency Evaluation: Evidence from a Panel of Romanian Banks." *Journal of Eastern Europe Research in Business & Economics*; Article ID 592522, pp. 1-14.

Staikouras, C., Mamatzakis E., and Koutsomanoli-Filippaki, A. (2008). "Cost Efficiency of the Banking Industry in the South Eastern European Region." *Journal of International Financial Markets, Institutions, and Money 18*, pp. 483-497.

Samawi, H. and Vogel, R. (2014). "Notes on Two Sample Tests for Partially Correlated (Paired) Data." *Journal of Applied Statistics 41*(1), pp. 109-117.

Stoichu, V. (2012). "Austerity and Structural Reforms in Romania: Severe Measures, Questionable Economic Results and Negative Social Consequences." Friedrich Ebert Foundation International Policy Analysis paper (August).

Zugravua, B.-G., and Sava, A.-Ş. (2012). "Recent Changes in Public Sector Efficiency in Romania: Determinants and Implications." *Procedia - Social and Behavioral Sciences 58*, pp. 423-433.