MEDIUM EFFICIENCY: COMPARING INPUTS AND OUTPUTS BY LANGUAGE OF INSTRUCTION IN SECONDARY SCHOOLS IN WALES

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This version; December 2019

ABSTRACT

A meta-frontier approach is used to evaluate the efficiency with which inputs into the education process are converted into outputs, using data for secondary schools in Wales obtained from the 2015 PISA study. The efficiency of schools in which teaching is conducted through the medium of English is compared with that of Welsh medium schools. On most measures, inputs into the latter are relatively high, having an impact on their observed levels of efficiency. Improving PISA scores in Wales likely requires enhancement of the performance of Welsh medium schools, but there needs to be explicit recognition of a trade-off between such improvement and the realisation of policy goals that are broader than those evaluated in PISA.

Introduction

It is well established that education facilitates successful life outcomes for individuals and contributes substantially to the wealth of nations (Barro and Lee, 1994). Recent work has highlighted the impact that differences in the quality of education can have on economic outcomes (Hanushek and Woessman, 2015). The delivery of high quality education has consequently become a priority for governments across the world; comparisons of school performance both within (Bradley and Taylor, 2010) and across countries (Hopfenbeck et al., 2017) have become common, with the aim of identifying and encouraging good practice.

Within Wales, the drive for improved performance has resulted in a plethora of policy initiatives (Andrews, 2011; Johnes, 2018). Policy-makers in Wales have resisted the temptation to pursue an aggressive quasi-market in education, and, in comparison with those in England, have tended to see a greater role for government as being appropriate (Power, 2016). This may partly result from an ethos that values equity and cooperation, but may also reflect the difficulties of providing effective competition in a context of lower population density.[1]

Another distinctive characteristic of the Welsh system of education, at both primary and secondary levels, is the existence of schools that teach through the medium of the Welsh language. These serve an important need in meeting demand from parents and in helping preserve national identity and culture. Welsh medium schools are often regarded as serving an elite constituency (Jones, 2017), and their presence is likely to have an impact on the distribution of pupils across schools that is not neutral. Moreover, through the operation of peer effects, this may have an impact on the overall performance of pupils educated in the Welsh system of education. Yet the efficiency of Welsh medium schools – and the impact of this on the efficiency of the whole system of schools in Wales – is an under-researched area.

The aim of this paper is thus to investigate the efficiency of provision of secondary education in Wales, with a particular focus on the role played by Welsh medium education. The remainder of the paper is structured as follows. In the next section, we briefly survey the literature on Welsh medium education. This is followed by an introduction to the methodological approach that will be used in the empirical part of the paper. Then we introduce the data. The following section reports the results of the analysis. The paper ends with a short concluding section.

Literature

Since the devolution of powers to the Welsh Government in 1999, education policy in Wales has diverged from the quasi-market orientation of the system in England. This reflects different conditions and priorities across the jurisdictions. The Welsh Government has prioritised equity (Welsh Government, 2016). Moreover the relatively low density of population in much of Wales is likely to dilute the effectiveness of choice based mechanisms. Recent concerns about standards in education in Wales have prompted a number of reforms

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[1] The appropriate size and number of schools in smaller communities in Wales has generated debate; see for example http://bit.ly/35Y89v8.

(Pont et al., 2017; Johnes, 2018), focused on the quality of teaching provision, curriculum reform, distribution of resources, and leadership development.

A distinctive characteristic of the education landscape in Wales concerns the presence of schools that deliver teaching through the medium of Welsh. At secondary level, there are just over 200 schools in Wales, catering for a little under 200000 pupils. Of these schools, some 24.4% are Welsh medium, and these cater for 20.5% of pupils at this level.[2]

Laugharne (2015) provides a recent history of Welsh medium education, and notes in particular the challenges that arise from providing schooling in a language that, for many pupils, is not that used in the home. Along with issues that arise from their slightly smaller scale, this likely impacts on the performance of schools that deliver teaching in the medium of Welsh, though the direction of such an impact is not clear and historically the performance of Welsh medium schools has been widely perceived to be good (Burge and Lenkeit, 2015). Indeed Reynolds and Bellin (1996) document superior outcomes in Welsh-medium schools, giving their paper the provocative subtitle 'why are they better'? Any implication that the higher performance of Welsh-medium schools on raw output measures reflects higher value-added has, however, been seriously challenged by more rigorous statistical analysis. Gorard (1998) shows that, once differences in relevant local characteristics are taken into account there is no significant difference between the performance of Welsh-medium and English-medium schools in Wales – and indeed no significant difference either between these and comparable schools in England. Gorard uses GCSE data, and, in comparing Welsh and English medium schools in Wales, finds that 'there is no clear evidence here that children are advantaged by attending either type of school' (as opposed to the other).

In a study focused on the Rhymney valley, Hodges (2010) finds cultural, rather than economic, educational or personal, reasons dominate parents' decisions in favour of Welsh medium schooling for their children. Similar results have more recently also been obtained by O'Hanlon (2015), who finds that the importance of culture is even stronger in the context of Gaelic education in Scotland than is the case for Welsh education in Wales. Jones (2017) builds on these analyses by examining the growth in Welsh medium education in south east Wales, and finds that English and Welsh medium schools differ markedly in their social composition, the latter having far fewer pupils eligible for free school meals – an oft-used measure of deprivation. Meanwhile, however, other groups of parents actively choose to avoid Welsh medium instruction for their children (Gorard, 1997).

The data provided in the studies referred to above indicate that schools that deliver their teaching in the medium of Welsh serve cohorts of pupils that are, on some measures, advantaged. Nevertheless there is evidence that this advantage is not reflected in the performance of pupils attending Welsh medium schools. Jerrim and Shure (2016, p.128) point out that in reading and science, the average score achieved by those attending these schools is lower than pupils in Wales attending English medium schools, albeit not significantly so. If it is indeed the case that the inputs into Welsh medium schools are relatively rich while outputs are no better than those of English medium schools, the relative efficiency of provision across the two types of school becomes a matter of interest. Yet how efficiently

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[2] https://bit.ly/2MCOFHb.

inputs are converted into outputs – typically measured by test results – has not been the subject of research. This is the subject of the remainder of this paper.

Methodology

The main analytical technique on which we draw in conducting our analysis is that of meta-frontiers in data envelopment analysis. A useful means of conveying the salient features of data envelopment analysis is to refer to Figure 1. This compares, for given inputs, the production levels of two distinct output types that are produced by four decision-making units, labelled A, B, C and D. Some of these producers, such as A, produce a relatively large amount of output 1 and relatively little output 2; others, such as C, produce a relatively large amount of output 2 and relatively little output 1. But all of them decide how much of these two outputs they wish to produce given the level of input that they employ. The line joining points A, B and C represents an important frontier: on the basis of the observed data, it shows how much of output 1 can be produced given the levels of input and output 2 (or, equivalently, how much output 2 can be produced given input and output 1). We know that it is possible to produce the levels of output 1 and output 2 that are produced by decision-making unit A, for example, simply because decision-making unit A produces them. Equally we know that it would be possible to produce the levels of output represented by point E, because this is a linear combination of the output vectors of decision-making units A and B.

Decision-making unit D, however, lies within the frontier. Given the level of inputs, it would be possible for this unit to produce more of both output 1 and output 2. We know this, because E lies on the frontier, involves the production of the same ratio of outputs 1 and 2 as does D, but can produce more of each; and point E is just a straightforward weighted average of the outputs of decision-making units A and B which already exist. The relative efficiency of D can therefore be represented by the ratio OD/OE. Units A, B and C, being on the frontier, all have efficiency scores of 1, but D has an efficiency score that is less than 1.

An important feature of this analysis is that it is agnostic about the relative merits of the two output types. Decision-making unit A is clearly the 'best' at producing output 1, while decision-making unit C is clearly the 'best' at producing output 2. But in the absence of any reason to prefer one output type to the other, both these units can be deemed equally efficient – in a technical sense. Decision-making unit D, by way of contrast, is not as efficient because it falls short of the frontier. In many contexts, market prices are available that provide information about the weight that society places on each type of output. But the method that is proposed here does not require data on such prices. Data envelopment analysis is therefore an ideal tool for evaluating the efficiency of producers that do not operate in a conventional market – that is, they operate in an environment in which prices are absent.

The diagrammatic analysis of Figure 1 focuses on the one input and two output case. Using linear programming techniques, this can be extended to higher dimensions in which multiple inputs are used to produce multiple outputs, and numerous software solutions facilitate the calculation of efficiency scores (and other measures) using such methods. The efficiencies reported later in the present paper have been evaluated using Limdep software.

Suppose now that the decision-making units considered so far all come from a clearly defined cluster of producers. Suppose further that a second cluster of producers can be identified too. The output vectors of the first cluster are identified by the points marked X in Figure 1, and these are reproduced in Figure 2. In the latter figure are shown also the output vectors of the second cluster – identified as points marked Y. The decision-making units in the second cluster of producers are labelled F (which concentrates on production of output 1) and G (which concentrates on production of output 2). It so happens that F is producing an output vector that lies outwith the frontier that is defined by the decision-making units in the first cluster – so, taking a global perspective, decision-making unit A can no longer be considered efficient, even though it is an efficient producer within its own cluster. Likewise, decision-making unit G, which is efficient within its own cluster, is clearly dominated by B which produces more of both outputs, so it is not globally efficient. So, while the piecewise linear frontier ABC defines efficiency within the first cluster, and the line FG defines an efficiency frontier for the second cluster, taking both clusters together the efficiency frontier is given by FBC.

Earlier, we identified the efficiency of D, within its own cluster, as OD/OE. A global definition of the efficiency of this decision-making unit is given by the ratio OD/OH. When compared with all decision-making units, not just those in its own cluster, decision-making unit D appears less efficient, since OD/OE > OD/OH. The comparison of these two efficiency measures is useful, since units operating in the first cluster may face a different set of environmental conditions than those in the second cluster – for example, they might be subject to different regulations. It is appropriate therefore to consider both how efficient a decision-making unit is relative to its peers in its own cluster and, separately, how efficient it is relative to all peers. The first of these measures provides an indication of the efficiency of the individual unit; and the ratio of the first measure to the second measure is indicative of the comparative efficiency of frontier units in the first and second clusters. Averaging these measures across all decision-making units provides the key indicators that are used in the sequel.

To be specific, in the context of the present paper, this method of meta-frontiers is used to analyse the performance of individual pupils (decision-making units) in secondary schools that are positioned in one of two clusters – the first cluster comprises schools that deliver their teaching through the medium of English, while the second is made up of Welsh medium schools. The extension of the Charnes et al. (1978) model of data envelopment analysis to meta-frontiers, as described above, is due to Charnes et al. (1981), Portela and Thanassoulis (2001) and Rao et al. (2003). It has subsequently been applied to provide insight in the context of education by Johnes (2006), Waldo (2007), De Witte et al. (2010), Thieme et al. (2013), Johnes (2018) and Johnes and Virmani (2019).

Data

The data used in the analysis that follows come from the Programme of International Student Assessment (PISA) of the Organisation for Economic Cooperation and Development (OECD). Every three years since the turn of the millennium, PISA surveys have been conducted, covering in total more than 80 countries. The data used in the present study come from the

year 2015.[3] The microdata providing information at the level of individual pupils are freely downloadable from https://bit.ly/2BAsXi9. These data cover 15 year old pupils attending a sample of schools. Within the United Kingdom sample, schools in Wales are separately identifiable; it is possible also to identify the language used in undertaking PISA assessments, and hence the language of instruction at the pupil's schools. Some 140 secondary schools in Wales participated in the 2015 PISA survey, of which 18 provide education through the medium of Welsh.

The microdata gather together a considerable amount of information about pupils – including their month of birth and characteristics of their households such as measures of economic social and cultural status (ESCS), and wealth. The data also include measures of class time spent at school, divided into relevant subject areas, as well as measures of time spent in private study. The key measures provided in the PISA data, however, are indicators of each pupil's performance on a series of specially designed tests in the areas of reading, mathematics and science. These are designed to be independent of quirks in the curriculum, so that they allow evaluation of performance across countries on a comparable basis.

The PISA results for Wales have generated some measure of consternation, leading to what has been described as PISA shock (Swaffield, 2017). The results are, however, consistent with comparisons based on more comprehensive information gathered over a longer period, including data GCSE results (Reynolds, 2008, Rees and Taylor, 2014). In the wake of results that have appeared disappointing relative to other parts of the United Kingdom, the authorities in Wales have introduced a number of initiatives aimed at improving outcomes (Johnes, 2018). The relative performance of English and Welsh medium schools has not, however, to the best of our knowledge, heretofore been examined using PISA data. That is the subject of the next section.

Analysis

To facilitate comparison with other research, we use the model specification used by Johnes (2018). The meta-frontier approach is based on a constant returns to scale data envelopment analysis of the type pioneered by Charnes et al. (1978). There are 9 inputs and 3 outputs. The inputs are: pupil's age (measured in months), the number of books they have at home, weekly hours spent in class for maths, language (reading), and science respectively, hours spent studying per week out of class, and the PISA measures of household possessions, wealth and ESCS[4]. The outputs are the 'plausible value' scores obtained by the pupil on the PISA maths, reading and science tests respectively[5].

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[3] The 2018 results became available in December 2019, too late for incorporation into this study.

[4] Where, as in the case of ESCS, household possessions, and wealth, the measures provided in the PISA database contain negative values, the measure has been augmented by 10 to ensure that all values are positive; this is a requirement of the DEA model. The measures reported in the PISA data for these variables are based on standardised variables – and in the case of ESCS on the first principal component of a group of standardised variables. See http://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-16-Procedures-and-Construct-Validation-of-Context-Questionnaire-Data.pdf.

[5] The computation of plausible value measures in the PISA data is discussed in https://www.oecd.org/pisa/sitedocument/PISA-2015-Technical-Report-Chapter-9-Scaling-PISA-Data.pdf.

Results are reported in Table 1. Within school types, there is less variation in pupil performance, given inputs, in Welsh medium schools than in English medium schools. Pupil level efficiencies in Welsh medium schools average around 87%, while those in English medium schools average 81%. This is likely to reflect, in part at least, a greater degree of homogeneity in unobservable variables amongst pupils attending the Welsh medium schools. However the frontier for English medium schools is typically higher than that for Welsh medium schools – markedly so. If the global frontier were comprised only of pupils at schools from one of the clusters (the other cluster not being represented on the frontier at all), then the school type within all school type measure for that cluster would equal one. It is readily observed from the table that, for the English medium schools, this is very close to being the case. Given inputs, a given pupil is thus likely to perform better at an English medium school than at a Welsh medium school. This finding sits uneasily alongside the conventional wisdom (Reynolds et al., 1998) and so warrants some further interrogation.

Table 2 reports descriptive statistics of variables used in the analysis, separately for pupils attending English and Welsh medium schools. Inputs based in the home are typically higher for those attending Welsh medium schools than those attending English medium schools, reflecting a measure of social advantage. By way of contrast, class time spent on mathematics and reading are greater in the English medium schools. Turning to the output measures, average test scores in all three subject areas are higher for pupils attending English medium schools. This contrasts with results obtained in earlier rounds of the PISA study (Burge and Lenkeit, 2015). The relatively low (school type within school type) efficiency of Welsh medium schools stems therefore both from these schools having inferior scores on the output measures and having superior scores on (many of the) input measures.

Some notes of caution are needed at this stage. First, the frontier established by data envelopment analysis is based on the best observed performance (given inputs), and so necessarily represents the performance of outliers; since most pupils attend English medium schools, it is more likely that this outlying performance is achieved by pupils at such schools than by those at Welsh medium schools. Nevertheless the gap between the 'school type within all school types' measure for the English and Welsh medium schools respectively is striking. Secondly, the number of observations – particularly in the Welsh medium schools – is fairly limited (based on a sample of schools rather than the population) and so the confidence intervals that attach to the measures reported here are likely wide. Thirdly, Akyol et al. (2018) have used data on non-response rates to multiple-choice questions on PISA as a check on the seriousness with which students take the (low stakes) PISA testing exercise, and find considerable cross-country differences. If there are systematic cultural differences between English and Welsh medium schools in the seriousness with which students take the PISA tests, then the test scores may be biased measures of ability. It is difficult to assess the extent to which this may be a factor in explaining the results reported here, not least because of the absence of data, comparable to PISA, that would allow schools in Wales to be evaluated using data on performance in high stakes examinations such as GCSE. Recent developments have led to an improvement in information sets about secondary schools in Wales (Welsh Government, 2018), but further advances are needed if serious insights are to become available from research into the relative performance of Welsh and English medium providers. As noted by Egan (2016), however, PISA tests concern specific aspects of learning, and the educational objectives of schools are typically broader than this; specifically in the case of Welsh medium schools, there is a language mission that is distinctive and that is not captured by PISA. Fourthly, many pupils being tested through the medium of Welsh come from homes where English is the usual medium of communication, and so they are being tested by way of a second language. This second language, moreover, is learned within a social context that is saturated by English language media. A related point is that pupils attending schools that deliver their teaching through the medium of Welsh are bilingual, and so have skills *in both languages* that many of those attending English medium schools do not; yet these skills are not tested by PISA (which tests students in either type of school in English only). There are clear challenges associated with assessing the

attainment of bilingual students using instruments that employ only one language, and it is not easy then to compare outcomes with those achieved by monoglots. Young et al. (2017) identify characteristics such as enhanced self-esteem that appear to be associated with receiving education through the medium of the minority language, and that are not captured by the international comparative tests.

Conclusion

As we have seen from the descriptive statistics reported in Table 2, the outcomes achieved in PISA by students in Welsh medium schools fall short, in all three areas, of those achieved in English medium schools. Since, if anything, students attending Welsh medium schools enjoy a richer set of inputs (such as home possessions and private study), the data are thus indicative of a gap between the efficiency of Welsh and English medium providers. This is confirmed by the meta-DEA analysis undertaken in the present paper – the 'school type within all school type' efficiency of English medium schools clearly dominates. Many factors may underpin this gap. One possibility is that there are systematic differences in how low stakes tests are approached; another is that Welsh medium schools face a more limited pool from which to recruit their teachers in comparison with English medium schools that can recruit internationally. These, however, are hypotheses that are in search of evidence that future research should address.

If improved performance in PISA is a policy objective, then an enhanced understanding of the constraints facing Welsh medium schools might enable quick wins. In addition to fulfilling educational goals characteristic of schools everywhere, however, these schools serve social and cultural purposes that may be of particular importance in the Welsh context and that compete with the narrower pedagogical aims reflected in PISA. While it would be useful to evaluate their achievements in meeting these broader purposes alongside the value that they add to students' education based on more traditional measures, data constraints mean that this must be left as an exercise for the future.

Table 1 Average value of pupil-level efficiencies

	English	Welsh
pupil within school type	0.8103	0.8678
school type within all school types	0.9979	0.8971

Note: Author's calculations on the PISA microdata for Wales, obtained from http://www.oecd.org/pisa/data/2015database/. Numbers of observations are 2321 for pupils being tested through the medium of English and 338 for pupils being tested through the medium of Welsh.

Table 2 Descriptive statistics by type of school

	English		Welsh	
	mean	standard deviation	mean	standard deviation
books	122.0	147.3	148.5	162.8
maths: class hours	231.7	81.9	210.0	69.5
science: class hours	296.0	133.5	308.3	128.7
reading: class hours	239.7	96.5	216.8	121.1
age	15.7	0.29	15.7	0.29
private study hours	17.3	12.2	19.8	13.0
home possessions	10.3	11.0	10.5	11.0
wealth	10.5	0.9	10.5	1.0
ESCS	10.2	0.8	10.3	0.8
maths score	484.6	75.6	475.9	72.2
reading score	494.3	81.9	469.0	77.3
science score	499.3	85.3	484.1	82.2

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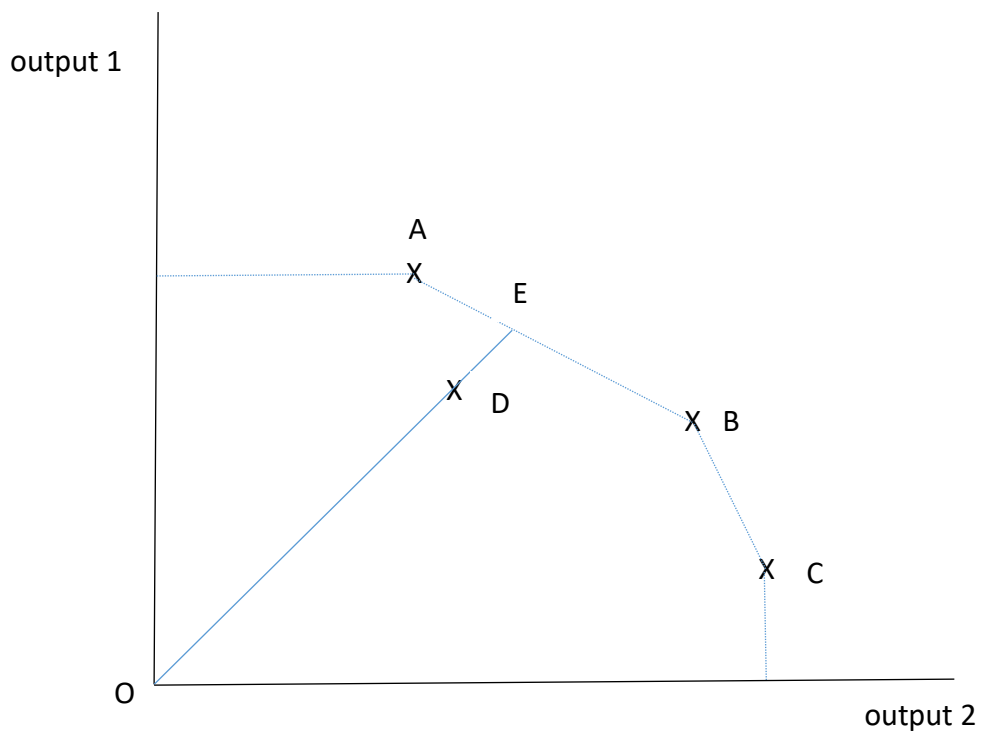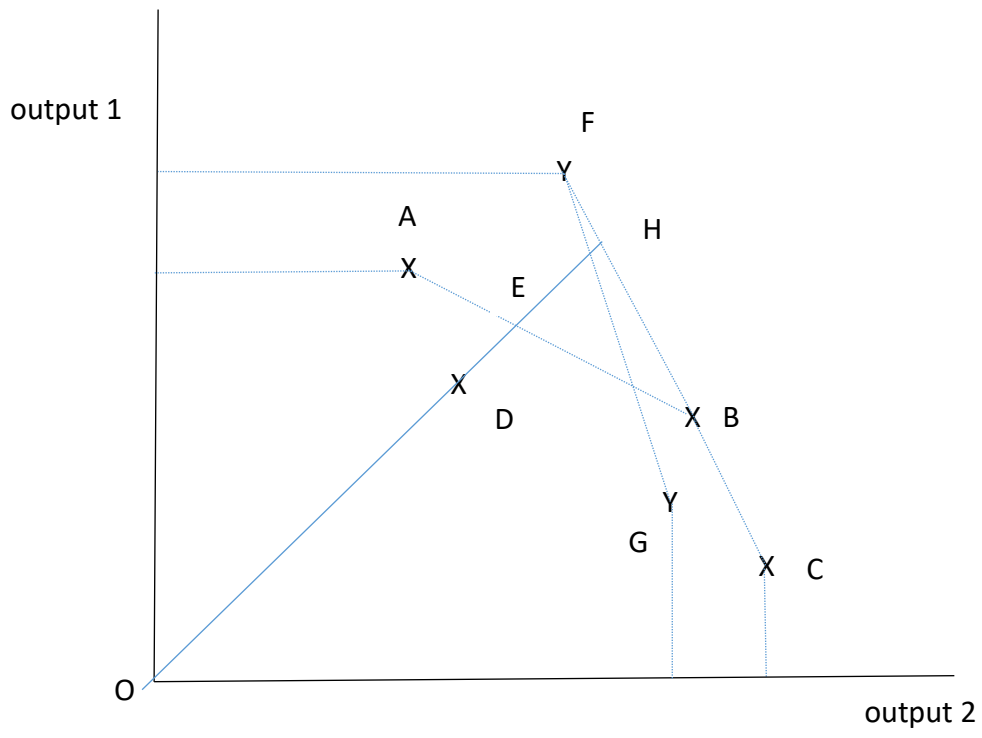
Figure 1 Data envelopment analysis

Figure 2 Meta-frontiers