

**DYNAMICS OF INEFFICIENCY AND MERGER IN ENGLISH HIGHER
EDUCATION 1996/97 TO 2008/9: A COMPARISON OF PRE-MERGING, POST-
MERGING AND NON-MERGING UNIVERSITIES USING BAYESIAN METHODS**

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Abstract

This paper investigates inefficiency/merger dynamics in the English higher education sector from 1996/97 to 2008/09. Merging can lead to greater efficiency, and this is the motivation for encouraging merger in the English higher education sector in a period of austerity. But inefficiency can also contribute towards the decision to merge, meaning that the relationship is two-way. Although there is literature on the effects of merging in higher education, the dynamics are typically not modelled. This paper examines differences in efficiency between pre-merging, post-merging and non-merging universities, and explores the evolution of the effects over time following the merger. We develop a dynamic model of inefficiency and merger the estimation of which relies on Bayesian techniques organized around the use of Markov chain Monte Carlo. We find that typically merger delivers efficiency gains in the first instance, but these plateau soon after merger. Moreover, there is a wide dispersion around mean efficiency and there is a substantial group of mergers where the probability of efficiency improvement is relatively low. The policy implication is that merging universities is not a universal solution to improving their efficiency.

Keywords: Universities; Merger; Efficiency; Bayesian methods

JEL classification: C11, D23, G34, I23

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1. Introduction

Firms in a sector engage in merger because they perceive there to be gains in efficiency. Typically higher education is funded (at least in part) from the public purse meaning that governments around the world are keen to use resources efficiently and have seen merger as a tool for reform in challenging times (Harman and Meek 2002).¹ As competition in the global higher education market intensifies, merger² is increasingly seen by higher education institutions (HEIs) as a means to grow, be more visible and succeed in the global market for students, staff and funding (Välilmaa *et al.* 2014).

Higher education mergers are divided into two groups: those which have been initiated externally, usually by the government as part of a policy agenda (termed involuntary mergers), and those which are initiated by the institutions themselves (labelled voluntary mergers) (Cai *et al.* 2016). The autonomous nature of HEIs in England means that there has not been a wave of top-down policy-driven (i.e. involuntary) mergers to the extent as has been seen in some other countries (see Cai and Yang 2016 for a summary of merger activity across countries). But an increasing demand for value from HEIs has been triggered by rising tuition fees and pressures on public funding caused by austerity (Viaene and Zilcha 2013). Various media reports have suggested that the UK higher education sector could benefit from consolidation (see, for example, Jump 2014).

This raises the question: what are the ‘benefits’ which accrue from HEIs merging? Efficiency theory suggests that merger will lower resource requirements by increasing efficiency. There is considerable research on mergers in the private sector, where 50-75% of mergers are

¹ Some examples of countries where HEI mergers have been used as a policy tool include: the Netherlands (Goedegebuure and Meek 1991), Portugal (Teixeira and Amaral 2007), Finland (Aarrevaara 2007; Aarrevaara *et al.* 2009; Green 2009), Norway (Stensaker 2006), Hungary (Berde and Ványolós 2008), Australia (Goedegebuure and Meek 1991; Mahony 1992; 1994; Goedegebuure 2012), South Africa (Botha 2001), Hong Kong (Mok 2005b), and China (Mok 2005a).

² We define merger as: ‘two or more partners combining to create a single institution, which may retain the name and legal status of one of them or be an entirely new legal entity.’ (HEFCE 2012 p11)

estimated to fail outright or fail to deliver in terms of efficiency or value gains (HEFCE 2012). There is less known about mergers in higher education although an early study puts the failure rate at 10% (Rowley 1997). Very little work of a statistical nature has been undertaken to evaluate quantitatively the impact on efficiency of mergers in higher education.

There are difficulties with measuring the effect on efficiency of merging – be that in higher education or any other sector. First, it is difficult to separate the effect of the act of merging from other underlying characteristics of the merged institutions. Universities which merge, especially if the decision to merge is an institution-level one rather than a top-down directive, are likely to have different characteristics from those which do not merge, and these characteristics could themselves cause the observed differences in efficiency.

Second, any analysis of the gains from merger needs to account for the possible endogeneity of efficiency and the decision to merge. The idea that merger can affect subsequent inefficiency, and that inefficiency can lead to merger is explored in a study of financial institutions (Worthington 2001), although the dynamics of the two-way relationship are not fully developed in that study. Here, the strategic motive for merger between universities suggests that ‘weak’ (possibly inefficient) HEIs may enter a merger in order to strengthen their position. Thus inefficiency is a driver for merger and merger is a driver for efficiency, the process is dynamic, and this should be explicitly modelled.

The purpose of this paper is to develop a methodology to investigate the subsequent effects on efficiency of merging, taking into account the dynamic process. The methodological approach is demonstrated in the context of the English higher education sector over the period 1996/97 to 2008/09, a period which encompasses 25 mergers. As well as the difficulties of modelling the two-way relationship between efficiency and merger activity, there are additional problems: historically, mergers in higher education have been small in number (Berriman and Jacobs

2010), and the benefits of merger can take time to reap – precisely how long is unknown (HEFCE 2012).

In this paper we develop a method which can be used to (i) assess efficiency, (ii) assess whether mergers have been due to inefficiency and whether they contributed to efficiency T periods after the merger, (iii) quantify the effects of the determinants of inefficiency and mergers. As inefficiency is a latent unobserved variable it is critical to allow for this fact when we examine the possible effect of inefficiency on mergers and *vice versa*. Both inefficiency and merger activity are assumed to be dynamic processes, and are also endogenous. Modelling the dynamic character of the relationships requires the development of new econometric techniques, and these rely on Bayesian techniques organized around the use of Markov chain Monte Carlo (MCMC).

While the specific application here is the higher education sector, a similar method could perhaps be developed in the context of other sectors both non-profit, for example, provision of police services where mergers and other collaborations have been mooted to increase efficiency (Stevens Report 2013), and for-profit. A methodology to identify the technical efficiency effects of merger is therefore widely relevant.

The paper is in 5 sections of which this is the first. In the next section we look at the diverse literature relating to (university) mergers focusing particularly on: what is already known about the efficiency of merging and non-merging institutions; the motives for merger; the efficiency effects of mergers; and the time path over which efficiency evolves following merger. Section 3 presents the dynamic model of merging and inefficiency, as well as the empirical context in which the model is applied. Section 4 presents and interprets the results, while conclusions are drawn in section 5. In addition, a Technical Appendix³ containing some proofs and more

³ <https://sites.google.com/site/johnesjill/home/papers>

detailed mathematical notation is included at the end in order to facilitate the reading of the paper.

2. Literature review

Much research into mergers in higher education has used case studies to focus on the motivation for mergers (Skodvin 1999; Patterson 2000; Harman and Meek 2002; Norgård and Skodvin 2002; Wan and Peterson 2007; Kyvik and Stensaker 2013; Ripoll-Soler and De-Miguel-Molina 2014; Bennetot Pruvot *et al.* 2015; Pinheiro *et al.* 2016; Stensaker *et al.* 2016; Tienari *et al.* 2016; Leslie *et al.* 2018), the various effects of merging on the intuitions and people within them (Wan and Peterson 2007; Bennetot Pruvot *et al.* 2015; Pinheiro *et al.* 2016; Evans 2017; Leslie *et al.* 2018), post-merger performance – including both benefits and problems (Skodvin 1999; Harman 2002; Norgård and Skodvin 2002; Wan and Peterson 2007; Bennetot Pruvot *et al.* 2015; Leslie *et al.* 2018), and the factors which might make a merger more likely to reach a successful conclusion (Norgård and Skodvin 2002; Kyvik and Stensaker 2013; Bennetot Pruvot *et al.* 2015; Tienari *et al.* 2016). Research into the efficiency or performance of merging compared to non-merging institutions, and into the effects of merger on performance using quantitative analysis of data relating to a whole sector, is much more limited.

In a paper on efficiency in English higher education, the purpose of which was to compare various approaches to measuring efficiency and the effects on the results and conclusions of applying those approaches,⁴ Johnes (2014) finds that average efficiency is significantly higher among merged than either pre-merger or non-merging universities. Moreover, this is true regardless of estimation method used. This is as far as that research goes, however, and it is clearly limited in that it is a simple comparison of means between groups of institutions. As

⁴ Efficiency is calculated in a variety of ways using both parametric and non-parametric output distance functions.

such, causality cannot be inferred: merging and non-merging universities are likely to have very different characteristics, and the observed differences in mean efficiency could be a consequence of these different underlying characteristics, rather than the merger itself. However, the paper serves as a motivation for more sophisticated research into the effects of merger on efficiency; before reviewing that literature, it is worth first considering the drivers for merging amongst universities, and hence understand more clearly the potentially complex relationship between merging and efficiency.

Motives for merger in higher education can be grouped under the headings of strategic reasons (Arbuthnott and Bone 1993; Rowley 1997; Botha 2001; Stewart 2003; Fazackerley 2017) or efficiency theory.⁵ Strategic mergers occur when two or more HEIs merge in order to achieve certain institutional goals. Policy-driven mergers in a variety of countries, such as Denmark and Finland, have been undertaken for strategic reasons (Goedegebuure 2012). There are three main strategy motives which are particularly pertinent in the higher education context.

- Survival and growth: A non-viable institution may enter into merger as a means to survive⁶ (Pritchard 1993; Harman and Meek 2002; Harman and Harman 2003; Fazackerley 2017), while small institutions may see merger as the best way to generate revenue to finance further improvements and growth (Rowley 1997). The UK has adopted a culture of ensuring that HEIs do not fail, and that merging should be considered as an option in the context of rescuing failing institutions (Browne 2010).

Thus inefficiency would be the driver for merger in this scenario.

⁵ We do not consider that managerial motives such as salaries, bonuses or desire for industry power (Williamson 1964) are of primary relevance in the context of the English higher education sector.

⁶ Note that in a survey of university vice-chancellors in the UK, 42% of vice-chancellors responding to the survey were reasonably or very confident that there would be a number of institutional failures and insolvencies in the next 5-10 years (Boxall and Woodgates 2014).

- Reputation: As higher education has become more market-driven,⁷ universities (and schools within universities) are increasingly aware of the importance of their ranking in both national and global league tables (Engwall 2007; Ripoll-Soler and De-Miguel-Molina 2014; Pinheiro *et al.* 2016). Reputation is important for teaching as universities with the best reputations can attract the best students (both nationally and internationally); reputation is also important for research as institutions with the best reputations can attract the best staff and research funding (Engwall 2008). Universities are therefore competing for reputation as part of their strategy, and may see a merger,⁸ by increasing size and visibility, as an effective means of building reputation both nationally and internationally (Skodvin 1999; Harman and Harman 2008; Tirronen and Nokkala 2009; Aula and Tienari 2011; Goedegebuure 2012; Docampo *et al.* 2015; Tienari *et al.* 2016). Thus poor performance (denoted by low ranking) would lead to merger, in this instance.
- International competitiveness: With increasing globalisation, merging in higher education has been seen as a specific strategy for improving competitive advantage in a global market for research, staff and students (Harman and Harman 2008; Yang 2015; Pinheiro *et al.* 2016; Zeeman and Bennenworth 2017). A merger of respected HEIs within a country can lead to more effective competition with renowned international universities, thereby strengthening the overall quality of the higher education sector of that country. Thus poor performance (in terms of maintaining competitive advantage) could lead to merger in this context.

⁷ The abolition of the student numbers cap for students entering higher education in England in 2015/16 has been accompanied by particularly strong inter-institution competition for students.

⁸ Networks and alliances may also be effective in this context (Kitagawa 2010); for example, the research funding councils manage the funding of PhD training through Doctoral Training Centres which comprise a small network of universities.

The efficiency theory predicts that a merger will occur when the merging institutions believe that they can be run more efficiently and effectively together than separately (Curri 2002; Harman and Harman 2003; Aarrevaara *et al.* 2009; Bösecke 2009). In this case the benefits accrue to the owners rather than the managers (Bösecke 2009). In the context of English higher education, the efficiency theory therefore predicts that merging will result in more efficient use of public funding (Mok 2005b; Tirronen and Nokkala 2009). An early examination of mergers in higher education concluded that efficiency theory was the main underlying cause of merger activity in Great Britain (Rowley 1997).

Merger contributes to efficiency and effectiveness through returns to scale and scope. Increasing returns to scale in a HEI might arise because management and administrative activity can be spread over larger output (Fielden and Markham 1997; Patterson 2000; Kyvik 2002; Norgård and Skodvin 2002; Green and Johnes 2009; Ripoll-Soler and De-Miguel-Molina 2014; Yang 2015), buildings and/or sites can be shed leading to lower maintenance and capital costs (Fielden and Markham 1997; Teixeira and Amaral 2007), small duplicate programmes across separate HEIs can be eliminated (Skodvin 1999), and teaching staff can be spread over more students (Fielden and Markham 1997).

Returns to scope can arise if there are synergies from, for example, producing teaching and research in the same university, or from producing teaching (or research) across disciplines in a single HEI. Thus resources are used more efficiently from producing a variety of outputs in the same organisation rather than producing them separately.

In this study we allow efficiency to be a function of merger, and also for merger to be a consequence of inefficiency. Thus it is possible to establish the validity of each of these relationships.

There are a limited number of studies which have attempted to examine the effect of merging on efficiency. In China, a policy of institutional merger was launched in 1992 aimed, in part, at improving efficiency (Yang 2015), and has seen more than 400 instances of merging institutions since the 1990s (Cai and Yang 2016). Studies evaluating the effect of mergers in China have shown that merging has a positive effect on efficiency and productivity in the first year after merger (Hu and Liang 2008; Mao *et al.* 2009). In a comparative study of universities in Nordic countries and those in China, the effects of merging on performance (measured by production of publications rather than efficiency) vary by size mix of the merging HEIs. If the two merging HEIs are the same size, there is no improved performance; if one is large and the other is small, publications performance is improved (Liu *et al.* 2018). Previous research into merging in English higher education using panel data shows that, not only is average efficiency significantly higher among merged than pre-merger and non-merging institutions (Johnes 2014), this difference is observed even when other factors such as mission, subject mix, source of income and size are also taken into account (Papadimitriou and Johnes 2018).

Findings regarding the evolution of efficiency over time following merger are particularly limited. Studies relating to samples of mergers in China in 2000 suggest that efficiency gains are short-lived, perhaps lasting for only one or two years (Hu and Liang 2008; Mao *et al.* 2009). A similar result is found for mergers in English higher education where the efficiency effects are enjoyed largely in the first year after merger (Papadimitriou and Johnes 2018).

The results of these statistical analyses of the purported effects of merger on efficiency should be interpreted with a great deal of caution: none of these studies models the possible endogeneity between efficiency and the decision to merge, and the results may therefore be misleading. This is potentially important for higher education managers and policy-makers who may erroneously base their decisions to merge on these studies. The studies are also

limited in the analysis of efficiency effects over time because of small numbers of observations, and/or limited length of time dimension in the panel data.

This study aims to address the endogeneity issue in particular, and is distinctive from previous studies (including work referring to English higher education) in a number of important respects. First, whereas previous work is based on static models of efficiency, in this paper we build a dynamic model which allows for endogeneity between inefficiency and merger. Thus we are able to assess efficiency differences between different types of universities (pre-merging, merging and non-merging) *taking into account any endogeneity in the relationship*. Second, we also assess the strength of the two-way relationship by examining the separate equations comprising the merger-efficiency model. Finally, we assess the evolution of efficiency effects over a number of years following the merger, again taking into account the endogeneity in the relationship. This last is possible despite only a small number of merger observations in any given year (time t) and hence small numbers of observations of subsequent efficiency in later years (time $t + 1$, $t + 2$, ...), because of the estimation approach used. A greater understanding of the evolution of efficiency over time following merger is an important contribution to the research in this area.

3. Conceptual framework and model specification

The literature review has highlighted gaps in research relating to mergers in higher education.

We are therefore interested in answering the following questions:

- How does efficiency compare between pre-merging, post-merging and non-merging universities?
- Does inefficiency lead to merger?
- Does merger improve efficiency in the merged institution?
- What is the time-path of the efficiency effects?

We use data relating to the period from 1996/97 to 2008/09 and including 25 instances of merger.⁹ The 25 mergers took place across the time period of the study, and represent an average annual merger rate of 2.27. This average rate varies, however, from below 2 in the first and last four years, to a rate of 3 in the middle 5 years. These mergers range from unions of institutions which are unequal in size (there are 19 of these)¹⁰ to mergers of equals (Tight 2013). Across the mergers, 6 can be considered unequal in terms of focus¹¹ (in each of the 6 cases, one partner has a clear research focus and the other partner does not), while a further 6 comprise partners which are roughly equivalent in their research focus. If we consider overall mission and outlook, 12 of the 25 mergers are between partners from the same mission group.¹² In terms of age of partners, the vast majority of the mergers are between partners which can trace their history to similar periods; just 3 of the mergers are between HEIs which differ in age.

The differences between partners, in terms of size, focus and mission, may well mean that the mergers have been undertaken for varying reasons, and have diverse objectives. These in turn could inevitably lead to differences in efficiency effects, and these themes will be picked up in in the next section. It is worth noting that the time period covered in this study is a relatively stable one, preceding as it does the global financial crisis and the effect that this had on public funding and hence HEIs. Like Kwoka and Pollitt (2010) our sample data allow us to overcome certain limitations of previous empirical studies of mergers as we: (i) include both merging and non-merging universities; (ii) over both pre- and post-merger periods allowing us to examine

⁹ Note that the data used here do not make any quality adjustment in undergraduate inputs and outputs as is done in Johnes (2014). This is discussed and justified in more detail later in this section.

¹⁰ We use the rule of thumb that two partners are unequal in size if one has more than twice the total number of students than the other (in the year preceding merger).

¹¹ We use the rule of thumb that a partner has a research focus if the ratio of research income to total students is greater than 10 (in the year preceding merger).

¹² We assign each HEI to one of three mission groups: pre-1992, post-1992 and former colleges of higher education. Pre-1992 universities are traditional HEIs which offer degree programmes across the academic subject spectrum and have an established research mission. Post-1992 HEIs typically have a balanced portfolio of teaching and research, offer degree programmes across a range of academic and vocational subjects, and have a growing research mission. Former colleges of HE have been awarded university status since 2003; they are often but not exclusively small and specialist, and may lack a strong research mission.

efficiency before and after the merger; and (iii) focus on a single industry (within a single country) thereby enabling a controlled comparison.

3.1 Efficiency

a) Model

We estimate the efficiency of a sample of universities which includes both merging and non-merging entities, and periods before and after the merger. The model assumes universities to behave rationally by making the decision to merge on the basis of the potential benefits (technical efficiency in this case) i.e. universities aim to keep their efficiency as high as possible and take the decision to merge on this basis. Inefficiency depends on merger (and other factors) and the decision to merge depends on inefficiency (as well as other characteristics). The model is therefore dynamic and allows for endogeneity between the two variables of interest – merger and inefficiency. In addition, the model is built around a complete set of data including both merged and non-merging institutions. Studies which focus only on the merged units can be affected by selectivity bias as the decision not to merge is as rational a choice as the decision to merge. By building the model around both mergers and non-mergers we overcome the potential problem of selectivity bias.

Suppose that universities use k inputs ($k = 1, \dots, K$) to produce l outputs ($l = 1, \dots, L$); we denote inputs and outputs by X and Y respectively, and subscript it is used to represent university i in time period t ($i = 1, \dots, N; t = 1, \dots, T$). We have a choice of parametric (for example, stochastic frontier analysis - SFA) and non-parametric (for example data envelopment analysis - DEA) methods to estimate inefficiency. While SFA can handle stochastic noise in the data, DEA does not; DEA in contrast can easily handle multiple inputs and multiple outputs, while SFA requires certain assumptions in order to do so. SFA, however, exploits the panel nature of the data in estimating the parameters of the function, while DEA

has not been adapted to utilize the panel data context (Badunenko *et al.* 2012).¹³ We estimate inefficiency using a standard parametric translog output distance function (ODF) and assume homogeneity of +1 in outputs in order to model the multiple input and multiple output framework. The ODF is of the form:

$$D(Y_{it}, X_{it}) = 1 \Rightarrow y_{1,it} = f(\tilde{y}_{m,it}, x_{s,it}) + v_{it} - u_{it} \quad (1)$$

where lower case letters indicate logs, and $\tilde{y}_m = y_m - y_1, m = 2, \dots, M$; $v_{it} \sim \text{iid}N(0, \sigma_v^2)$ represents the error; $u_{it} \sim \text{iid}N_+(0, \sigma_u^2)$ is the one-sided component, independently distributed and independent of the regressors. It has been suggested that there is endogeneity in this model caused by the explanatory variables being related to the error term (Coelli *et al.* 2005; O'Donnell 2011). One might indeed expect that the existence of inefficiency would lead firms to change their production decisions and therefore that the assumption of independence between u_{it} and the regressors would be violated. We are satisfied that the assumption is reasonable for two reasons. With regard to the regressors representing inputs, in English higher education (over the period of study) universities are restricted by government in the amount of certain inputs, such as (domestic) undergraduate numbers. This inflexibility in input decisions means that the assumption is more plausible than might be the case for other industries. With regard to the regressors representing outputs, it has been argued that endogeneity is not a problem in an output distance function which (as here) uses a translog functional form where some of the regressors are output ratios rather than the outputs themselves (Coelli and Perelman 2000).

b) Model specification

¹³ For more discussion of DEA and SFA see Stone (2002); Hollingsworth (2004); Smith and Street (2005); Cooper *et al.* (2008).

We first of all specify the ODF used to derive measures of efficiency for each HEI in each time period. We assume that HEIs are engaged in teaching and research activities.¹⁴ Inputs are the number of full-time equivalent (FTE) postgraduate students (PGINPUT), the number of FTE undergraduate students (UGINPUT), the number of FTE academic staff (STAFF), spending on non-academic staff (ADMIN) and spending on academic services such as computer and library facilities (ACSERV). Outputs are number of graduates from postgraduate programmes (PGOUTPUT), number of graduates from undergraduate programmes (UGOUTPUT) and research income (RESEARCH). A full description of the variables used is presented in table 1. In addition to the input and output variables we include in the ODF HEI dummies, a time trend, and time trend interacted with the inputs and outputs.

[Table 1 here]

We include students as inputs and graduates as outputs (to reflect both undergraduate and postgraduate teaching activities) in order to capture the incidence of non-completion which varies considerably by HEI at both undergraduate and postgraduate levels (HEFCE 2010; HESA 2013). We do not adjust either the student input or graduate output measures for quality, although this may well vary by HEI. For postgraduates, there is no obvious measure of quality (on either the input or output side), and for undergraduates, the choice is limited. On the input side we could use the average A level score of undergraduate entrants as has been used previously (Johnes 2014). But this is unsatisfactory for a number of reasons. First, not all entrants to English universities have A levels; many have other prerequisite qualifications, and so the A level score may not adequately capture quality. Second, the grades awarded at A level changed in 2002/03, and this makes it difficult to obtain a consistent series of data. Third, the

¹⁴ It is generally accepted that HEIs also produce ‘third mission’ or social outputs. These include such services as storage of knowledge, commentary on current issues, and advice and training to businesses. These activities are difficult to measure and in line with many other previous studies we make no attempt to do so here. To the extent that HEIs may vary in their commitment to third mission activity, results may be biased by its exclusion from the model.

A level data is not published but can be requested; some HEIs do not supply this optional data and use of the A level variable reduces the number of mergers in the sample. On the output side, we could use data on degree classification to adjust graduate numbers for quality, but this would be an arbitrary weighting, and, given the suggestion of grade inflation in degree results over time (Johnes 2004; Popov and Bernhardt 2013; Bachan 2015), would be inappropriate.

We therefore proceed, as in earlier studies (see, for example, Abbott and Doucouliagos 2003; Flegg *et al.* 2004; Flegg and Allen 2007a; Worthington and Lee 2008) without quality adjustment, and justify this here for three reasons. First, quality is likely to vary over universities but not time, and hence the panel data estimation, which takes into account unobserved heterogeneity, should address the issue. Second, variables reflecting quality are included in the merger/inefficiency models. Thus quality is incorporated into the overall model at that stage. Third, in a comparison of efficiency results based on a distance function where a) undergraduate input and output quality is taken into account and b) undergraduate input and output quality is not taken into account, there was no difference in the overall conclusions (Johnes 2014).

The measurement of research output is notoriously difficult as data are not easily available. HEIs in England are subject to periodic evaluations of their research, but these are available only at intervals rather than annually over the study period. Research income is now generally accepted as a measure of research output as it reflects current research activity (Flegg *et al.* 2004; Flegg and Allen 2007a; 2007b; Worthington and Lee 2008; Worthington and Higgs 2011); citation counts, publication records and patents all have the problem that these arise with a lag and are therefore a reflection of past rather than current activity.¹⁵

¹⁵ In a recent report, a comparison was undertaken of possible measures of research output: number of publications by institution; number of times work from each institution is cited, and research income of each HEI. The measures were found to be highly correlated (Johnes and Johnes 2013).

3.2 The relationship between merging and inefficiency

a) Model

The relationship between merging activity and inefficiency is captured using a ‘tendency to merge’ model which we specify as follows:

$$W_{it}^* = \mathbf{z}'_{it}\boldsymbol{\gamma} + \rho_1 \log u_{it} + \rho_2 \log u_{i,t-1} + \phi W_{i,t-1}^* + \phi I_{i,t-1} + \varepsilon_{it}, \quad \varepsilon_{it} \sim \text{iid}N(0,1) \quad (2)$$

There is an observed merging indicator $I_{it} = \mathbf{1}(W_{it}^* \geq 0)$ which is 1 if a merger takes place and zero otherwise. Here \mathbf{z}_{it} is a vector of covariates; in addition tendency to merge depends on current and past inefficiency and is also possibly persistent (autoregressive).

The relationship between inefficiency and tendency to merge is specified as follows:

$$\log u_{it} = \alpha_0 + \alpha_1 \log u_{i,t-1} + \mathbf{z}'_{it}\boldsymbol{\delta} + \alpha_2 W_{i,t-1}^* + \alpha_3 I_{i,t-1} + \xi_{it}, \quad \xi_{it} \sim \text{iid}N(0, \sigma_\xi^2) \quad (3)$$

For the error terms we assume

$$\begin{bmatrix} \varepsilon_{it} \\ \xi_{it} \end{bmatrix} \sim N \left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \boldsymbol{\Sigma} = \begin{pmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_{22} \end{pmatrix} \right) \quad (4)$$

The dependence of technical inefficiency on both the latent tendency to merge, W_{it}^* , as well as the actual merging indicator, I_{it} , helps to distinguish between “latent” and “actual” effects of mergers. Allowing for persistent inefficiency implies that we allow for the possible existence of adjustment costs and inertia in decreasing inefficiency which could be present even after a possible merger. Previous econometric studies of mergers have examined the effect of merger on efficiency (see, for example, Kwoka and Pollitt 2010) or the effect of efficiency on merger (see, for example, Worthington 2001). Our study is original in that it allows for the potential endogeneity in the relationship between merger and inefficiency.

At a given time (say time period $t-1$) institutions i and j merge to become a new institution, say n . We are interested in inefficiency improvement: $\Delta u_{nt} = u_{nt} - u_{n,t-1}$. Such events have

probabilities which are difficult if not impossible to compute using the classical approach. In the Bayesian approach, use of MCMC methods (Geweke 1999) considerably simplifies the task.

In this form we estimate the ODF in an unrestricted manner and then we examine the probability that improvements in inefficiency have taken place. The required probability is $P(\Delta u_{nt} > 0 | Data)$ marginally on the parameters to account for parameter-related uncertainty. Through the use of MCMC such probabilities can be computed easily and routinely for all n and t . Information conveyed from these probabilities is important as it shows clearly whether efficiency improvements have taken place after a merger, under the assumption that mergers and inefficiency are endogenous. Further technical details about the model and the implementation of MCMC are contained in the Technical Appendix¹⁶ sections A1 to A3.

b) Model specification

We include a number of exogenous variables (a full description of the variables can be found in table 2) in the tendency to merge and inefficiency models. First of all the logarithm of the number of postgraduate and undergraduate students (LSIZE) and its square (LSIZESQ) are included to test whether size of HEI affects both tendency to merge and inefficiency. Since quality is not explicitly incorporated into the ODF (for reasons explained above), we include the numbers of graduates in each classification category (FIRST, UPSEC, LOWSEC, THIRD and UNC) as a proxy for quality in the tendency to merge and inefficiency models. Other variables of interest for which we do not have data include faculty salary, which has been found to be positively related to merger; and tuition fee and size of student pool both of which have been found to be negatively related to merging (Bates and Santerre 2000). Their omission should be considered when interpreting results.

¹⁶ <https://sites.google.com/site/johnesjill/home/papers>

[Table 2 here]

4. Results

The results from estimating the model were obtained using a transient or burn-in phase consisting of 500,000 draws followed by another 1,000,000 which was used to obtain these statistics as well as other functions of interest like posterior distributions and probabilities that the efficiency of HEIs improved after a merger. Convergence was assessed, to our satisfaction, using the convergence diagnostic of Geweke (1992).

In table 3 we report Bayes factors of the new model against three alternatives: (i) a conventional stochastic frontier model (SFM), (ii) a probit SFM and (iii) a dynamic SFM. These models are special cases of the new specification. Bayes factors are computed using the Verdinelli and Wasserman (1992) approach as the three models are nested in the general, baseline model (see Technical Appendix¹⁷ section A4). The conventional SFM uses the restrictions $\rho_1 = \rho_2 = \varphi = \alpha_1 = \alpha_2 = \alpha_3 = 0$ so, in fact, this yields a truncated normal distribution for the one-sided error term with inefficiency effects. The probit SFM is based on the restrictions $\alpha_1 = \alpha_2 = \alpha_3 = 0$. Finally, the dynamic SFM model has $\gamma = \rho_1 = \rho_2 = \varphi = \alpha_1 = \alpha_2 = \alpha_3 = 0$.

[Table 3 here]

The results in table 3 provide unambiguous evidence that the new model is superior to the alternatives, and this is true for the sample as a whole and for subgroups of pre- and post-1992 universities and former colleges of HE. We see from figure 1 that the sample densities of technical efficiencies for each of the models are quite different. The new model has lower average than the conventional SFM and dynamic SFM models, and greater dispersion in efficiency than any of the other models.

¹⁷ <https://sites.google.com/site/johnesjill/home/papers>

[Figure 1 here]

4.1 Comparison of efficiency between pre-, post- and non-merging institutions

The sample distributions of efficiency for pre-, post- and non-merging institutions are reported in figure 2. Taking into account any endogeneity between inefficiency and merging, we see that merged universities have the highest average efficiency. Institutions which are pre-merger (i.e. they will merge but have not yet done so) have the lowest average efficiency, while non-merging universities have average efficiency which is in the middle of those observed for her two groups. These results seem to be largely in line with previous findings for the HE sector based on static models (Hu and Liang 2008; Mao *et al.* 2009; Johnes 2014).

[Figure 2 here]

4.2 Does inefficiency lead to merger?

Table 4 reports posterior means and posterior standard deviations of the basic parameters of the estimated models. Also reported are the marginal effects of each variable in order to simplify interpretation. Looking first at the tendency to merge model, we see that while there is indeed a positive relationship between inefficiency and tendency to merge, the result is not significant at conventional levels of significance. However, not surprisingly, merging in period $t-1$ results in a lower tendency to merge in period t (by 0.072), and this result is significant. With regard to the exogenous (z) variables, the higher the ‘reputation’ of the institution (as measured by graduates obtaining good degree classifications) the lower the tendency to merge, whilst size has a positive but declining effect on tendency to merge. Finally tendency to merge appears to be persistent as indicated by the significance of the lagged dependent variable.

[Table 4 here]

4.3 Does merger improve efficiency?

Turning now to the inefficiency model also shown in table 4, the main result is the significance of the relationship between tendency to merge and inefficiency: an increase in tendency to merge in time $t-1$ lowers inefficiency in time t . Tendency to merge therefore has a positive effect on efficiency. Similarly actual merger as indicated by I_{t-1} has a negative relationship with inefficiency. So HEIs which merged in period $t-1$ had lower inefficiency (higher efficiency) in period t . Taking into account the potential endogeneity between merger and inefficiency, merging appears to have a beneficial effect on subsequent efficiency.

With regard to the exogenous (z) variables, the positive significant coefficients on all the categories of degree classification suggest that HEIs with greater proportion of honours degree graduates (compared to the base category of graduates from other undergraduate degrees) have higher inefficiency. It is reasonable to assume that production of quality graduates might be resource-intensive and hence appear to increase inefficiency. In addition size has a positive but declining effect on inefficiency. Finally inefficiency appears to be persistent as indicated by the significance of the lagged dependent variable.

In order to gain further understanding of the efficiency effects of merging, in table 5, we report all mergers that took place in English HEIs along with efficiency at the time of the merger and post-merger efficiency (posterior means and standard deviations), as well as the posterior probability that efficiency improved after merger. We can be relatively certain that a merger improved efficiency if the posterior probability is ‘high’ – we use a value of 70% as our threshold. The more the posterior probability is closer to unity the more plausible it appears, in the light of the data, that a merger improved efficiency. The posterior probability and the efficiency measures are first of all based on individual HEI-specific efficiency weighted by the size of each HEI involved (column (3) of table 5). In order to check the sensitivity of these

results to the weighting system used, we also calculate the probability and efficiency measures using a number of alternative weighting systems and report (column (4) of table 5) the lower bound efficiency improvement from the different weighting schemes. The results are remarkably similar. The alternative approaches to calculating the values are explained in full in the Technical Appendix¹⁸, section A5.

[Table 5 here]

Of the 25 merger events, 11 (just under one half of mergers) have a probability of post-merger improvement in efficiency below 0.70 (our threshold) if we weight efficiency by HEI size; this rises to 12 HEIs if we use the more flexible weighting approach. Thus the previous results suggesting that merger is typically good in terms of efficiency improvement should be treated with caution: when we look at individual mergers, it is not a foregone conclusion that the act of merging will result in an increased level of efficiency. It would be useful to know which mergers are likely to lead to increased efficiency and which are not, and we examine the 25 instances more closely to try to identify patterns.

- Age: Most of the mergers are between HEIs with similar roots in terms of when they were founded. Of the 3 which are different, 1 of those is from the set of mergers with probability less than 0.7 that there will be efficiency improvement, and the remaining 2 are from the group of mergers where efficiency improvement is more likely. There is therefore little evidence that relative age is a determinant of later success in terms of efficiency.
- Culture and focus: Of the 25 mergers, 12 are between HEIs of the same type or mission group (where we define three mission groups: pre-1992, post-1992 and former college of HE). Of these 12 mergers, 6 have a probability of post-merger improvement in

¹⁸ <https://sites.google.com/site/johnesjill/home/papers>

efficiency below 0.70. These are the very types of merger which might be assumed, *a priori*, to have greatest chance of success as outlook, mission and culture are likely to be close and this is known to increase chance of a successful merger (HEFCE 2012). Yet our results cast doubt on this premise. This is further confirmed when we look at focus. We know that 6 of the mergers in our data set are between HEIs with different focus (i.e. one partner has a research focus, the other partner does not). Of these, 4 are amongst the HEIs with probability of increased efficiency below 70%.

- Relative size: Looking at size, the vast majority of the mergers (19) are amongst HEIs which are highly dissimilar in size. Of these, 9 are in the group of universities which have probability of increased efficiency less than 70%. Thus there seems to be no obvious effect of relative size of partners on probability of increasing efficiency following merger, and this contrasts with the results of Liu *et al.* (2018)
- Geographical location: Another characteristic which may be influential in improving efficiency following merger is the geographical distance between the merging institutions (Norgård and Skodvin 2002). Of the 11 mergers with probability of efficiency improvement less than our 0.70 threshold, 5 are between institutions which are less than 5 miles apart, whereas 6 of the 14 mergers with probability of efficiency improvement more than 0.70 are similarly closely situated. There is therefore no obvious relationship between likelihood of increasing efficiency following merger and geographical proximity.

One aspect which is not taken into account in this analysis stems from the fact that merging activity can attract considerable additional funding from HEFCE: the merger which resulted in the University of Manchester, for example, received £10 million from HEFCE's Strategic Development Fund (now called the Catalyst Fund) and a further £10 million in repayable

grants.¹⁹ To the extent that these funds are not expended on higher inputs as defined in the ODF model (they may, for example, be used to aid rationalization and hence lower inputs following the merger) then they will not feed through the ODF into lower measured efficiency (and may, if used for rationalization, lead to higher measured efficiency following the merger).²⁰ Information on funding support for merger activity in HE is not routinely recorded, and it is therefore beyond the scope of this particular study to explore its effect on efficiency, but would be an area of future research.

4.4 What is the time path or efficiency effects following merger?

Finally, it has been suggested that increased efficiencies from mergers accrue over time. We therefore examine the time path of efficiency T periods after merger (see figure 3). Compared to the merger year ($T = 0$) there is clear improvement in mean efficiency in the following year ($T = 1$). In the second year after merger ($T = 2$), mean efficiency is higher than in the merger year but slightly lower than at $T = 1$. It is particularly remarkable that there is a wide dispersion in efficiency around the mean at this point, and this continues into subsequent periods (particularly 3 to 5 years after the merger). Mean efficiency therefore seems to plateau two periods after merger at a mean value of around 0.95, but there is considerable (and growing) dispersion around this mean, suggesting that different mergers can experience differing success (in terms of efficiency effects). This is likely to be because each merger is different: mergers differ in terms of culture, focus, relative size and geographical proximity of partners, and in terms of motivation for merger. The last is particularly important in that a merger undertaken for strategic reasons, for example, may have lower efficiency effects than one undertaken explicitly to reap economies of scale or scope (Skodvin 1999). Each merger therefore has a

¹⁹ See <http://www.manchestereveningnews.co.uk/news/greater-manchester-news/universities-get-20m-to-help-fund-merger-1105150>.

²⁰ Unfortunately the HEFCE Board Papers are not available from HEFCE for the whole of the period under study, and so an in-depth analysis of the role of HEFCE funding is not currently possible.

unique combination of characteristics and it is this grouping (rather than one individual factor) which is likely to determine the subsequent effect on efficiency, as well as the timing of that subsequent effect. This is an area where future research could prove fruitful in identifying such groups of characteristics.

[Figure 3 here]

5. Conclusions

In this paper we consider a new model for the study of efficiency, efficiency improvement and their determinants for educational institutions in a dynamic setting. The propensity to merge and educational inefficiency follow a joint, dynamic process which, along with an output distance function, can be estimated using Bayesian techniques organized around MCMC. The new model is compared to more conventional models using Bayes factors. Some 25 mergers that took place in England's HEIs between 1996/97 and 2008/09 are examined in the context of the new model and they are evaluated based on the posterior probability of positive efficiency improvement. There are several main findings.

Let us consider the tendency to merge and inefficiency models first. The results indicate that while inefficiency appears to be significantly and negatively affected by both the tendency to merge and the action of merging (in the previous time period), the tendency to merge is not significantly affected by inefficiency. Both inefficiency and tendency to merge are positively and significantly related to the size of HEI. Thus the greater the size of the HEI the greater the inefficiency and the higher the tendency to merge. The relationship is non-linear in both cases.

While these models suggest that merging typically increases efficiency, an analysis of each individual merger indicates that efficiency improvement is not experienced across the board. Of the 25 mergers examined, 11 have probability below 0.70 that efficiency does not improve in time t compared to time $t-1$ (the year of the merger).

An examination of efficiency gains in the periods following merger suggest that mean efficiency peaks soon after the merger, and plateaus at a value of 0.94 to 0.95. Dispersion around the mean is wide, however, particularly in the 2 to 5 periods after merger. Not all mergers therefore experience the same gains in efficiency. The results are, in some respects, unsurprising given that each merger is different and likely to be undertaken for diverse reasons and with different objectives. It is worth emphasising, however, that these results are derived from a dynamic model which takes into account possible endogeneity between merger and inefficiency, and which provides richer insights than previous studies into the likelihood of efficiency gains following merger and the evolution of efficiency gains over time following merger. This is the first study in higher education to adopt such an approach. A superficial examination of the characteristics which might be related to raising the likelihood of increasing efficiency following merger did not reveal any specific factors, and this is an area for future research.

Some caveats should be borne in mind when considering these results. Each merger differs in terms of culture, focus, relative size and geographical proximity of partners, and in terms of motivation for merger. Thus each merger has a unique combination of characteristics and it is this grouping (rather than one individual factor) which is likely to determine the subsequent effect on efficiency, as well as the timing of that effect. Future research might focus on opening up the black box and identifying the precise combination of institutional characteristics and organisational processes which determine the size and timing of the efficiency gains.

In addition, the role of HEFCE funding in facilitating mergers may be important and is not included in the model here. The measurement of efficiency is limited and does not incorporate any loss imposed by the merger in terms of learning experience on the part of students or quality of working life on the part of staff. Furthermore, we do not consider the possible social costs arising from reduction in diversity between HEIs caused by merging.

The results nevertheless offer clear policy advice that merging is not necessarily the route to unambiguous efficiency gains and should be entered into with caution.

Table 1: Inputs and outputs used in the distance function

Variable name	Definition
Inputs:	
PGINPUT	The total number of FTE postgraduate students (i.e. students on programmes of study leading to higher degrees, diplomas and certificates, including Postgraduate Certificate of Education (PGCE) and professional qualifications)
UGINPUT	The total number of FTE first degree and other undergraduates. The ‘other undergraduates’ category includes qualification aims below degree level such as Foundation Degrees and Higher National Diploma (HND) ²
STAFF	The number of full-time academic staff plus 0.5 times the number of part-time academic staff ³
ACSERV¹	Expenditure incurred on centralised academic services such as the library and learning resource centres, central computer and computer networks, centrally run museums, galleries and observatories, and any other general academic services (in £000s)
ADMIN¹	Expenditure on total administration and central services including expenditure on staff and student facilities (including, for example, Careers Advisory Service, all grants to student societies, emoluments to wardens of halls of residence, accommodation office, athletic and sporting facilities, excluding maintenance, and the institution’s health service) and general educational expenditure (in £000s)
Outputs	
PGOUTPUT	The number of higher degrees plus total other postgraduate qualifications awarded (including doctorate, other higher degrees, PGCEs and other postgraduate qualifications)
RESEARCH¹	Income received in funding council grants plus income received in research grants and contracts (in £000s)
UGOUTPUT	The number of first degree and other undergraduate degrees awarded (see definition of UG)

Notes:

1. These variables are deflated to July 2008 values using the higher education pay and prices index (from Universities UK)
2. A full description of students included in the categories can be found in the HESA data documentation.
3. The data on FTE academic staff are not published for the entire period. We therefore approximate FTE numbers by using the stated calculation.

Table 2: Exogenous (z) variable used in the tendency to merge and inefficiency models

Variable name	Definition
LSIZE	Total number of students i.e. PGINPUT+UGINPUT (in logarithms)
LSIZESQ	The square of LSIZE
FIRST	Proportion of first degree graduates achieving first class honours
UPSEC	Proportion of first degree graduates achieving upper second class honours
LOWSEC	Proportion of first degree graduates achieving lower second class honours
THIRD	Proportion of first degree graduates achieving third class honours
UNC	Proportion of first degree graduates achieving unclassified degree

Note:

The missing category is other undergraduate qualification. Full details of the categories can be found in the HESA data documentation

Table 3: Posterior means and standard deviations; Marginal effects and standard deviations

	Dependent variable		Dependent variable	
	Posterior means		Marginal effects	
	W_{it}^*	$\log u_{it}$	W_{it}^*	$\log u_{it}$
constant	-0.2481 (0.0972)	0.0445 (0.0138)	---	---
$W_{i,t-1}^*$	0.1734 (0.0315)	-0.0107 (0.00315)	0.072 (0.0212)	-0.034 (0.0021)
$\log u_{it}$	0.3115 (0.6781)	---	0.085 (0.071)	---
$\log u_{i,t-1}$	0.0971 (1.2234)	0.0126 (0.0031)	0.0401 (0.373)	0.0215 (0.0027)
LSIZE	0.2341 (0.0732)	0.02415 (0.0116)	0.0151 (0.0022)	0.0341 (0.0071)
LSIZESQ	-0.0110 (0.0113)	-0.0021 (0.0002)	-0.0035 (0.0001)	-0.0017 (0.0002)
FIRST	-0.0003 (0.0001)	$3 \cdot 10^{-5}$ ($7 \cdot 10^{-6}$)	-0.0005 (0.0001)	$1 \cdot 10^{-5}$ ($1 \cdot 10^{-6}$)
UPSEC	-0.0002 (0.0001)	$3 \cdot 10^{-5}$ ($2 \cdot 10^{-6}$)	-0.0004 (0.0001)	$1 \cdot 10^{-5}$ ($3 \cdot 10^{-6}$)
LOWSEC	0.0002 (0.0001)	$1 \cdot 10^{-5}$ ($2 \cdot 10^{-6}$)	0.0001 (0.0001)	$2 \cdot 10^{-5}$ ($2 \cdot 10^{-6}$)
THIRD	0.0001 (0.0002)	$2 \cdot 10^{-5}$ ($4 \cdot 10^{-6}$)	0.0004 (0.0001)	$3 \cdot 10^{-5}$ ($1 \cdot 10^{-6}$)
UNC	0.0003 (0.0001)	$2 \cdot 10^{-5}$ ($1 \cdot 10^{-6}$)	0.0003 (0.0001)	$2 \cdot 10^{-5}$ ($1 \cdot 10^{-6}$)
$I_{i,t-1}$	-0.0138 (0.0012)	$-1 \cdot 10^{-5}$ ($1 \cdot 10^{-6}$)	-0.0212 (0.0013)	$-2 \cdot 10^{-5}$ ($1 \cdot 10^{-6}$)

Notes: Posterior standard deviations are based on Newey-West HAC correction using 10 lags.

Table 4: Model comparison (Bayes factors)

	Entire sample	Pre-1992	Post-1992	Former Colleges of HE
<i>New model against:</i>				
Conventional SFM	61.332	58.415	77.315	144.01
Probit SFM	31.225	21.006	42.206	24.12
Dynamic SFM	11.344	9.727	20.015	22.09

Table 5: English HE Mergers

Year of merger	Time $t-1$ (time of merger)	Time t (post-merger)	<i>Posterior probability that efficiency improved</i>	<i>Lower bound on probability for $w \in [0, 1]$</i>
2000/01	0.944 (0.0031)	0.925 (0.0034)	0.000	0.000
1998/99	0.938 (0.0134)	0.901 (0.0104)	0.015	0.006
2000/01	0.955 (0.0221)	0.928 (0.0012)	0.111	0.081
1997/98	0.921 (0.0033)	0.901 (0.0172)	0.127	0.082
2007/08	0.935 (0.0201)	0.914 (0.0044)	0.154	0.117
2006/07	0.938 (0.0219)	0.917 (0.0117)	0.239	0.142
2000/01	0.940 (0.0117)	0.931 (0.0115)	0.292	0.174
1999/00	0.932 (0.0048)	0.928 (0.0071)	0.421	0.317
2008/09	0.944 (0.0115)	0.941 (0.0055)	0.507	0.415
2002/03	0.942 (0.0134)	0.945 (0.0015)	0.588	0.415
2001/02	0.921 (0.0121)	0.922 (0.0084)	0.627	0.532
2006/07	0.915 (0.0117)	0.922 (0.0032)	0.718	0.664
2005/06	0.905 (0.0100)	0.910 (0.0110)	0.722	0.701
2004/05	0.935 (0.0410)	0.963 (0.0021)	0.812	0.784
1998/99	0.921 (0.0110)	0.932 (0.0028)	0.834	0.801
2001/02	0.925 (0.0173)	0.944 (0.0055)	0.852	0.713
2004/05	0.947 (0.0126)	0.961 (0.0028)	0.861	0.855
2000/01	0.928 (0.0035)	0.938 (0.0012)	0.997	0.881
2004/05	0.931 (0.0022)	0.955 (0.0071)	0.999	0.817
1997/98	0.929 (0.0032)	0.940 (0.0011)	0.999	0.893
1997/98	0.916 (0.0033)	0.935 (0.0011)	0.999	0.893
1998/99	0.922 (0.0045)	0.944 (0.0012)	0.999	0.883
2004/05	0.939 (0.0028)	0.952 (0.0014)	0.999	0.874
2004/05	0.931 (0.0135)	0.998 (0.0010)	0.999	0.833
2005/06	0.918 (0.0034)	0.944 (0.0012)	1.000	0.845

Figure 1: Technical efficiency sample distributions by merger type

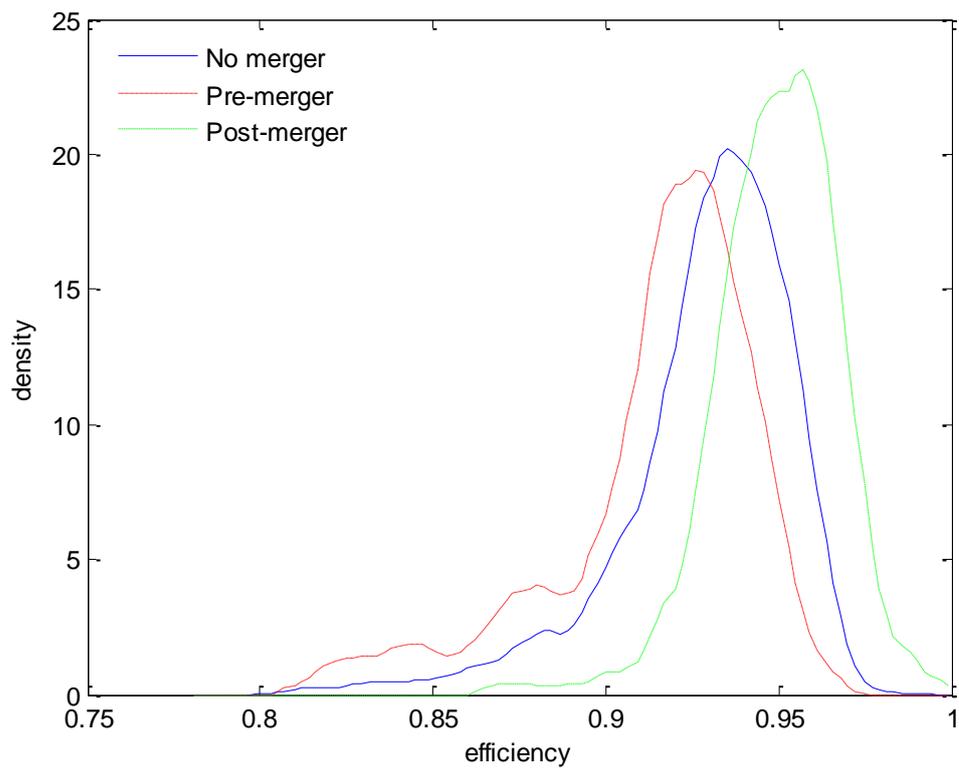


Figure 2: Technical efficiency averages, sample densities

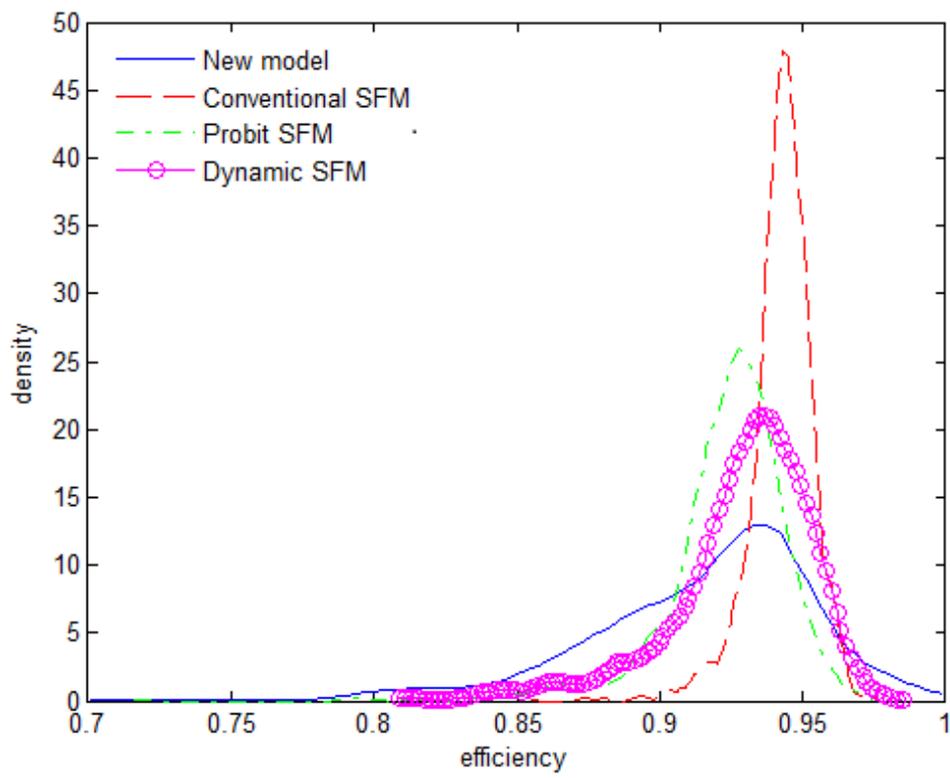
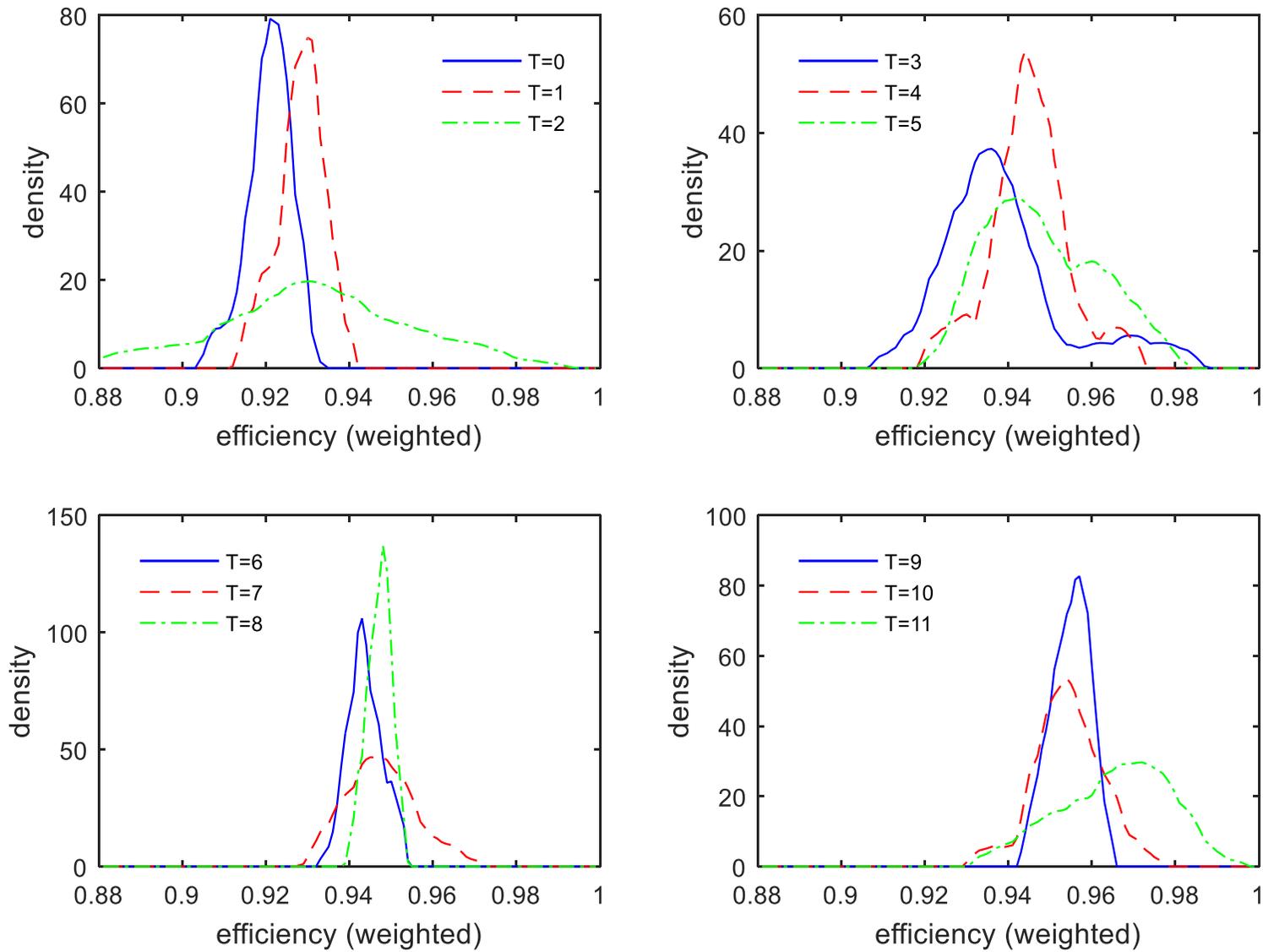


Figure 3: Efficiency of merged HEIs after T periods



References

- Aarrevaara, T. (2007). 'Enhancing universities in Finland.' *Journal of Finance and Management in Colleges and Universities* 4: 261-292.
- Aarrevaara, T., I. R. Dobson and C. Elander (2009). 'Brave new world: higher education reform in Finland.' *Higher Education Management and Policy* 21(2): 89-106.
- Abbott, M. and H. Doucouliagos (2003). 'The efficiency of Australian universities: a data envelopment analysis.' *Economics of Education Review* 22: 89-97.
- Arbuthnott, J. P. and T. R. Bone (1993). 'Anatomy of a merger.' *Higher Education Quarterly* 47(2): 103-119.
- Aula, H.-M. and J. Tienari (2011). 'Becoming “world-class”? Reputation-building in a university merger.' *Critical Perspectives on International Business* 7(1): 7-29.
- Bachan, R. (2015). 'Grade inflation in UK higher education.' *Studies in Higher Education*: DOI: 10.1080/03075079.2015.1019450.
- Badunenko, O., D. J. Henderson and S. C. Kumbhakar (2012). 'When, where and how to perform efficiency estimation.' *Journal of the Royal Statistical Society: Series A* 175(4): 863-892.
- Bates, L. J. and R. E. Santerre (2000). 'A time series analysis of private college closures and mergers.' *Review of Industrial Organisation* 17(3): 267-276.
- Bennetot Pruvot, E., T. Estermann and P. Mason (2015). *DEFINE thematic report: University mergers in Europe*. Brussels, European University Association.
- Berde, É. and I. Ványolós (2008). 'Impact of institutional changes on Hungarian higher education after 1989.' *Higher Education Quarterly* 62(3): 297-317.
- Berriman, J. and M. Jacobs (2010) 'In the eye of the storm: Moving from collaboration to consolidation'. *Talking Points*
- Bösecke, K. (2009). *Value Creation in Mergers, Acquisitions, and Alliances*. Weisbaden, Springer Gabler.
- Botha, M. M. (2001). 'Models for mergers in higher education.' *South African Journal of Education* 21(4): 3-8.
- Boxall, M. and P. Woodgates (2014). *Here be dragons: How universities are navigating the uncharted waters of higher education*. London, PA Consulting Group.
- Browne, J. (2010). *Securing a sustainable future for higher education: An independent review of higher education funding and student finance*. London, Department for Business, Innovation and Skills.
- Cai, Y., R. Pinheiro, L. Geschwind and T. Aarrevaara (2016). 'Towards a novel conceptual framework for understanding mergers in higher education.' *European Journal of Higher Education* 6(1): 24;7;-24.
- Cai, Y. and X. Yang (2016). 'Mergers in Chinese higher education: Lessons for studies in a global context.' *European Journal of Higher Education* 6(1).
- Coelli, T. J. and S. Perelman (2000). 'Technical efficiency of European railways: a distance function approach.' *Applied Economics* 32: 1967-1976.
- Coelli, T. J., D. S. P. Rao, C. J. O'Donnell and G. E. Battese (2005). *An Introduction to Efficiency and Productivity Analysis*. New York, Springer.
- Cooper, W. W., S. C. Ray and M. Stone (2008). 'A Response to M. Stone: 'How not to measure the efficiency of public services (and how one might)'. ' *Journal of the Royal Statistical Society, Series A* 171(2): 433-448.
- Curri, G. (2002). 'Reality versus perception: Restructuring tertiary education and institutional organisational change – a case study ' *Higher Education* 44(1): 133-151.
- Docampo, D., D. Egret and L. Cram (2015). 'The effect of university mergers on the Shanghai ranking.' *Scientometrics* 104(1): 175-191.

- Engwall, L. (2007). 'Universities, the state and the market: Changing patterns of university governance in Sweden and beyond.' *Higher Education Management and Policy* 19(3): 87-104.
- Engwall, L. (2008). 'The university: A multinational corporation'. *The University in the Market*. L. Engwall and D. Weaire (ed). London, Portland Press.
- Evans, L. (2017). 'The worst of times? A tale of two higher education institutions in France: Their merger and its impact on staff working lives.' *Studies in Higher Education* 42(9): 1699-1717.
- Fazackerley, A. (2017). 'University mergers: Academics fight to be heard in marriage of minds'. *The Guardian*. London 18th April
- Fielden, J. and L. Markham (1997). 'Learning lessons from mergers in higher education.' *CHEMS Paper No 17: 8pp CHEMS Consulting, Hampshire.*
- Flegg, T. and D. Allen (2007a). 'Does expansion cause congestion? The case of the older British universities, 1994-2004.' *Education Economics* 15(1): 75-102.
- Flegg, T. and D. Allen (2007b). 'Using Cooper's approach to explore the extent of congestion in the New British universities.' *Economics Issues* 12(2): 47-81.
- Flegg, T., D. Allen, K. Field and T. W. Thurlow (2004). 'Measuring the efficiency of British universities: a multi-period data envelopment analysis.' *Education Economics* 12(3): 231-249.
- Geweke, J. (1992). 'Evaluating the accuracy of sampling-based approaches to calculating posterior moments'. *Bayesian Statistics, volume 4*. J. M. Bernardo, J. O. Berger, A. P. Dawid and A. F. M. Smith (ed). Oxford, UK, Clarendon Press.
- Geweke, J. (1999). 'Using simulation methods for Bayesian econometric models: Inference, development and communication.' *Econometric Reviews* 18(1): 1-73.
- Goedegebuure, L. J. (2012). 'Mergers and more: The changing tertiary education landscape in the 21st century.' *HEIK Working Paper Series* University of Oslo, Oslo, Norway.
- Goedegebuure, L. J. and V. L. Meek (1991). 'Restructuring higher education: A comparative analysis between Australia and the Netherlands.' *Comparative Education* 27(1): 7-22.
- Green, C. and G. Johnes (2009). 'Economies of scale and mergers in higher education'. *The Routledge International Handbook of Higher Education*. M. Tight, K.-h. Mok, J. Huisman and C. Morphet (ed). New York, Routledge: pp369-380.
- Green, M. (2009). 'A merger with innovation at its heart'. *The Financial Times*. London
- Harman, G. and K. Harman (2003). 'Institutional mergers in higher education: Lessons from international experience.' *Tertiary Education and Management* 9(1): 29-44.
- Harman, G. and K. Harman (2008). 'Strategic mergers of strong institutions to enhance competitive advantage.' *Higher Education Policy* 21(1): 99-121.
- Harman, K. (2002). 'Merging divergent campus cultures into coherent educational communities: Challenges for higher education leaders.' *Higher Education* 44(1): 91-114.
- Harman, K. and V. L. Meek (2002). 'Introduction to special issue: Merger revisited: international perspectives on mergers in higher education.' *Higher Education* 44(1): 1-4.
- HEFCE (2010). 'Research degree qualification rates: Full-time students starting in 2000-01, 2001-02 or 2003-03; Part-time and mode-switch students starting in 1999-2000.' HEFCE 2010/21 Higher Education Funding Council for England, Bristol.
- HEFCE (2012). 'Collaborations, alliances and mergers in higher education: Consultation on lessons learned and guidance for institutions.' HEFCE 2012/06 Higher Education Funding Council for England, London.
- HESA (2013). 'UK Performance Indicators in Higher Education.' Retrieved 10th September 2014, from <https://www.hesa.ac.uk/pis/>.

- Hollingsworth, B. (2004). 'Non parametric efficiency measurement.' *Economic Journal* 114(496): F307-F311.
- Hu, Y. and W. Liang (2008). 'Malmquist index analysis of the dynamic changes in scientific research productivity of some Chinese universities before and after merger.' *Frontiers of Education in China* 3(3): 429-447.
- Johnes, G. (2004). 'Standards and grade inflation'. *International Handbook on the Economics of Education*. G. Johnes and J. Johnes (ed). Cheltenham, Edward Elgar: pp462-483.
- Johnes, J. (2014). 'Efficiency and mergers in English higher education 1996/97 to 2008/9: Parametric and non-parametric estimation of the multi-input multi-output distance function.' *The Manchester School* 82(4): 465-487.
- Johnes, J. and G. Johnes (2013). *Efficiency in the Higher Education Sector: A Technical Exploration*. London, Department for Business Innovation and Skills.
- Jump, P. (2014). 'Cut 50% of universities and bar undergraduates from Oxbridge'. *Times Higher Education*. London, Times Supplements Ltd 25th June 2014
- Kitagawa, F. (2010). 'Pooling resources for excellence and relevance: An evolution of universities as multi-scalar network organisations.' *Minerva* 48(2): 169-187.
- Kwoka, J. and M. Pollitt (2010). 'Do mergers improve efficiency? Evidence from restructuring the US electric power sector.' *International Journal of Industrial Organization* 28(6): 645-656.
- Kyvik, S. (2002). 'The merger of non-university colleges in Norway.' *Higher Education* 44(1): 53-72.
- Kyvik, S. and B. Stensaker (2013). 'Factors affecting the decision to merge: The case of strategic mergers in Norwegian higher education.' *Tertiary Education and Management* 19(4): 323-337.
- Leslie, H., A. Abu-Rahma and B. Jaleel (2018). 'In retrospect: A case of merger in higher education.' *International Journal of Educational Management* 32(3): 382-395.
- Liu, Q., D. Patton and M. Kenney (2018). 'Do university mergers create academic synergy? Evidence from China and the Nordic Countries.' *Research Policy* 47(1): 98-107.
- Mahony, D. (1992). 'Establishing the university as the sole provider of higher education: The Australian experience.' *Studies in Higher Education* 17(2): 219-236.
- Mahony, D. (1994). 'Counter images of Australia's movement to an undifferentiated higher education system: An analysis.' *Higher Education* 28(3): 301-323.
- Mao, Y.-q., Y. Du and J.-j. Liu (2009). 'The effects of university mergers in China since 1990s.' *International Journal of Educational Management* 23(1): 19-33.
- Mok, K.-h. (2005a). 'Globalization and educational restructuring: University merging and changing governance in China.' *Higher Education* 50(1): 57-88.
- Mok, K.-h. (2005b). 'The quest for world class university: Quality assurance and international benchmarking in Hong Kong.' *Quality Assurance in Education* 13(4): 277-304.
- Norgård, J. D. and O.-J. Skodvin (2002). 'The importance of geography and culture in mergers: A Norwegian institutional case study.' *Higher Education* 44(1): 73-90.
- O'Donnell, C. J. (2011). 'Econometric estimation of distance functions and associated measures of productivity and efficiency change.' *Centre for Efficiency and Productivity Analysis Working Paper Series WP01/2011*.
<http://www.uq.edu.au/economics/cepa/docs/WP/WP012011.pdf> University of Queensland.
- Papadimitriou, M. and J. Johnes (2018). 'Does merging improve efficiency? A study of English universities.' *Studies in Higher Education*: 1-21.
- Patterson, G. (2000). 'Findings on economies of scale in higher education: implications for strategies of merger and alliance.' *Tertiary Education and Management* 6(4): 259-269.

- Pinheiro, R., L. Geschwind, T. Aarrevaara, Lärande, Kth and I. Skolan för teknikvetenskaplig kommunikation och (2016). 'Mergers in higher education.' *European Journal of Higher Education* 6(1): 2-6.
- Popov, S. V. and D. Bernhardt (2013). 'University competition, grading standards, and grade inflation.' *Economic inquiry* 51(3): 1764-1778.
- Pritchard, R. M. O. (1993). 'Mergers and linkages in British higher education.' *Higher Education Quarterly* 47(2): 79-102.
- Ripoll-Soler, C. and M. De-Miguel-Molina (2014). 'Are mergers a win-win strategic model? A content analysis of inter-institutional collaboration between higher education institutions.' *Tertiary Education and Management* 20(1): 44-56.
- Rowley, G. (1997). 'Mergers in higher education: A strategic analysis.' *Higher Education Quarterly* 51(3): 251-263.
- Skodvin, O.-J. (1999). 'Mergers in higher education - success or failure?' *Tertiary Education and Management* 5(1): 65-80.
- Smith, P. C. and A. Street (2005). 'Measuring the efficiency of public services: The limits of analysis.' *Journal of the Royal Statistical Society, Series A* 168(2): 401-417.
- Stensaker, B. (2006). 'Governmental policy, organisational ideals and institutional adaptation in Norwegian higher education.' *Studies in Higher Education* 31(1): 43-56.
- Stensaker, B., M. Persson and R. Pinheiro (2016). 'When mergers fail: A case study on the critical role of external stakeholders in merger initiatives.' *European journal of higher education* 6(1): 56;70;-70.
- Stevens Report (2013). *Policing for a Better Britain*. Report of the Independent Police Commission.
- Stewart, G. (2003). 'College mergers: Lessons to be learned from other sectors.' *Research in Post-Compulsory Education* 8(3): 305-328.
- Stone, M. (2002). 'How not to measure the efficiency of public services (and how one might).' *Journal of the Royal Statistical Society Series A* 165(3): 405-422.
- Teixeira, P. N. and A. Amaral (2007). 'Waiting for the tide to change? Strategies for survival of Portuguese private HEIs.' *Higher Education Quarterly* 61(2): 208-222.
- Tienari, J., H.-M. Aula and T. Aarrevaara (2016). 'Built to be excellent? The Aalto University merger in Finland.' *European Journal of Higher Education* 6(1): 25-40.
- Tight, M. (2013). 'Institutional churn: Institutional change in United Kingdom higher education.' *Journal of Higher Education and Policy Management* 35(1).
- Tirronen, J. and T. Nokkala (2009). 'Structural development of Finnish universities: achieving competitiveness and academic excellence.' *Higher Education Quarterly* 63(3): 219-236.
- Välilmaa, J., H. Aittola and J. Ursin (2014). 'University mergers in Finland: Mediating global competition.' *New Directions for Higher Education* 2014(168): 41-53.
- Verdinelli, I. and L. Wasserman (1992). 'Computing Bayes factors using a generalization of the Savage-Dickey density ratio.' *Journal of the American Statistical Association* 90(430): 614-618.
- Viaene, J.-M. and I. Zilcha (2013). 'Public funding of higher education.' *Journal of Public Economics* 108: 78-89.
- Wan, Y. and M. W. Peterson (2007). 'A case study of a merger in Chinese higher education: the motives, processes and outcomes.' *International Journal of Educational Development* 27(6): 683-696.
- Williamson, O. E. (1964). *The Economics of Discretionary Behavior: Managerial Objectives in a Theory of the Firm*. New Jersey, Prentice-Hall.
- Worthington, A. C. (2001). 'Efficiency in pre-merger and post-merger non-bank financial institutions.' *Managerial and Decision Economics* 22(8): 439-452.

- Worthington, A. C. and H. Higgs (2011). 'Economies of scale and scope in Australian higher education.' *Higher Education* 61(4): 387-414.
- Worthington, A. C. and B. L. Lee (2008). 'Efficiency, technology and productivity change in Australian universities 1998-2003.' *Economics of Education Review* 27(3): 285-298.
- Yang, R. (2015). 'Institutional mergers in Chinese higher education'. *Mergers and Alliances in Higher Education: International Practice and Emerging Opportunities*. A. Curaj, L. Georghiou, J. C. Harper and E. Egron-Polak (ed), Springer International Publishing.
- Zeeman, N. and P. Benneworth (2017). 'Globalisation, mergers and 'inadvertent multi-campus universities': reflections from Wales.' *Tertiary Education and Management* 23(1): 41-52.