Box 3. Post-crisis dynamics of total factor productivity (TFP): a sectoral analysis

Economic recovery in Romania after the financial crisis was driven by the expansion in most economic sectors. Considering the high sectoral heterogeneity in the relative utilisation of production factors, as well as in capital and labour endowments, the box aims to identify the business areas that made positive contributions to economic growth as a result of the more efficient utilisation of the aforementioned factors. The level of detail is given by the breakdown into 10 economic sectors, in compliance with the Statistical classification of economic activities in the European Community (NACE Rev. 2).

Under the circumstances, the box: (i) provides a brief presentation of the production function methodology, which helps assess sectoral efficiency; (ii) shows gross value added (GVA) dynamics in the analysed economic sectors and their contribution to total GVA in the economy, highlights developments in capital stock and employment (and also in their shares), and (iii) presents the results regarding total factor productivity (TFP), assessed by applying the production function methodology for each economic sector.

(i) The production function methodology applied at sectoral level

The production function and economic theory on productivity measurement are generally associated with the outstanding contribution of economist Robert Solow (1957). Specifically, the performance of economic activity (measured by the GDP variable or, alternatively, the GVA variable) can be seen as a result of the contributions from the two production factors, capital and labour, to which adds total productivity, namely the efficiency of factor utilisation. TFP is determined as a residual component (known, in fact, as the Solow residual), being interpreted as an indicator of technological progress. TFP may be correlated with structural factors (such as the quality of institutions or labour and capital mobility) or circumstantial factors (like capacity utilisation – see, for instance, Planas *et al.*, 2010) in the economy.

The production function has alternative specifications. This box uses the Cobb-Douglas production function, in which the shares of capital and labour make up 100 percent and technological progress is *Hicks-neutral* (meaning that a technology shock does not affect the shares of labour and capital). Thus, economic growth is decomposed as follows:

$$\Delta y_t = (1-\alpha)\cdot\Delta k_t + \alpha\cdot\Delta l_t + \Delta tfp_t \qquad (1)$$

where: α is the share of labour and Δy, Δk, Δl and Δtfp – the dynamics of GDP (GVA), capital stock, labour and TFP respectively. The aforementioned specification has the advantage of lending itself to an easy interpretation of the contributions of production factors to economic growth, being also preferred by both the

academia and several institutions[1] for theoretical and quantitative analyses. The key properties of this specification refer to: (i) constant returns to scale (for instance, a 10 percent rise in each production factor – capital and labour – results in a 10 percent increase in total output); and (ii) elasticity of substitution equal to one (a change in relative factor prices does not lead to shifts in the shares of the two factors).

The *α* parameter may be estimated using the income method. Nevertheless, the drawback of this method is that only the compensation of employees is available in the national accounts data, corresponding to a fraction (approximately ¾) of employment economy-wide, the rest being self-employed, family workers, etc. This box builds on the approach employed by the IMF and the European Commission (in publications such as *World Economic Outlook*, 2012 or Arpaia *et al.*, 2009)[2], based on the simplifying assumption of workers in the other categories being remunerated at the average compensation of wage earners. Under these circumstances:

$$\alpha = \frac{C}{GVA} \cdot \frac{E}{N} \tag{2}$$

where: *C* – compensation of employees; *GVA* – gross value added; *E* – employed persons; *N* – number of employees.

Given that the box aims to assess sectoral TFP, the empirical analysis builds on applying equation (1) for each of the 10 economic sectors under analysis. This procedure implies estimating, for each sector, time series for capital and labour stock, as well as their corresponding shares, in line with equation (2).

The formula to assess sectoral TFP is thus the following:

$$\Delta tfp_{i,t} = \Delta GVA_{i,t} - (1 - \alpha_i) \cdot \Delta k_{i,t} - \alpha_i \cdot \Delta l_{i,t} \tag{3}$$

where: i is a sector-specific index taking values from 1 to 10.

(ii) Main developments in economic sectors in the post-crisis period

Between 2011 and 2017, economic sectors posted highly heterogeneous developments. Specifically, GVA in "Information and communication", "Retail trade" and "Professional activities" saw substantial average annual increases (over 10 percent), whereas GVA in "Agriculture", "Financial and insurance activities", "Real estate activities" and "Industry" witnessed only moderate rises (Chart A). GVA in the other sectors reported modest average annual increases (below 2 percent). These developments were mirrored in sector contributions to economic growth. Thus, the major contributors were "Retail trade", "Services" (particularly "Professional activities", "Information and communication" and "Real estate activities") and

1 For instance, this specification is employed by the European Commission to assess potential GDP for EU-28 Member States. This methodology is detailed in Havik *et al.*, 2014.

2 The box titled "Labour income share: level, trend, determinants" in the 2016 issue of the NBR's *Annual Report* illustrates alternative approaches.

"Industry". "Agriculture" made a slightly positive average contribution marked by increased variability, given the weak agricultural output in 2012 and 2015 and the bumper crops in 2013 and 2017 respectively.

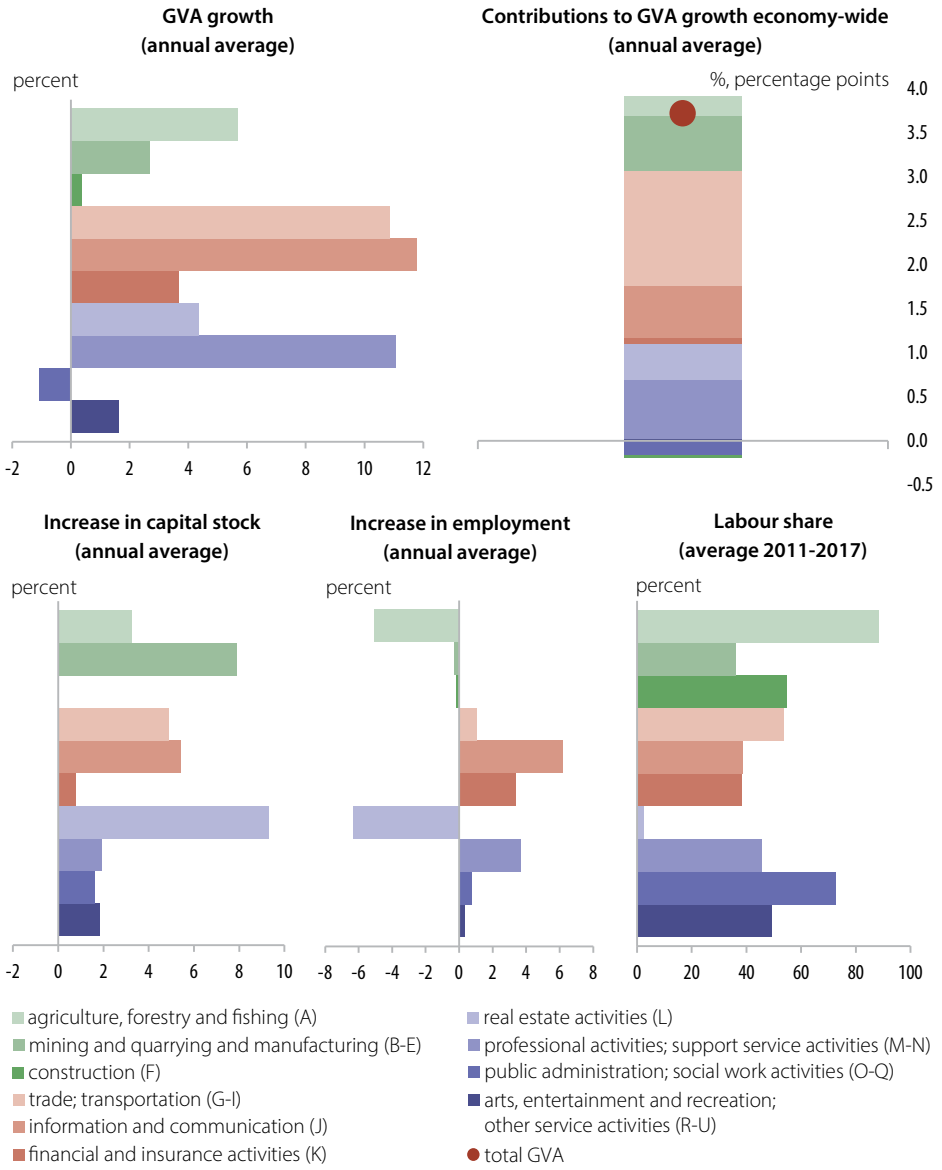

Chart A
Sectoral developments during 2011-2017

Note: The corresponding NACE codes are given in parentheses.

Source: NIS, Eurostat, NBR estimates

The mixed sectoral dynamics were recorded against the background of a wide range of developments in the capital stock[3] and labour (expressed as total hours worked economy-wide[4]). Specifically, "Real estate activities" and "Industry", as well as "Information and communication", "Trade" and "Agriculture" witnessed

[3] The capital stock for each sector is estimated based on a capital accumulation equation that takes into consideration the gross fixed capital formation of the previous year and the depreciation rate of the capital stock (assumed to equal 5 percent for all the sectors under analysis). The initial capital stock was estimated employing a procedure designed to increase the robustness of results proposed by Levenko *et al.*, 2017.

[4] Computed by multiplying the number of employed persons by the average number of hours worked.

significant capital increases. Turning to labour, a key role had the broad-based decline (with the notable exception of "Public administration") in average hours worked, especially in "Agriculture". Moreover, between 2011 and 2017, the number of employed persons decreased economy-wide, chiefly on account of that in the agricultural sector (down by approximately 670 thousand persons, i.e. -25 percent). The halving of the number of employed persons in "Real estate activities" is also worth mentioning. Conversely, the number of employed persons rose in sectors such as "Trade" (+7 percent) and most services, with the advance in "Information and communication" (up approximately 65 thousand persons) accounting for a 50 percent increase.

As regards the share of labour, assessed[5] by applying formula (2), "Agriculture, forestry and fishing" and "Public administration" posted the highest readings (88 percent and 72 percent respectively). Labour shares in "Construction", "Trade" and "Arts, entertainment and recreation" were close to 50 percent, whereas in the other sectors they stood slightly lower, except for "Real estate activities", where the said weight is very small (on account of the size of GVA being well above that of the compensation of employees).

(iii) Sectoral efficiency in the utilisation of production factors

Chart B shows the annual change in TFP, measured by applying formula (3). The upper panel illustrates sector contributions to enhancing the efficiency in the utilisation of production factors economy-wide, whereas the lower panels display the average annual TFP growth in economic sectors for the whole post-crisis period (2011-2017) by taking into consideration two alternative measures of labour contribution.

In the post-crisis period, the contributions made by "Trade" and the related services to higher efficiency economy-wide are worth noting, on the back of efforts to create economies of scale once with the wider geographical area covered by these economic activities[6]. Efficiency gains were also detected in "Professional activities" (which include outsourcing and consultancy services), "Information and communication" (amid the favourable legal framework) and "Agriculture" (in the context of a rise in equipment purchases, also via the EU funds for rural development). Conversely, TFP decreases were identified in "Industry" (only in the first half of the period under review, as efficiency gains were subsequently accompanied by a relatively stable capacity utilisation rate), "Real estate activities" (especially in the past two years) and "Public administration" (with a notable drop in 2015, amid the approximately 10 percent increase in the number of employed persons, along with a decline of the same magnitude in GVA).

5 The estimation of labour share required, particularly in the case of "Agriculture", a limitation to 100 percent, a value which would have been exceeded given the high ratio of total self-employed to employees (approximately 8:1 in the period under review).

6 Between 2011 and 2016, large retailers (with over 250 employees or a turnover amounting to over EUR 50 million) saw their market share (measured in terms of turnover) increase by 14 percentage points and thus become prevalent.

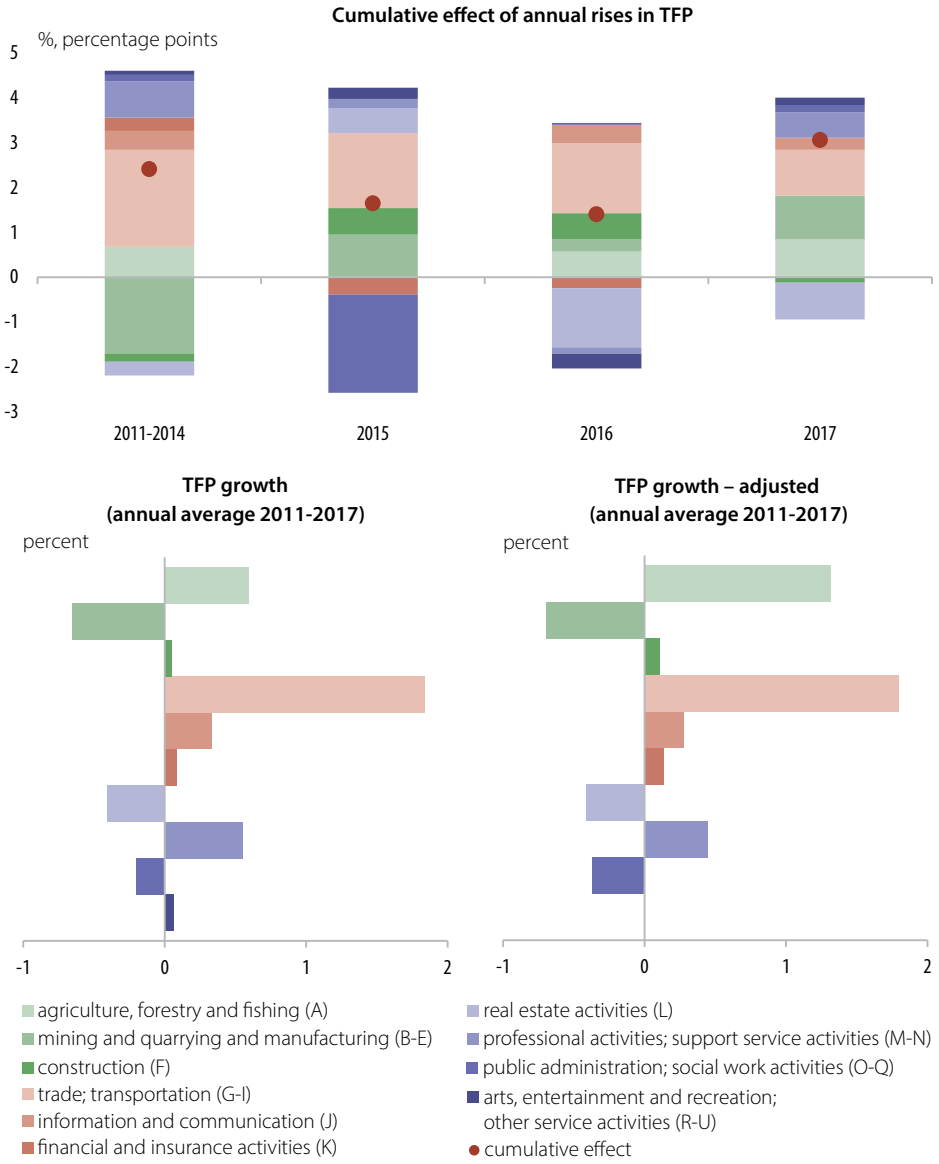

Chart B
TFP assessments at sectoral level during 2011-2017

Note: The corresponding NACE codes are given in parentheses.

Source: NBR estimates

An alternative estimation of TFP may be made by using the quality-adjusted labour input[7], approximated in the analysis by the share of compensation of employees in a given sector in the average compensation of employees economy-wide. The main differences appear in "Agriculture", where TFP growth is higher (mirroring the larger negative contribution of labour, amid lower compensation per employee than the economy-wide average), as well as in "Professional activities" and "Public administration", characterised by a slight deterioration in TFP (given the higher compensation per employee than the economy-wide average, which favours labour contribution).

7 For details, see Chapter 4 of the OECD *Measuring Productivity Manual*, 2001.

TFP increase in most economic sectors in the post-crisis period may be correlated with a series of favourable developments in structural indicators such as the lower cost of starting a business[8], the higher activity rate of the working-age population or the larger share of economic agents (both households and corporations) with internet access[9]. At the same time, the share of R&D intrasectoral expenditure in GDP relatively stalled (at significantly lower levels than in both EU developed countries and regional peers[10]) and the quality of infrastructure remained poor, weighing also on labour mobility. These are but a few areas that might benefit from a faster implementation of structural reforms, including through the swifter absorption of dedicated EU funds.

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8 According to *Doing Business 2018* by World Bank, which indicates an improvement in Romania's aggregate score, on the one hand, and its dropping several positions in the final ranking, on the other hand.

9 NBR assessments. Data source: Eurostat.

10 Between 2011 and 2016, the average share of R&D intrasectoral expenditure in GDP was 0.5 percent in Romania versus 2.1 percent in the euro area, 1.3 percent in Hungary, 0.9 percent in Poland and 0.7 percent in Bulgaria. NBR assessments. Data source: Eurostat.