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Technology and education effects on labor productivity in the agricultural sector in Iran

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ABSTRACT

This article estimates the major determinants of labor productivity in the agricultural sector and investigates how effects of Technology and Education have changed labor productivity in the agricultural sector in Iran. The theoretical framework is based on this assumption that the Technical progress is divided to two sections; first section is the specified technical progress and second section is the unspecified technical progress. This study uses annual time series data (1961-2007) and unit root tests and analyze them using Auto Regressive Distributed Lag (ARDL) model by Pesaran et. al. (2001). This co-integration technique accommodates potential structural breaks that could undermine the existence of a long-run relationship between labor productivity in the agricultural and its main determinants. Together the independent variables explained 92% of the variance in the dependent variables. The remaining 8% was due to unidentified variables. In relation to that, we can conclude that explanatory power is high for the equation. It showed that one percent change Technology and Education rate lead to decrease 23% in labor productivity in the agricultural sector. Therefore Technology and Education have positive effects on labor productivity in the agricultural sector and is regarded as an important factor in labor productivity in the agricultural sector in Iran.

Key words: Technology and Education, labor productivity, Agricultural sector, Auto Regressive Distributed Lag (ARDL)

INTRODUCTION

Technology is a system of integrated so that by entering one of its products, the way is opened for other system components. It isn't detachable from their roots and to access it is necessary preparing specific preliminary. Also technology has culture of its own and use of technological products leads to cultural change in society by itself. At this moment, several countries in the world have already completed or nearly completed a demographic transition which is a transition from a rural agrarian society with high fertility and mortality rates to an urban industrial society with low fertility and mortality rates [1]. During such a period of time, working-age population (15 – 64 years old) is likely to grow slower than old-age dependent population (65 years old and over), leading to the diminishing proportion of working-age population and the increasing proportion of old-age population.

It is obvious that governments all over the world are holistically executing Information and Communication Technologies (ICTs) as a key enabler for accelerating and achieving economic and social development in their country [2]. ICT has been a must and an important tool for improving delivery of public services, making government more transparent and accountable, broadening public participation, facilitating the sharing of information and knowledge among the people, and integrating marginalized groups and deprived regions. The constructive looking to regional analysis revels that there have been some notable successes in e-governance in the Asian region, for example in Korea, Malaysia and Singapore, the overall rate of failure of e-government initiatives internationally has been very high as well. The challenge facing many governments today, especially those in developing countries like Sri Lanka, is to avoid the temptation of introducing ICT for ICT's sake. Instead, the focus must firmly be on the human aspect and the needs of the citizens, and then deciding how best, and in what context to apply ICTs to enable effective delivery of those needs.

Ways of labor productivity by education: Human capital is included: Science, knowledge, migration, experience, ability, health, abilities and regularity and discipline that is stored by education and health workforce and is to increase work efficiency in production. The concept of human capital not only is used for education and training, but refers to any activity which increases the quantity and productivity of the workforce and will further increase income levels. The costs of health and migration can also be considered apart from investment in human capital. Today, skilled workforce is as one of the most important sources of economic growth, therefore, training human resources professional and efficient (producing human capital) and use it located in the center planners. Human capital is responsible an important role in process development of advanced industrial countries and is the result of human capital the main difference between these countries and low-income countries. Generally, education through the following increase workforce productivity: 1) Educated people are doing more work at the same time and their work has a higher value in addition to have high efficiency increase the efficiency of the group. 2) Educated people lead to increase the final factor in the productivity of capital and in particular, production equipment and facilities and increasing the national production provide areas to achieve economic growth in the community. 3) Educated people will find lead to suspend the law of diminishing returns, in practice. Also cause the increased levels of technology manufacturing enterprises. 4) Educated people on equal terms, able to carry out the invention, exploration and innovation more this also, increases the productivity quickly. 5) Educated people can create major developments at industrial countries with the optimal allocation scarce resources, and with savings due scale they contribute to more economic growth.

There are studies in literature which focused on the same question [3, 4 and 5], But these studies mainly investigate the impact of information and communication technology development for productivity growth for the panel of highly developed economies. Their main aim is to explain the productivity differential between Europe and US. Moreover most of above mentioned studies covered the period of 1992-2001. There are various countries specific case studies exploring the determinant of labor productivity growth in a particular country [6, 7 and 8].

Studies performed in Iran shows about 90 percent of Iranian territory are located in the Iranian Plateau. The Land of Iran is considered generally mountainous and semi-arid. More than half the area of the country is formed mountains and highlands, one-fourth of it deserts and less than one-fourth other also arable land. Generally nearly 31 percent of Iran's soil, i.e. about 51 million hectares, is with good and moderate agricultural potential the 64% of it means that about 33 million hectares not used for production (operating [9]). Also rate of fixed investment is negligible in the agricultural sector compared with other major sectors of the economy and particular does not fit with value added of this sector. Growth rate of value added of this sector often has been in the past two decades, positive and significant while the value added in other sectors of the economy, has been affected by reducing or increasing oil revenues [10]. Thus, the evaluation workforce productivity is necessary in the agricultural sector in Iran's economy.

The present research explores from macro perspective an alternative way in which the labor productivity growth in agricultural sector could be explored employing time series data. Following Greenan [11], the theoretical framework is based on this assumption that the Technical progress is divided to two sections; first section is the specified technical progress and second section is the unspecified technical progress. For that purpose, we use the bounds testing (or ARDL) approach to co-integration proposed by Pesaran [12] to test the relationship between Technology and Education and labor productivity in agricultural sector using data over the period 1961–2007. The ARDL approach to co-integration has some econometric advantages which are outlined briefly in the following section. Finally, we apply it taking as a benchmark Greenan [11] study in order to sort out whether the results reported there reflect a spurious correlation or a genuine relationship between Technology and Education and labor productivity and the variables in agricultural sector. This contributes to a new methodology in the labor productivity literature. Next section starts with discussing the model and the methodology. Then in next section we describe the empirical results of unit root tests, the F test, ARDL co-integration analysis, Diagnostic and stability tests and Dynamic forecasts for dependent variable and next sections summarizes the results and conclusions.

MATERIALS AND METHODS

The model: The model proposed here is based on Greenan [11] that their model was established based on Harrod. Before investigation of the effects of education and technology on labor productivity, we explain about summary of technical progress. Technical progress is divided to two sections; first section is the specified technical progress and second section is the unspecified technical progress so that unspecified technical progress is divided to three sections; capital-saving, labor-saving and unbiased. Unbiased technical progress can be defined to three methods; Hicks, Harrod and Solow economic growth model. Now we investigate theoretical Principles in the effects of education and technology on labor productivity and we focus on growth accounting. We assume that production function to be as following:

$$Y = f(K,L) \qquad (1)$$

Where, Y is amount of production, K is capital stock and L is a mount of human capital and it's expected to be product growth due to growth of inputs. After the performance of totally differentiating Equation (1) and mathematical operations it gives:

$$dY = f_K dK + f_L dL \qquad (2)$$

$$\frac{dY}{Y} = f_K \frac{dK}{K}.\frac{K}{Y} + f_L \frac{dL}{L}.\frac{L}{Y} \qquad (3)$$

$$\dot{Y} = \eta_K \dot{K} + \eta_L \dot{L} \qquad (4)$$

Where, $\dot{Y}$ is production growth rate, $\dot{K}$ is capital growth rate, $\dot{L}$ is human capital growth rate, η_K is capital share of income and η_L is human capital share of income. In 1950s, economists studying America's economy founded that amount of seventy percent of product growth was explained by Production of growth factors and the remaining 30% is due to residual [13]. Edvard Denison called it as measure of our ignorance. Now there is one question so that what shows residual? In Harrod technical progress, production function is as following:

$$Y_t = F(K_t, E_t) \qquad (5)$$

$$E_t = e^{\lambda t}$$

The mathematical operations give:

$$\dot{Y} = \eta_K \dot{K} + \eta_L \dot{L} + \eta_E \lambda_L \qquad (6)$$

Where $\eta_E \lambda_L$ is residual and λ_L is technical progress as enhancing workforce so that is called the growth rate of labor productivity. Therefore can be conclude that technical progress effects on labor productivity [13]. Based on Greenan [11], technical progress Harrod is as following:

$$Q = AK^{\alpha}E^{\beta} \qquad (7)$$

Where Q is value added, E is labor productivity, K is capital, A is technology coefficient and α, β are fixed parameters. In equation (7), labor productivity is defined as following:

$$E = Le^{\text{Ɣ}\rho} \qquad (8)$$

Where ρ is Information and Communication Technology (ICT) indicators and Ɣ is workforce performance. By substitution of effective labor (E) in equation (7) and the two sides divided on L and natural logarithm performed it gives:

$$Ln\left(\frac{Q}{L}\right) = Ln(A) + \alpha Ln\left(\frac{K}{L}\right) + (\alpha + \beta - 1)Ln(L) + \delta\rho \qquad (9)$$
$$\delta = \gamma\beta$$

Indeed this equation can show the relationship between labor productivity, physical capital growth, workforce growth and ICT indicator in economic growth. We use technology and education progress instead of ICT indicator therefore, the following modified in logarithm form is used to examine the technology and education progress in labor productivity in Iran. The logarithm equation corresponding to Eq. (9) and breakdown of the factors labor productivity gives:

$$LLP_t = \alpha_0 + \alpha_1 LK_t + \alpha_2 LL_t + \alpha_3 LTE_t + e_t \qquad (10)$$

Where LLP_t and LK_t are Logarithm of labor productivity and investment in 1997 constant prices based on million dollars, *LLt* and LTE_t is Logarithm of workforce and Technology-Education based on thousand numbers. Technology-Education data is based on the number of employed workforce with a higher education than total labor. Our empirical analysis in next section is based on estimating directly long-run and short-run variants of Eq. (10). All the data in this study are obtained from *Central Bank of Iran (2004)*[1] and the *Statistical Center of Iran* during the period 1961-2007.

The methodology: In order to examine short run and long run relationships between independent variable and explanatory variables, it can be used Engle Grenger [14] model and Error Correction Model. However, it is suggested to use Auto Regressive distributed lag [15] model because of Limitations in the Engle Grenger [14] and Error Correction Model, avoid the shortcomings of these models such as existence of skewed in small samples and lack of ability in testing statistical hypothesis. In using this approach not required to be identical the degree collective variables which it is essential in the Engel Granger. Also this method Short-term and long-term patterns in the model estimates simultaneously and solves Problems related to omitted variables and solidarity, so estimates method ARDL because avoid, such problems, auto correlation and the endogenous are non diagonal and efficient and therefore was used in this study ARDL Model [16]. Can be showed ARDL model[2] extended as follows:

$$a(L,P)y_t = a_0 + \sum_{i=1}^{k} \beta_i(L,q_i)\chi_{it} + u_t, \qquad i = 1,2,\ldots\ldots, k \qquad (11)$$

Where, α_0 is constant, y_t is dependent variable and L is lag factor and it is defined as following:

$$L^j y_t = y_{t-j} \qquad (12)$$

Therefore

$$\alpha(L,P) = 1 - \alpha_1 L^1 - \ldots - \alpha_p L^p$$
$$\beta_i(L,q_i) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + \ldots + \beta_{iqi}L_i^q$$

Therefore, ARDL model for labor productivity function is as following:

$$LLP_t = \alpha_0 + \sum_{i=1}^{m} \beta_i LLP_{t-i} + \sum_{i=1}^{n} \varepsilon_i LK_{t-i} + \sum_{i=1}^{k} \gamma_i LL_{t-i} + \sum_{i=1}^{f} \mu_i LTE_{t-i} +$$
$$\varepsilon_0 LK_t + \gamma_0 LL_t + \mu_0 LTE_t + u_{1t} \qquad (13)$$

Where, *m*, *n*, *k* and *f* are the optimal number of lag for LLP_t, LK_t, LL_t and LTE_t respectively. For the estimation of long run relationship can be use two-stage method so that in first method, it is tested the existence of long run relationship between variables being investigated. In this equation, if total estimated coefficients related to

[1] *National Accounts of Iran* in 1997 constant prices
[2] Auto Regressive Distributed Lag developed by Pesaran and Pesaran [15] and Pesaran and shin [18]

dependent variable lags was be smaller than one, dynamic pattern is oriented toward long-term equilibrium. Therefore, for co-integration test it is necessary to hypotheses test as following [17]:

$$\begin{cases} H_0 : \sum_{i=1}^{m} \beta_{i-1} \geq 0 \\ H_1 : \sum_{i=1}^{m} \beta_i - 1 \prec 0 \end{cases}$$

$$t = \frac{\sum_{i=1}^{m} \hat{\beta}_t - 1}{\sum_{i=1}^{m} S\hat{\beta}_i} \qquad (14)$$

t statistic calculation compared with critical value presented by Banerjee [19], Dolado and Mester in the desired bound level, can be discover existence or non existence long run relationship between model variables. If there be proved a stable long run relationship, in second step, it is performed estimation and analysis of long run coefficient and inferences about their values. In long run, the following variables are established as:

$$\begin{aligned} LP_t &= LP_{t-1} = \ldots = LP_{t-m} \qquad & K_t &= K_{t-1} = \ldots = K_{t-n} \qquad (15) \\ L_t &= L_{t-1} = \ldots = L_{t-k} \qquad & TE_t &= TE_{t-1} = \ldots = TE_{t-f} \end{aligned}$$

Therefore, long run relationship for labor productivity can be showed as following:

$$LLP_t = \delta_0 + \delta_1 LK_t + \delta_2 LL_t + \delta_3 LTE_t + u_{2t} \qquad (16)$$

Basis of use Error Correction Models (ECM) is provided by the existence of co-integration between a series of economic variables. ECM equation for ARDL model can be showed as following:

$$\Delta LLP_t = \Delta\hat{\alpha}_0 + \sum_{i=1}^{m} \hat{\beta}_i \Delta LLP_{t-i} + \sum_{i=1}^{n} \hat{\varepsilon}_i \Delta LK_{t-i} + \sum_{i=1}^{k} \hat{\gamma}_i LL_{t-i} + \sum_{i=1}^{f} \hat{\mu}_i \Delta LTE_{t-i} + \theta ECM_{t-1} + u_{3t} \qquad (17)$$

Where, ECM_{t-1} is as following:

$$ECM_t = LLP_t - \hat{\alpha}_0 - \hat{\varepsilon}_1 LK_t - \hat{\gamma}_1 LL - \hat{\mu}_1 LTE_t \qquad (18)$$

Where, Δ is the first difference operator and $\hat{\beta}_i, \hat{\varepsilon}_i, \hat{\gamma}_i and\ \hat{\mu}_i$ are estimated coefficient in equation (13) and θ is error correction coefficient that can measure the speed of adjustment. For each of the variables, the number of optimum lags can be determined by Akaike, Schwarts Bayesian and Hannan-Quinn information criterion.

RESULTS AND DISCUSSION

Unit Root Tests: A random process when is stationary that Average and variance is fixed during the time and value covariance between two periods of time, depends on only the distance or interval between two periods communication is not real-time covariance calculation. Despite variable non stationary causes that have not of credit t and F tests and regression become to a false regression. Hence, it is necessary that before any other action, first be performed test for stationary identified. Different test there is to identify variables stationary one of these tests is unit root test. The problem there is in conducting such a test, this is the statistic t, is not have normal distribution, even for large samples. As a result, cannot be used of critical value t for testing. To resolve this problem, used Dickey-Fuller [20] generalized Test (ADF). The ADF test should utilize of following equations and then examined approve or reject the zero hypotheses.

$$\Delta Y_t = \delta Y_{t-1} + \theta_i \sum{}^{m}{}_{i=1} \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

$$\Delta Y_t = a + \delta Y_{t-1} + \theta_i \sum{}^{m}{}_{i=1} \Delta Y_{t-i} + \varepsilon_t \qquad (2)$$

$$\Delta Y_t = a + bt + \delta Y_{t-1} + \theta_i \sum{}^{m}{}_{i=1} \Delta Y_{t-i} + \varepsilon_t \qquad (3)$$

In the above equations, δ is equal to $\rho - 1$ and zero hypothesis is based on existence of unit root or non stationary variable studied including $\delta = 0$ and against hypothesis is based on stationary variable studied including $\delta \prec 0$ or $\rho \prec 1$. Also in estimation above equation, interruptions number of dependent variable is determined by Akaike, Schwarz Bayesian and Hannan-Quin information Criterion to eliminate auto correlation between error sentences in regression. A summary of the unit root tests using the Dickey-Fuller [20] data set is given below in Table 1.

Table 1: Results of unit root by ADF test

Variables	Level	1st Differences	integrated of order
LLP	-1.11	-4.46*	I(1)
LK	-1.51	-5.18*	I(1)
LL	-0.87	-3.52*	I(1)
LTE	-3.01	-7.09*	I(0)

*Note: * denote statistical significance at 1%*

The results reported in Table 1 indicates that null hypothesis of ADF unit root is accepted in case of *LLP*, *LK* and *LL* variables but rejected in first difference at 1% level of significance. This unit root test indicate that *LLP*, *LK* and *LL* variables considered in the present study are difference stationary *I(1)* while *LTE* variable is level stationary *I(0)* as per ADF test. On the basis of this test, it has been inferred that *LLP*, *LK* and *LL* variables are integrated of order one *I(1)*, while *LTE* variables is integrated of order zero *I(0)*. The computed break dates correspond closely with the expected dates associated with the effects of the revolution and war in 1979 and 1980 respectively. Under these circumstances and especially when we are faced with mix results, applying the ARDL model is the efficient way of the determining the long-run relationship among the variable under investigation. Therefore, we will apply this methodology in the next section.

The F test: The calculated F-statistics in the co-integration test for labor productivity in agricultural sector as dependent variable is displayed in table 2. The critical value is reported together in the same table which based on critical value suggested by Narayan [21] using small sample size between 30 and 80. Firstly, an Ordinary Least Square (OLS) regression is estimated for the first differences part of equation and then tested for joint significance of the parameters of the lagged level variables. The joint null hypothesis of the coefficients being equal to zero means no long-run relationship has been tested with F-statistics. The presence of co-integration between the variables is accepted if F-statistics reject the null at 95 per cent critical bound values.

Table 2: Bound Test for Co-integration

Dependent Variable (Intercept and no trend)	SBC Lag	F-Statistic	Probability	Outcome
F_{LLP} (LLP| LK, LL, LTE)	1	5.897	0.005	Co-integration
F_{LK} (LK| LLP, LL, LTE)	1	0.5743	0.344	No Co-integration
F_{LL} (LL| LLP, LK, LTE)	1	0.3126	0.354	No Co-integration
F_{LTE} (LTE| LLP,LK, LL)	1	1.4561	0.471	No Co-integration

The calculated F-statistics (5.897) is higher than the upper bound critical value at 5 per cent level of significance (4.306), using restricted intercept and no trend. This implies that the null hypothesis of no co-integration cannot be accepted at 5 percent level when regression is normalized on variables other than *LLP*. This implies that there exists only one long-run co-integrating relationship.

ARDL co-integration analysis: The empirical result based on ARDL tests repeated showed that the most significant break for variables of under investigation are consistent with time of revolution and war. Therefore, at this stage we include two dummies variable (revolution in 1978 and war in 1979); in order to take into account the structural breaks in the system. Based on equations (11) and (12), results of the estimated model were presented for labor productivity in agricultural sector by Schwarts Bayesian criterion and considering 2 lag. The estimated coefficients of the long-run relationship and Error Correction Mode (ECM) are displayed in Table 3.

Table 3: Estimated Long-run and ECM Coefficients using ARDL (2,0,0,0,0) Model

Estimated long-run coefficients			Estimated ECM coefficients (LLP as dependent variable)		
Regressor	Coefficient	t-Ratio(prob)	Regressor	Coefficient	t-Ratio(prob)
LK	0.34	2.75[005]	DLK	0.32	3.34[004]
LL	-0.27	-5.34[002]	DLL	0.24	5.65[001]
LTE	0.11	5.94[001]	DLTE	0.09	6.32[000]
C	3.97	3.24[004]	DC	2.01	4.87[003]
DU1978	-0.12	-5.45[002]	DDU1978	-0.11	-5.68[001]
DU1980	-0.14	-2.81[005]	DDU1980	-0.13	-4.64[003]
			ECM(-1)	-0.45	-5.48[002]

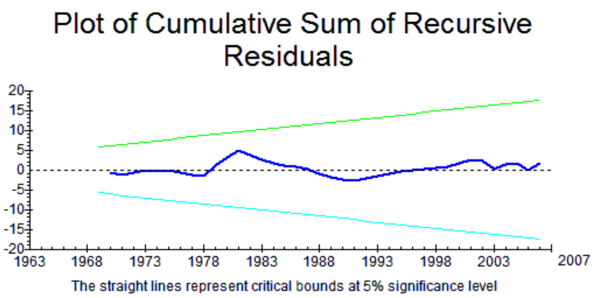
Note: The order of optimum lags is based on the specified ARDL model.

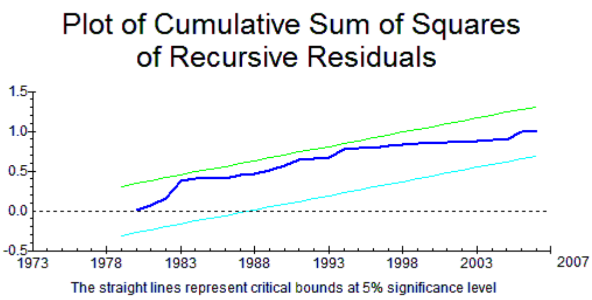
The results of above table shows that all estimated coefficients are significant in 5 per cent and signs are consistent with the theoretical principles. Technology-Education and physical capital growth in agricultural sector have positive and significant effect on labor productivity growth in Iran's economic. The role of physical capital growth is most effect on labor productivity than other variables. Other results this paper is that in short term workforce growth has a positive and significant effect on labor productivity but in long run has a negative and significant effect on labor productivity. After physical capital growth, workforce growth in agricultural sector has most effect on labor productivity and Technology-Education growth has less effect on labor productivity. It may be due to low years of university because in during studied, the average of educational years is 4.2 i.e. it is less than the number of educational years in primary school. Therefore, cannot be expected that Technology-Education will be large effects on labor productivity in agricultural sector.

As we see in Table 3, ECM version of this model show that the error correction coefficient which determined speed of adjustment, had expected and significant negative sign. Bannerjee [19] holds that a highly significant error correction term is further proof of the existence of a stable long-term relationship. The results indicated that deviation from the long-term in inequality was corrected by approximately 45 percent over the following year or each year. This means that the adjustment takes place relatively quickly, i.e. the speed of adjustment is relatively high.

Diagnostic and Stability Tests: Diagnostic tests for serial correlation, normality, heteroscedasticity and functional form are considered, and results are show that short-run model passes through all diagnostic tests in the first stage. The results indicate that there is no evidence of Autocorrelation and that the model passes the test for normality, and proving that the error term is normally distributed. Functional form of model is well specified but there is existence of white heteroscedasticity in model. The presence of heteroscedasticity does not affect the estimates and time series in the equation are of mixed order of integration, i.e., *I (0)* and *I (1)*, it is natural to detect heteroscedasticity.

Also, analyzing the stability of the long-run coefficients together with the short run dynamics, the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) are applied. According to Pesaran and Shin [22] the stability of the estimated coefficient of the error correction model should also be empirically investigated. A graphical representation of CUSUM and CUSUMSQ are shown in Fig. 1.





As the results show, statistic tests above are inside straight lines i.e. they are stability coefficients significant at 5%. It means that cannot be rejected zero hypothesis based on stability coefficients bound at 95%.

CONCLUSION

The goal of this paper was to test the existence of long run relationship determinants of labor productivity growth in agricultural sector in Iran. This objective was aided by the technique of Pesaran et al. (2001) approach to co-integration which presents non-spurious estimates. Subsequently, our work provides fresh evidence on the long run relationship between labor productivity growth and Technology-Education growth in Iran. The results at relationship between labor productivity growth and Technology-Education growth confirm the studies of Greenan et. al. (1996) but our results is more robust. Also, this paper showed that there is a long run relationship between labor productivity growth and workforce, Technology-Education and physical capital growth and in Iran Technology-Education growth have been had a less effect on labor productivity than other determinants.

Therefore, is recommended encourage investment in Technology-Education by internal and external resources to be improve electronic substrates and to be result areas for technology advances. Also, it must be provided the use of technology in field of production, sale, marketing, purchase of raw materials and macro-economic investment because industries and firms can be enters in external and internal rivalries.

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