TFP estimation at firm level: The fiscal aspect of productivity convergence in the UK[☆]

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ABSTRACT

This paper reviews the state of the art in firm-level Total Factor Productivity (TFP) estimation employing an unbalanced panel of 7400 manufacturing firms in the UK during 2004–2011. The five methodologies considered are Superlative Index Numbers, System-GMM, Olley and Pakes (1996), Levisohn and Petrin (2003) and Ackerberg et al. (2015). Each of these estimators assumes different underlying properties for some inputs, which potentially affect the TFP measurements. We analyze the role of corporate taxation within a TFP catch-up model, providing new insights on the unexplored fiscal aspect of the UK productivity puzzle. Our findings are summarized as: (i) the Ackerberg et al. (2015) algorithm is the cutting-edge estimation technique with most plausible results, while GMM system (GMM-SYS) is the second best estimator; (ii) the global financial crisis in 2009 impacted negatively on TFP; (iii) corporate tax adversely affects TFP growth as it induces distortive effects on productivity enhancing investment; (iv) the adverse effect is found to be severe in the groups of R&D and exporting firms, suggesting that the distortive nature of corporate tax affects disproportionately the firms that are more financially constrained and more exposed to risk.

1. Introduction

Productivity growth in the UK has been sluggish during the last ten years following a similar trend in many OECD countries (McMorrow et al., 2010; Braconier and Ruiz-Valenzuela, 2014). The consensus in the literature has been how policy changes affect productivity performance, including product and labour market regulations (Bourlès et al., 2013; Andrews and Cingano, 2014; Bravo-Biosca et al., 2016). There is very limited evidence on how fiscal changes affect productivity at the firm level (Arnold et al., 2011), which is a vital issue given the evolution of recent literature about firm heterogeneity and public policy changes (Bernard et al., 2012). The present paper aims to understand the evolution of firm Total Factor Productivity (TFP)[1] in a large group of UK Manufacturing Firms during a period of substantial financial turbulence and changes in the corporate tax schedule.[2]

A central issue in implementing this empirical investigation is to obtain reliable measures of TFP at the firm level. We treat this part of the analysis systematically and not as a trivial mechanical process. There is a bulk of literature focusing on alternative approaches for the estimation of productivity (Van Biesebroeck, 2007; Eberhardt and Helmers, 2010; Del Gatto et al., 2011; Van Beveren, 2012). Nonetheless, the enormous heterogeneity across firms suggests that the appropriateness of each method for TFP calculation depends on the nature of data in use and more importantly to what extent the underlying assumptions of each method are compatible to the data generating process (DGP). Conceptually, TFP is a residual which represents the amount of output that cannot be explained by the use of inputs. This definition highlights the existence of unobservables in the productivity measurement that should be controlled accurately in order to avoid misspecification and errors in TFP computations. The contribution of the paper is twofold: first, we provide a comprehensive discussion of the most up to date approaches in measuring firm level TFP including non-parametric, parametric and

semi-parametric techniques that we apply in a large data set of UK manufacturing firms over the period 2004–2011. The objective of this illustration seeks to compare merits and weaknesses of each methodology and then to identify the degree of correlation and commonality across TFP methods. This part of the analysis is also used to evaluate the effect of the 2009 global financial crisis on the evolution of TFP in UK Manufacturing firms. The second part of the paper, which is our second contribution, investigates the effects of tax burden on TFP assessing whether the nature of the corporate tax-TFP relationship is robust or subject to TFP computation choices and definition of variables.

Regarding the nexus of corporate tax-TFP, the paper puts forward a simple as well as an intuitive hypothesis that a higher level of profit tax bill induces distortive effects on productivity growth. This argument draws upon the fiscal effects on R&D on the one hand (Hall and Van Reenen, 2000) and on investment and entrepreneurship (Djankov et al., 2010) on the other. Both strands of the literature highlight the existence of two mechanisms though which corporate taxation can generate distortive effects on firm performance (Lucas, 1990).[3] First, a higher statutory tax increases the user cost of capital, which might serve as a disincentive for gaining higher profitability through the use of new capital equipment (Fullerton, 1987; Hubbard, 1998; Devereux and Griffith, 2003).[4] Second, more recent studies (Keuschnigg and Ribi, 2013; Brekke et al., 2014) associate corporate tax liabilities with the existence of moral hazard and asymmetric information between the firm and its external creditors. As firms operate under financial constraints, their current income is the main asset that can be promised for loan repayment, and, therefore, anything that decreases cash flows and working capital such as tax liability can also weaken the borrowing capacity of the firm. Following this argument, the weakening of borrowing capacity due to lower post-tax income undermines the ability to invest in productivity enhancing investment; thus productivity growth slows down.

The effect of a weaker borrowing capacity due to higher tax liability affects disproportionally the groups of firms that are typically more risk-takers, and thus more dependent on the use of external finance (Cullen and Gordon, 2007; Bricongne et al., 2012). Representative examples of firms with greater exposure to risk are R&D and exporting firms. R&D activity usually encounters substantial sunk costs that must be covered up-front and will require substantial liquidity usually obtained from external creditors. In addition, R&D projects always involve a high degree of uncertainty, which generates pressure for cash-flows and sufficient working capital, covered from external financial sources (Máñez et al., 2014). Firms prefer outsourcing research activities in geographical regions with low corporate tax while locating final production units in markets with high consumer tax rates (i.e., VAT) (Dischinger and Riedel, 2011). This within-firm fragmentation of production implies that R&D firms make decisions regarding location of research activities taking into account the corporate tax regime.

In a similar line of argument, exporters encounter higher levels of business costs relative to non-exporters due to the establishment of new market and transportation networks, which require substantial financial strength (Görg and Spaliara, 2014). Reducing the scale of research and export activity due to higher corporate tax liabilities is likely to induce substantial productivity losses that might affect both the evolution of TFP and the catch up process towards the frontier.

The paper is organized as follows: Section 2 overviews five main approaches in the measurement of TFP at the firm level; Section 3 shows results from a neo-Schumpeterian model of TFP catch up which permits

us to assess the role of corporate tax on both the rate of TFP growth and TFP convergence, and Section 4 concludes the paper.

2. TFP estimation: methodology and measurement

2.1. Non-parametric techniques and superlative index numbers

We start with the index number approach in the TFP measurement. The main advantage of this approach is the degree of flexibility in accommodating different underlying production functions. Additionally, this non-parametric approach avoids the usual econometric bias in the estimation of production input parameters. Nonetheless, the index number approach uses some fairly strong economic assumptions with the most prominent being the existence of perfect competition in product and input markets. Let us specify a standard Cobb-Douglass production function:

$$Y_{it} = A_{it} K_{it}^{a_k} L_{it}^{a_l} \qquad [2.1]$$

K and L represent capital stock and labour input for firm i at year t, parameter A stands for Hicks neutral technical change (TFP). Based on this set-up, productivity is derived as:

$$A_{it} = \frac{Y_{it}}{K_{it}^{1-a} L_{it}^{a}} \qquad [2.2]$$

Equation [2.2] expresses productivity (the ratio of output to weighted capital and labour). The weight is the share of labour a calculated as labour cost to value added, and under the assumption of constant returns to scale, capital share is $1 - a$. Because the aggregate sum of inputs is not scale invariant, the TFP measures make better sense if they are compared to a reference point. In the seminal work of Solow (1957), production units are characterized from cost minimizing behavior; so the TFP formula can be viewed as a discrete approximation to the Divisia index. Caves et al. (1982) provide a broader interpretation of this, considering that the Tőrnqvist index number has a broader validity as it allows the derivation of TFP from more flexible underlying production functions such as the translog. The Tőrnqvist index proposed in Caves et al. (1982) is:

$$TFP \equiv \left(\ln Y_{it} - \ln \overline{Y}_t\right) - \left[\tilde{a}_{it}^L\left(\ln L_{it} - \ln \overline{L}_t\right) + \left(1 - \tilde{a}_{it}^L\right)\left(\ln K_{it} - \ln \overline{K}_t\right)\right] \qquad [2.3]$$

With $\tilde{a}_{it}^L = \frac{a_{it}^L + \overline{a}_t^L}{2}$, upper bar in labour share represents the arithmetic mean across all observations in the sample in year t, while upper bars above inputs and output denote geometric means in year t. There are two disadvantages with the Tőrnqvist index specified in [2.3]; first labour share a is in fact a revenue share and it is biased if market structure deviates from perfect competition, which raises the need to adjust observed labour shares to total cost.[5] Second, this approach does not allow for any measurement error, which is easily accommodated in parametric estimations.

2.2. Parametric estimates of TFP and simultaneity bias

The next family of estimators specifies a parametric log-linear form (letters in lower cases) of the production function [2.1] in order to recover estimates for labour and capital shares.

$$y_{it} = a_0 + a_k k_{it} + a_l l_{it} + \omega_{it} + \varepsilon_{it} \qquad [2.4]$$

The technical efficiency parameter is decomposed as follows: $\ln A_{jt} = a_0 + \omega_{it} + \varepsilon_{it}$, ω_{it} and ε_{it} are i.i.d idiosyncratic error terms. It is assumed that ω_{it} is an unobserved factor that affects firm i's output,

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[3] Lucas (1990) supports the view that corporate income should not be taxed in the long run as this income is the main engine of investment and growth (also see Zellner and Ngoie, 2015).

[4] The effect of corporate income tax on investment is initially founded in the seminal paper of Modigliani and Miller (1958). In their set up, firms operate in a financially unconstrained environment; so a higher level of marginal corporate tax affects only the marginal cost of investment. In a more complex business environment corporate tax might also impact a firm's ability to gain external finance.

[5] See Hall (1998), Roeger (1995) and De-Loecker and Warzynski (2012) for the construction of price mark-ups associated with the measurement of market power.