NEW ECONOMY Section

HOW SENSITIVE ARE ESTIMATES OF TOTAL FACTOR PRODUCTIVITY GROWTH TO MEASUREMENT ASSUMPTIONS IN THE CASE OF THE ROMANIAN ECONOMY?

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Abstract. *Total factor productivity (TFP) growth is a key aspect of assessing the growth potential of a country. In this paper, we evaluate the sensitivity of estimates of total factor productivity growth to different assumptions on the value of the output elasticity of capital and on the extent of returns to scale. The calculation is based on a Cobb-Douglas production function approach for the Romanian economy over the period 1995 to 2017. The results indicate that small variations in assumptions can lead to considerable differences, particularly in the case of the assumptions on the output elasticity of capital. The sensitivity of TFP estimates highlights the importance of considering the endogeneity of labor and capital inputs when estimating TFP growth, especially for countries, like Romania, which have experienced significant structural change.*

Keywords: *total factor productivity growth, Cobb-Douglas production function, output elasticity of capital, returns to scale.*

1. Introduction

Total Factor Productivity (TFP) is defined as the portion of output not explained by the quantity of inputs used in production (Comin, 2008). In the broadest sense, it captures how efficiently factors of production are utilized. An extensive literature on growth accounting, beginning with Solow (1956), finds that long run growth of income per capita cannot be driven by factor accumulation alone, not least due to diminishing returns (Hall and Jones (1999). This holds even when measures of capital are broadened to include education (human capital) (Prescott, 1997).

Benkovskis et al. (2012) also highlight the particular importance of TFP in Central and Eastern European economies like Romania. Between

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the culmination of economic transition and the onset of the financial crisis, growth in the region was supported by factor accumulation, large inflows of foreign capital, and ample availability of credit. It is unclear whether similarly favorable conditions will return in future. In Romania, the contribution of capital to potential GDP has shrunk in the years since the crisis, and demographic pressures have weighed on the contribution of labor. TFP has been the main driver of potential growth since 2012 and is expected to remain so in the coming years (European Commission, 2018, see Graph 1.2).

Furthermore, the sustainability of successive ad-hoc increases in public sector wages and the statutory minimum wage since 2016 has been called into question, creating a policymaking imperative for exploring Romanian TFP. Most recently stoked by a further 9% increase in the minimum wage (January 2018) and 25% increase in public sector wages (July 2017), the former has increased more than 60% since 2015, and the latter more than 70% (European Commission, 2018). In 2017, labor compensation grew twice as fast as productivity, and a continuation of this trend may put pressure on competitiveness and inflation unless productivity can keep pace. Accurate estimation and meaningful interpretation of TFP in Romania is therefore more important than ever to understand past growth and recognize opportunities to promote future growth and stability.

Pritchett (1996) highlights the controversy around interpreting TFP, ranging a residual 'measure of our ignorance' (Abramovitz, 1956) to a scale-factor representing physical technology or the stock of technical knowledge (Comin, Hobijn and Rovito, 2006). This controversy, and his findings that technical knowledge does not account for all changes in TFP, lead Prescott (1997) to call for a new theory of TFP, to better understand its far-reaching role in economic growth. Subsequent research identifies entrepreneurship (Erken et al., 2016), economic openness (Brøchner-Madsen, 2005) and working practices (Prescott, 1997) as determinants of TFP, amongst others.

Two other growth drivers beyond technical knowledge which the standard neoclassical production function will attribute to TFP are structural and institutional change. The importance of these to TFP in the Romanian economy cannot be overstated, as complex socio-political transformations were required before technological innovations became productivity gains (Freeman and Perez, 1989; Romer, 1993).

Any empirical efforts to better understand TFP and its role alongside labor and capital hinge on its accurate estimation, which is highly sensitive

to assumptions underpinning the production function (Ghosh and Kraay, 2000). Given that uncertainty around these assumptions is greater in Romania and similar economies than in more established and developed Western countries, this paper explores the sensitivity of TFP to the output elasticity of capital and on the extent of returns to scale.

Given its residual nature, the growth rate of TFP is perhaps more important than its level. In this context, acknowledging the endogeneity of capital and labor is important when assessing the role of TFP growth in the economy. Pritchett (1997) highlights the potential for TFP-induced factor accumulation, arguing that that capital per worker in developed countries is high precisely *because* TFP is high. This mechanism is particularly important in the context of the drastic structural change in the Romanian economy over the analyzed period (1995-2017). Benkovskis et al. (2012) use industry-level data to explore the endogenous role of TFP growth in driving the growth of other components of GDP. Whereas in most Central and Eastern-European economies, TFP growth was most important in driving growth of exports, in Romania it was most important in driving gross fixed capital formation. This endogeneity is tackled using the ratio between the covariance and variance of TFP growth and GDP growth (Klenow and Rodriguez-Clare, 1997) as a more representative estimate of the extent to which TFP drives growth in output.

2. Measuring total factor productivity growth

This paper models the Romanian economy using a Cobb Douglas production function, whereby real output is a function of labor, capital and total factor productivity (TFP). The functional form assumes constant elasticity of factor substitution.

$$Y_t = A_t(L_t^{\beta}K_t^{\alpha})^{\gamma}. \quad (1)$$

Where Y stands for output, A stands for the total factor productivity, L for the labor input, K the capital input and $\beta = 1- \alpha$. γ measures the extent of returns to scale, such that if $\gamma = 1$, $\gamma > 1$ or $\gamma < 1$, there are constant, increasing and decreasing returns to scale, respectively. β and α represent the output elasticities of labor and capital respectively. These are constants determined by technology and economic conditions.

In countries with a smaller grey economy, β can be calculated as the ratio of labor compensation to gross value added, but this is inadequate for Romania for two reasons. Firstly, this method does not account for the income of family workers and the self-employed (Bergoeing et al., 2002),

and the size of this group in Romania means that failure to consider its role in the economy would be to significantly underestimate the labor share of income. Romania's shadow economy has been estimated at 28% of GDP (Schneider, 2016), and the share of employees receiving envelope wages (underreported salaries) is double the EU average (Williams and Horodnic, 2017). Secondly, the low values of beta produced by this labor compensation method imply unrealistically high returns on capital (Altar, 2010). Many papers on the Romanian economy (Dobrescu, 2004; Altar, 2010 and Galatescu et al., 2007) assume $\beta = 0.65$ (and consequently $\alpha = 0.35$).

The contribution of Total Factor Productivity (TFP) to GDP can be indirectly measured by rearranging Equation (1) which gives the following identity:

$$A_t = \frac{Y_t}{(L_t^{\beta} K_t^{\alpha})^{\gamma}} \tag{2}$$

Where *A* stands for the total factor productivity, *Y* for real GDP, *L* for the labor input, *K* the capital input and $\beta = 1 - \alpha$.

3. Data and methodological issues

The labor input was estimated using a method similar to Burns et al. (2014); as a function of the working age population (15-64), the participation rate (PR), and unemployment (UR). Formally:

$$L_t = P_{(15-64)t} PR_t (1 - UR_t). \tag{3}$$

Once more, the sizable grey economy in Romania means that participation is underestimated by official statistics, though existing information still allows us to be more accurate than data sparse countries.

Calculating Romania's capital stock proved to be the main challenge of the production function approach, since frequent revaluations of capital stock by the National Institute of Statistics makes official statistical data unreliable. In light of this, the capital stock was calculated using the perpetual inventory method (PIM):

$$K_t = K_{t-1}(1-\delta) + GFCF_t. \tag{4}$$

Where K stands for capital stock, δ stands for capital depreciation rate and GFCF stands for gross fixed capital formation. Consistent with existing literature specific to Romania (Galatescu et al., 2007; Altar et al., 2010), this paper uses a constant value of 5% for.

Furthermore, whilst gross fixed capital formation data is readily available, sourcing a reliable initial estimate of the capital stock (in our case K_{1996}) remains problematic. This was calculated through a two-step process:

First, WIOD data (Timmer et al. 2015) was used to estimate the Capital (*K*) to GDP ratio in 1995 (1.69), by which the real GDP for 1995 was multiplied to give a preliminary capital stock. The PIM method was then applied, and *K*/GDP ratio was calculated for subsequent years.

Second, a method similar to that of Bergoeing et al. (2002) was used to refine these estimates. The *K*/GDP ratio at the start of the period was assumed to be equal to the average of the *K*/GDP ratios for the rest of the period (1996-2017, calculated in the first step). This gave us a higher starting *K*/GDP (2.27) than the first step (see Table 1 for comparison), and this was then used to construct a new capital stock series using the perpetual inventory method (PIM).

It must be noted that a common alternative method for the second step exists – as suggested by Harberger (1978). By this methodology, the growth rates of GDP and of capital stock are assumed equal, on the basis that the economy evolves on a balanced growth path. As such $(K_{2017} / K_{1995})^{1/23} = (Y_{2017}/Y_{1995})^{1/23}$, where *K* and *Y* are growth rates of capital stock and GDP respectively. Rearranging this equation gave a 1995 *K*/GDP ratio of 2.75, which likely overestimates the capitalization of the Romanian economy so early in its economic transition. As such, the lower alternative produced by Bergoeing's methodology was preferred. After calculating the capital stock for Romania in the period 1995-2017 using the procedure presented above, we obtained an average capital to GDP ratio of 2.54, consistent with the values found in the literature.

Table 1
Capital to output ratio estimates

Methodology	Min	Max	Average
Bergoeing et al. (2002)	2.23	2.42	2.32
Denis et al. (2006)	2.18	2.39	2.27
Harberger (1978)	2.33	2.57	2.45
IMF (2003)	1.98	2.30	2.11

Source: Data compiled for the period 1996-2008 by Altar et al., 2010.

Given the capitalization of Romania's economy in the nine years since the end of Altar's sample, our higher K/GDP ratio is to be expected. It should also be stressed that the accuracy of the initial value of *K* has a

decreasing impact on subsequent estimates. As time passes and capital depreciates, less and less of the starting capital stock is still in use. At a depreciation rate of 5%, only 32% of the 1995 capital stock remains in use by the end of our estimation period in 2017.

Separately, Pritchett (1996) highlights a further problem with using the PIM to estimate the capital stock in countries like Romania where venality, corruption and patronage are pervasive. 85% and 82% of Romanian firms still identify corruption and patronage as obstacles to business respectively (European Commission, 2017). The cost of these forces above the value of an investment itself may lead gross fixed capital formation (cost of investment) to overestimate the capital stock (economic value of investment), leading the production function to underestimate TFP. Tacking this is beyond the scope of this paper but is worth noting when considering results.

4. Results: the assumptions about the production function matter

The resulting estimates of TFP growth depend on the values of the parameters α and ϒ. These parameters are not directly observable and are based on various assumptions, documented in the previous chapters, from which specific values are derived. To explore the sensitivity of TFP growth estimates to changes in these assumptions, the paper calculates TFP growth for different values of α and ϒ. The results (see table 2) suggest that the assumptions regarding the capitalization of the economy has the highest impact.

Table 2

The assumptions about the production function matter

	Average annual TFP growth in Romania (%)		
	α = 0.3	**α = 0.35**	**α = 0.4**
ϒ= 0.8	2.4	2.1	1.7
ϒ= 1	2.5	2.3	2.0
ϒ= 1.2	2.6	2.4	2.2

Source: Authors calculations

Increases in α reflect increases in the weight of capital. Since average annual growth of the capital stock over the analyzed period (1995-2017) was 4.1 percent, compared to –0.8 percent for the labor force, an increase in α leads to a decrease in the TFP growth. An increase in α from 0.3 to

0.35, which is the most common value used for the Romanian economy, results in an up to 0.3 percentage point drop in the average TFP growth (see Table 2). In other words, a change in the value of α in the range of values used for the Romanian economy lead to a change in the TFP growth estimation of around 13 percent.

Increases in γ quantify how much of output growth can be ascribed to an increase in resource utilization or to the shifting of resources from less productive to more productive firms. Institutional arrangements play an important role, since markets which are less rigid and have better regulation in place can better allocate resources and adjust to change. Romania's institutional environment has made significant progress since transition but has very recently begun to deteriorate (World Bank 2017, World Economic Forum, 2017). As expected, higher values of γ lead to higher values of TFP growth. For α equal to 0.35, an increase of γ from 1 to 1.2 leads to a change in the TFP growth estimation of over 5 percent. This could be attributed to the sensitivity of the estimation to changes in γ, but also can also be understood as the positive impact of good institutional arrangements on TFP growth.

GDP grew on average by 3.1 percent in the analyzed period, while TFP only by 2.3 percent, for α equal to 0.35 and γ equal 1. A rule of thumb calculation indicates that the contribution of TFP to growth was just over 70 percent. However, this result could be misleading because it ignores the endogeneity of capital and labor in calculating TFP growth. The results of Benkovskis et al. (2012) empirically demonstrate TFP-induced gross fixed capital formation in Romania.

This endogeneity be addressed by investigating the ratio between the covariance and variance of TFP growth and GDP growth (Klenow and Rodriguez-Clare. 1997). This ratio indicates a much higher contribution of TFP to growth of 97 percent, compared to the initial rule of thumb estimation. The result points to the type of TFP growth observed in the Romanian economy, especially during the transition to a market economy, namely the ample correction of resource allocation. From this perspective, employment contraction before 2005 (as high as 11 percent in 2002) reflected profound labor restructuring and structural changes in the economy.

5. Conclusions

The estimation of TFP growth for the Romanian economy is highly sensitive to the assumptions on the capitalization of the economy. A

change in the value of α in the range of values used for the Romanian economy led to a change in the TFP growth estimation of around 13 percent.

The sensitivity to the assumptions regarding ɤ is lower. For a value of α equal to 0.35, which is the most common value used for the Romanian economy, an increase of ɤ from 1 to 1.2 led to a change in the TFP growth estimation of over 5 percent. The result can also be viewed from the perspective of the positive impact of institutions (decreased market rigidities and better regulation) on TFP growth.

The contribution of TFP to GDP growth reflects the correction of the resource misallocation in the Romanian economy and the profound labor restructuring process that took place especially before 2004. These results highlight the importance of considering the endogeneity of labor and capital inputs in estimating TFP growth, especially for countries which have experienced significant structural change in their economies.

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