AN EFFICIENCY AND TOTAL FACTOR PRODUCTIVITY ANALYSIS OF THE ISLAMIC AZAD UNIVERSITY

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Abstract - This study examines the role productivity and efficiency in the Islamic Azad University (IAU) of Iran by using the stochastic frontier production function over the period 2006 through 2009. The focus of this paper is using a model of stochastic frontier analysis (SFA). The gap between the most efficient and least efficient state has decreased by 34% across the study. An often made assumption of constant returns to scale may not be appropriate for IAU of regions. The elasticity of capital and labor are calculated at 0.376 and 0.530 respectively indicating diminishing returns to scale. In IAU, TFP growth stems from both improved technical efficiency and technological progress. TFP growth accounts for 84.2% of all growth in output. Just over 31% of the regions output growth IAU has experienced between 2006 and 2009 is the result of advancement in the production frontier.
Key words: Efficiency, Productivity, Stochastic Frontier Analysis, Elasticity, Islamic Azad University (IAU)

1. INTRODUCTION

The remarkable economic growth in Iran since the 1990s has highlighted the importance of human capital investment. It is well documented that investment in human capital is one of the key factors sustaining the growth of any economy. Changes in the education sector have long-term impacts on an economy, but particularly on an economy like Iran′s undergoing economic petroleum. Assessing the education sector in Iran during its education reforms thus provides a real-world case for understanding the education sector′s responses to the changing environment during economic petroleum. Interpreting the effects of the recent education reforms in Iran is complicated by the economic reforms in progress at the same time. It is well documented that the economic reforms of the past two decades have resulted in growth imbalances among Iran′s regions. Based on the fourth development plan, all of the I.R of Iran, total factor productivity (TFP) should reach 2.5% per year. Thus, according to the plan, all organization, institutions and enterprises should recognize the factors affecting their total factor productivity growth (TFPG). Productivity has been always one of the important issues and a faced challenge by managers in business firms. These firms try to set directions in their planning so that increase organizational productivity or total factor productivity (TFP). One of the key factors to increase TFP is human resource. By developing and simple access to academic education in Iran, many employees tend to gain higher education so that it has created some opportunities and challenges for both employees and firms. In recent years demand for accountability and transparency has increased in most industrialized countries.

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The pressure on public budgets has led governments to control and pursue efficiency and productivity in the allocation and management of public sector resources, Bonaccorsi & Daraio (2005). This public concern has forced government to take responsibility for evaluation and control of public funding institutions. Governments have started to develop evaluation systems and programs to control these institutions, systems that are proving beneficial for the design of policy to improve the effectiveness of funding institutions. There is a wide range of public institutions involved. Education institutions are of interest because education, especially higher education, is one of the main sources of economic growth Denison (1962). Verry & Davies (1976) comment that "Universities are major users of the nation's resources. Inefficiency in the university sector represents a real welfare loss as surely as does the misallocation of resources elsewhere in the economy. In this sense, at least, higher education is no different from any other industry." Thus, designing and making improvements in educational policy can lead to higher economic growth. In this paper, we use a mathematical concept called stochastic frontier analysis (SFA) to study the research performances of the Islamic Azad University (IAU) OF regions in Iran.

2. Literature review

Inclusion of a random component in the model allows the SFA approach to account for uncontrollable production disturbances such as natural disaster or bad luck. Selecting a suitable functional form to represent the production technology is an important concern of this approach.Various functional forms have been employed in analysis utilizing SFA. Many authors have selected the Cobb-Douglas function to represent the production technology, for example, Battese and Coelli (1995) and Mahadevan (2000). The transcendental-logarithmic (translog) function is the most prevalent functional form used in efficiency studies, , Lundvall and Battese (2000), and Margono and Sharma (2003) among others. Choosing the appropriate functional form will affect the quality of efficiency estimates. Other functional forms have been used to define the production technology. The Fourier-flexible functional form has been widely used as well, e.g., and Carbo, Gardner and Williams (2002). Using shadow cost and distance functions, for stochastic estimation of inefficiency, has been proposed by Atkinson, Fare and Primont (2003). SFA has been applied across a broad range of economic sectors to analyze efficiency. These methods have been widely used to estimate efficiencies in various industries including manufacturing, power generation, farming, and mining. Many studies have applied SFA to the agriculture sector, recent examples include:, Coelli, Sanzidur, and Thirtle (2003), and Latruffe, Balcombe, Davidona, and Zawalinska (2004) among others. Some manufacturing sector studies include:, Margono and Sharma (2002) among many others. Sharma et al. (2005) used SFA to estimate efficiency in the underground mining industry. Efficiency studies have included the financial sector as well. Much of this attention has been directed towards U.S. and European banks, for example Margono and Sharma (2007) look at efficiency among Indonesian banks. Most of the SFA literature is applied to microeconomic units such as firms, factories, or farms. But more recently, SFA has been employed to estimate regional economic efficiency. Wu (2001) estimated efficiency of Chinese Provinces. Sharma, Sylwester, and Margono (2007) estimate efficiency among states in the U.S. Adkins, Moonmaw, and Savides (2002) used SFA to estimate a worldwide production frontier.SFA has also been extended to other fields of study. Chakraborty, Biswas, and Lewis (2001) use SFA to rank Utah school districts in terms of technical efficiency.

Depken, Nguyen, and Sarkar (2006) use SFA to analyze the link between the principal agent problem and stock price.

3. Description of the Islamic Azad University system in Iran

Universities and higher education institutes are governed by a board of trustees. Newly founded and smaller higher education institutes are governed by a joint regional board of trustees. The number of state universities has grown from 32 in 1988 to 127 in 2008. Islamic Azad University, as the first private university, Azad University benefited from educational facilities including buildings, equipment and laboratories offered by local officials and generous people. Islamic Azad University is a private chain of universities in Iran. Headquartered in Tehran, Iran, the Islamic Azad University was founded in 1982 and currently has an enrollment of 1.5 million students; making it the world's third largest. Azad University has over 400 branches across the country and also in other countries. It has branches and universities in U.A.E, United Kingdom, Tanzania, Lebanon and Armenia. Islamic Azad University has started to launching universities and branches in Malaysia, Canada, Afghanistan and Tajikistan. These will open in a near future. Over the years, the university has accumulated assets estimated to be worth between $20 and $25 billion. The university system also operates a news agency similar to ANA, named "Azad News agency". Islamic Azad University's activities quickly expanded throughout the country, so that today thousands of students are benefiting from its high educational standards. Not relying on government funding, it receives charitable donations and charges students with tuition fees. The certificates issued by this university are recognized by the Ministry of Science and Higher Education. Master's and doctorate programs have been offered in many different branches of Islamic Azad University. The Islamic Azad University is Iran's largest private university with a proud history of achievement in its rather short life and with an ambitious agenda for the future to appear as one of the leading universities in the world. The University has more than 3,700,000 graduates, successfully involved in various fields in the country and overseas; and also about 1,600,000 students currently studying in various majors in all university levels. It covers almost every subject in its curriculum and delivers extensive flexibility and choice to its students. The Islamic Azad University has an exceptional record of generating and sharing new ideas and the quality, breadth and volume of its research activity is unparalleled in Iran,Fathi et al. (2012).

4. METHODOLOGY

Kumblakar and Lovell (2000) defines technical efficiency (TE) as a feasible input output vector where it is technically impossible to increase any output (or reduces any input) without simultaneously reducing another output (or increasing another input). The production frontier describes the technical relationship between the input and output of a production process. It defines the maximum outputs attainable from a given set of inputs. States operate on that frontier if they are technically efficient or beneath the frontier if they are not technically efficient. A state that is technically efficient may still be able to improve its productivity (measured as the ratio of output to inputs) by exploiting scale economies (SC). Altering scale of production may be difficult to achieve quickly, therefore SC can be given a long-term interpretation while TE can be thought of as a short term phenomenon.When comparisons of productivity across time are considered, it is possible to encounter another source of productivity change described as technological progress.Technological progress (TP) can be

defined as a shift in the production frontier. An upward shift in the production frontier may represent advances in technology. If it is observed that a state has increased its productivity from one time period to the next, the improvement need not have been from efficiency improvements alone, but may have been due to technological progress, exploitation of scale economies, or from some combination of these factors (Coelli, Rao, O'Donnell, and Battese, 1998). Traditional measures of productivity are labor productivity, capital productivity, land productivity, etc. These are considered partial measures of productivity. However, it is desirable to have a measure of productivity involving all factors of production that takes into account TE, TP, and SC. Kumblakar and Lovell (2000) provided such a measure for the stochastic production frontier model that is called total factor productivity (TFP) growth. Following Aigner, Lovell and Schmidt (1977) and Meesuen and van den Broeck (1977), the production function to be estimated is expressed as:

$$y^{it} = f(x_{it}, t, \beta)e^{\varepsilon it} \quad where \ \varepsilon^{it} = v_{it} - u_{it} \tag{1}$$

In equation (1), y^{it} denotes the observed output level of state i at time t, x_{it} is the vector of productive inputs specific to state i at time t, β is a vector of unknown coefficients, the disturbance term ε_{it} □is composed of vit and uit which are independent of each other and the time trend t captures TP. The exponential factor $e^{\varepsilon it}$ measures TE for the state concerned and v_{it} is a random error component. The u_{it} term includes a vector of state specific factors that are associated with technical inefficiency. To obtain the estimate of TE, it is necessary to define the functional form $f(x_{it}, t, \beta)$ in equation (1) prior to estimation. The translog production function developed by Christiansen, Jorgensen and Lau (1973) is the most prevalent functional form used in stochastic frontier analysis literature for a number of reasons. First, it provides some degree of generality as it is a second order approximation to an arbitrary functional form. Other familiar functional forms such as the Cobb Douglas and CES are special cases of the translog function so these common forms are encompassed by the translog production function. Second, the translog function allows for varying returns to scale and for technological progress to be both neutral and factor augmenting. Additionally, partial elasticities of substitution are allowed to vary and elasticity of scale can vary with output and input proportions (Sharma, Sylwester, and Margono, 2005). The time varying translog production function of state i can be specified as in (2)

$$\ln y_{it} = \beta_0 + \Sigma_j \beta_j \ln_{j,it} + \beta_i t + \frac{1}{2}\Sigma_j \Sigma_k \beta_{jk} \ln x_{j,it} \ln x_{k,it} \tag{2}$$
$$+ \frac{1}{2}\beta_{it} t^2 + \sum_j \beta_{it} \ln x_{j,it} t + \varepsilon_{it}$$

where $\varepsilon_{it} = v_{it} - u_{it}$ $i = 1,2,\ldots,n$ $t = 1,2,\ldots,T$ *and* $j,k = 1,2,\ldots,k$; N is the number of states included in the analysis, T is the number of time periods in the data series, and K is the number of inputs considered. Maximum likelihood method is used to estimate the translog production frontier in equation (2). Using the stochastic frontier framework facilitates the deconstruction output growth into individual components. The three components of output growth (OG) are defined as: output growth due to a change in the quantity of inputs employed Y*□, output growth due to a change in technical efficiency TE* and growth in output due to a change in technological progress TP*. Consequently, observed productivity changes between periods may not have resulted exclusively from changes in

efficiency. Productivity changes may emanate from any combination of these three components. To decompose observed output growth into individual components we follow the framework of Madhadevan and Kalirajan (1999). Decomposition of output growth is illustrated graphically in Figure (1). Technological progress is represented by advancement in the frontier from F1 to F2. Capitalizing on technological innovation will allow a state to achieve higher output while employing the same level of inputs. Technological progress is defined as the Distance between the frontiers, for example F1 and F2 evaluated at X1 or (Y1* -Y1**). A state that is technically efficient can produce at output level Y1* and Y1** in periods 1 and 2 respectively while employing X1 level of inputs. Production output levels Y1* and Y2* are consistent with technical efficiency in period 1.
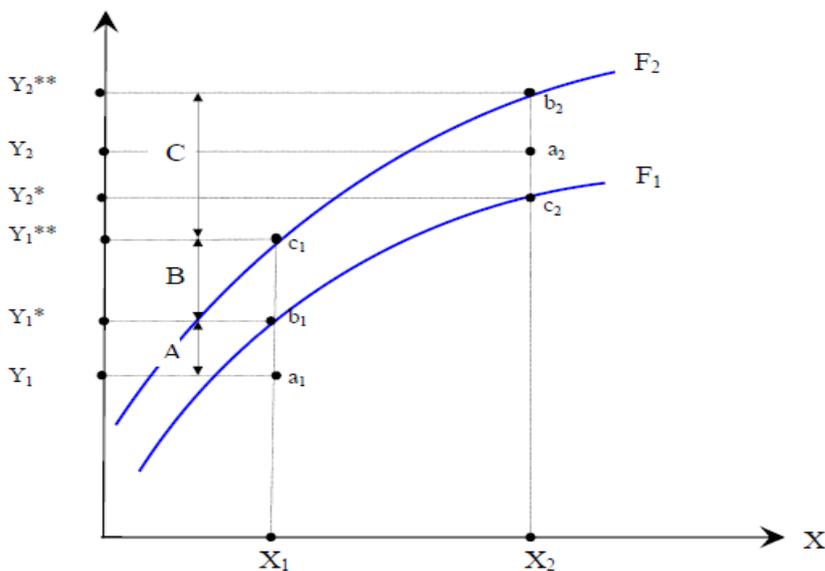

Figure (1) Graphical Representation of Output Growth Due to
Technological Progress, Efficiency, and Input Growth
Technical inefficiency is evident when a state is producing at an output level that is
below the production frontier. For example, producing output Y1 in period 1 using input level X1, and producing Y2 with inputs X2 would indicate the presence of technical inefficiency. The difference between the frontier level of output and the observed level of output represents inefficiency in terms of output loss. Technical efficiency in period 1 (TE1) is measured by the vertical distance between Y1* and Y1. Technical efficiency in period 2 (TE2) is measured by the vertical distance between Y2** and Y2. The contribution to output growth from the change in technical efficiency TE* □can be expressed by the difference between TE2 and TE1 or equivalently (Y2**_ Y2) _ (Y1*_Y1). Technical efficiency improvements are indicated by a positive value TE*□. Comparing the output levels associated with X1 and X2 along the frontier F2 or equivalently (Y2**_Y1**) determines the output growth due to a change in inputs (Y*) Using this framework, total output growth can be decomposed into three components:

OG =A+B+C
= (Y1*-Y1) + (Y1**- Y1*) +(Y2-Y1**)
= (Y1*-Y1) + (Y1**-Y1*) +(Y2-Y1**) +(Y2**-Y2**)
= (Y1*-Y1) + (Y1**-Y1*) +(Y2**-Y2) +(Y2**-Y1**)
=((Y1*-Y1) + (Y2**-Y2)) +(Y1**-Y1*) +(Y2**-Y1**)
= TE+ TP*+Y*   (3)
Where total factor productivity growth TFP* ☐is defined as TE* +TP*

5. DATA
The annual survey of IAU is the principal source in Iran; consistent data is available for 12 regions for the time period included in this study. Output for this study is the value of total IAU output for each region; Total output is comprised of tuition, income housing and other revenues. Inputs into the production function estimation include capital and labor.

6. EMPIRICAL RESULTS
6.1. ESTIMATION
Following Battese and Coelli (1995), maximum likelihood estimation is used to simultaneously estimate the parameters of stochastic production frontier (2) and the factors contributing to inefficiency. The software program FRONTIER 4.1C is used for estimation.2 the inputs for model (2.2) includes capital (K), labor (L), and the time trend (t).
The output elasticity of capital and labor is determined by taking the partial derivative of the production function (2.2) with respect to each of the inputs. The output elasticity's are given by:

$$ek_{it} = \beta_1 + \beta_4 lnlnk_{it} + \beta_7 lnL + \beta_8 t \qquad (4)$$
$$el_{it} = \beta_2 + \beta_5 lnl_{it} + \beta_7 lnK + \beta_9 t \qquad (5)$$

6.2. EFFICIENCY ANALYSIS
Parameter estimates for the translog production frontier depicted by equations (2) is presented in Table (1). The null hypothesis that β4 ☐through β9 ☐are all equal to zero is rejected at conventional significance levels with a chi-square statistic of 56.04 so we find that the translog is preferred to the Cobb-Douglass functional form. γ denotes the variance from the inefficiency component of the error term divided by the total variance. Since the estimation of γ is very close to 1, we conclude that the majority of variation in the total error, ε, comes from the inefficiency component and not from measurement error. The likelihood ratio test for the null hypothesis that $\gamma = 0$ and $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$
is 30.49 with 6 degrees of freedom. In the event this null hypothesis had been rejected, it would indicate that none of the state characteristics matter for inefficiency and the model could be consistently estimated using ordinary least squares.

Table (1) Coefficient Estimates of Translog Production Function and Efficiency Components of IAU

		Coefficient	Standard Error	
β0	(intercept)	3.89476	0.15275	*
β1	(lnK)	-3.53470	0.28963	*
β2	(lnL)	4.89113	0.50420	*
β3	t	-0.18675	0.01169	*
β4	$.5(lnk)^2$	-0.38942	0.08715	*
β5	$.5(lnl)^2$	-1.17317	0.14180	*
β6	$.5(t)^2$	-0.00884	0.01137	
β7	(lnK lnL)	0.73976	0.10848	*
β8	(lnK t)	0.01855	0.00886	*
β9	(lnL t)	-0.00195	0.01665	
Inefficiency components				
δ0	(intercept)	0.03602	0.49235	
δ1	(% ser. Industry)	0.12741	0.53535	
δ2	(% ag. Industry)	1.54689	0.59547	*
δ3	(% man. Industry)	-1.63828	0.54146	*
δ4	(relative output size)	-2.80677	1.11065	*
σ2	(Variance of Inefficiency)	0.09696	0.01303	*
Γ	$\sigma_u^2 \big/ (\sigma_u^2 + \sigma_v^2)$	0.99999	0.00292	*

* Denotes significance at the 5% level

Most of the coefficients are statistically significant with the expected signs. A negative sign associated with capital is not expected. However, to accurately determine the effect of a change in output due to a change in capital requires the evaluation of the output elasticity of capital. The sign of the coefficient for the time trend is negative and significant. A negative time trend indicates the deterioration of technological progress. The second order term of the time trend indicates the direction and acceleration of technological progress with respect to time. From the small and statistically insignificant coefficients associated with the time trend second order term, it would appear that technological progress with respect to time has been stagnant over this period.

Mean technical efficiency for the IAU of regions over the period from 2006 to 2009 is estimated to be 73.83%. Overall, average annual efficiency displays an increase from a low of 69.78% in 2006 to the highest average annual efficiency of 83.83% occurring in 2009. Increasing technical efficiency indicates that IAU has moved closer to the production frontier over time. Using the estimated annual technical efficiency for each region across the study period, we are able to rank regions in terms of efficiency. Table (2) displays the efficiency, also includes mean technical efficiency estimates for each region and its rank over the entire 2006 to 2009 periods. Region (8) has the highest mean technical efficiency across the entire time period at 93.46% and Region (2) is the least efficient at 45.45%. region (5) has experienced the largest change in technical efficiency. In 2006, at 76.20% and in 2009 it rises to 95.66%. There is evidence of convergence among IAU of regions in terms of technical

efficiency. In the first year under study, Region (2) is least efficient at 40.20% and Region (8) is the most efficient at 98.89%. In the final year under study, Region (2) is the least efficient at 56.65% and Region (6) is the most efficient at 99.59%.

Table (2) Technical Efficiency Estimates in IAU of segregated regions

Region	2006 Eff	2007 Eff	2008 Eff	2009 Eff	Mean Eff	Rank
Region (1)	71.19	63.31	77.74	69.00	63.27	9
Region (2)	40.20	38.02	57.88	64.77	45.45	12
Region (3)	70.43	80.63	83.11	94.81	82.97	5
Region (4)	77.42	83.60	90.29	88.70	84.03	4
Region (5)	76.20	79.22	97.17	95.66	79.39	6
Region (6)	84.89	84.31	96.56	99.59	87.42	2
Region (7)	57.26	60.22	80.15	85.70	73.65	8
Region (8)	98.89	90.52	96.64	94.17	93.46	1
Region (9)	74.05	62.36	73.59	85.56	74.41	7
Region (10)	76.87	89.69	89.79	88.43	86.19	3
Region (11)	54.78	56.43	65.34	69.77	58.77	10
Region (12)	55.29	61.75	66.47	69.90	56.95	11
Average	69.78	70.83	81.22	83.83	73.83	

6.3. ELASTICITY ANALYSIS

Table (3) displays the mean estimates of both the capital and labor elasticity for each region as calculated using equations (4) and (5). For all IAU of regions, the average value across the sample for output elasticity of capital is 0.376 while that for labor is 0.530. Both elasticities are positive indicating that as these inputs are increased, output increases. This Table represents elasticity estimates of each state in each period of the study. Returns to scale is determine by summing the two elasticities eK and eL. If the sum is less than one decreasing returns are indicated, if greater than one increasing returns to scale are indicated. Adding the two together, we determine the returns to scale for IAU of regions is 0.942, implying that there are decreasing returns to scale. Much of the literature that examines aggregate economies often relies on the assumption of constant returns to scale. Assumption of constant returns to scale may not be appropriate for examining the IAU of regions. Three regions exhibit negative capital elasticity but indicate increasing returns to scale due to very high labor elasticity. region (3), region (7) and region (12) have eK of -0.270, -0.103, and - 0.215 respectively while returns to scale for these regions are 1.20, 1.18, and 1.21.

Table (3) Mean Elasticity Estimates in IAU of segregated regions

	eK		eL		
Region	mean	Std.dev	mean	Std.dev	Ek+eL
Region (1)	0.883	0.044	-0.199	0.093	0.683
Region (2)	0.105	0.154	0.793	0.345	0.898
Region (3)	-0.270	0.090	1.472	0.180	1.202
Region (4)	0.419	0.034	0.217	0.094	0.636
Region (5)	0.371	0.063	0.731	0.155	1.102
Region (6)	0.390	0.089	0.489	0.181	0.879
Region (7)	-0.103	0.096	1.287	0.206	1.184
Region (8)	0.412	0.018	0.556	0.067	0.968
Region (9)	0.633	0.046	0.017	0.070	0.650
Region (10)	0.162	0.047	0.862	0.106	1.023
Region (11)	0.748	0.075	0.122	0.179	0.870
Region (12)	-0.215	0.067	1.429	0.171	1.214
Avrage	0.294		0.647		0.942

eK and eL denote elasticity of capital and labor respectively

6.4. TOTAL FACTOR PRODUCTIVITY ANALYSIS

From equation (3) along with the parameter estimates, values for the components of IAU output growth can be calculated for the time period encompassed by this study. The results of IAU output growth decomposition for India overall is presented in Table (4). IAU experienced average annual real industrial output growth of 7.9% over the period. Growth is positive the first and last of the 4 periods with highest output growth level occurring in the last year of the study 18.2%. TE* □averages 4.2% with the greatest change in output due to technical efficiency occurring in the last period at 11.1%. TP* is positive in all periods and averages 2.5% across the study, implying that average TFP* is 6.7%. Industrial output growth attributed to increasing of inputs averages 1.2%. A substantial portion of growth in industrial output observed in this study emanates from increases in total factor productivity.

Table (4) Decomposition of IAU Output Growth

Time period	Output Growth	Due to Input Growth	TFP Growth	Due to Change in TE	Due to TP
2005-2006	0.167	-0.027	0.139	0.102	0.038
2006-2007	-0.024	-0.020	-0.003	-0.032	0.029
2007-2008	-0.009	-0.016	-0.007	-0.012	0.020
2008-2009	0.182	0.059	0.123	0.111	0.012
Average	0.079	0.012	0.067	0.042	0.025

7. CONCLUSION

This paper examines efficiency, elasticity and total factor productivity growth in IAU. The objective of this paper is the application of SFA to analyze economic problems beyond the

traditional IAU. This objective will be achieved by completing three separate studies using SFA. Technical efficiency in the IAU of the 12 regions encompassed by this study averaged 73.5% over the period. The gap between the most efficient and least efficient state has decreased by 34% across the study. There is evidence of convergence among IAU regions in terms of technical efficiency. The gap between the most efficient and least efficient state has decreased by 34% across the study. An often made assumption of constant returns to scale may not be appropriate for IAU. The elasticities of capital and labor are calculated at 0.376 and 0.530 respectively indicating diminishing returns to scale. In IAU, TFP growth stems from both improved technical efficiency and technological progress. TFP growth accounts for 84.2% of all growth in output. Just over 31% of the regions output growth IAU has experienced between 2006 and 2009 is the result of advancement in the production frontier.

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