TASK COMPLEXITY, ORGANIZATION SIZE AND ADMINISTRATIVE INTENSITY: THE CASE OF UK UNIVERSITIES

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ABSTRACT
The task complexity and size of public service organizations are arguably key determinants of their administrative intensity. Moreover, the combined effect of these two variables is also likely to have important implications for the scale of the administrative function. To explore the separate and combined effects of task complexity and size on administrative intensity in public service organizations, we examine the determinants of the relative proportion of resources allocated to central administration rather than academic departments in UK universities between 2003 and 2008. The results suggest that there is a nonlinear u-shaped impact of both task complexity and size on administrative intensity, and that in combination these characteristics lead to a bigger central administrative component in universities. Theoretical and practical implications are discussed.

INTRODUCTION

Public service organizations are complex professional bureaucracies, large and frequently difficult to manage. Their effective management is dependent upon the creation of a cadre of central administrative staff and support units responsible for the coordination of organizational activities. The central administrative function of any organization typically comprises those personnel with no direct role in delivery of a service or production of a good, such as the senior management, central administrative divisions (e.g. finance, human resources), and clerical workers providing services to the whole of an organization. The central administration function is therefore distinguished from the production functions responsible for the delivery of services (e.g. professionals and street-level bureaucrats in public organizations, and their immediate administrative support personnel). The ratio of corporate administrative resources to the resources expended in service departments constitutes the central administrative intensity of an organization. Since the administrative function is an "overhead" that is added to service delivery costs, it is important to investigate its potential determinants. But what determines whether the administrative centre of a public organization is large or small?

After a number of studies of the determinants of administrative intensity between the 1960s and 1980s, this topic has been largely neglected in recent years (Boyne and Meier, 2013). Much of the previous work drew on various forms of contingency theory which posit that organizational characteristics are influenced by, or contingent upon, their external and internal contexts. In a comprehensive review of the development of contingency theory, Donaldson (2001, 16) argues that the various strands of the contingency view of organizational structure "may be integrated by stating that there are two main contingencies, task and size". Furthermore,

contingency theory implies that there is no 'right' level of administrative intensity, other than the level that 'fits' circumstances such as the complexity of the task an organization faces and the scale of the operations that are being undertaken (Van de Ven, Ganco and Hinings, 2013). In this paper we revisit the topic of administrative intensity in the public sector, and empirically evaluate whether task complexity and size are important influences on the proportion of resources devoted to administrative overheads rather than front-line service provision.

We not only revisit the contingency perspective on administrative intensity, but also extend previous work in several ways. First the focus of prior work has usually been on organizational size, and in most studies only the linear effect of size is considered (Boyne and Meier, 2013). In this paper we examine not only the effects of size but also whether task complexity makes a difference to administrative intensity in the public sector. Second, we hypothesise that both task complexity and size have non-linear effects, and that increases in either of these organizational characteristics at first lead to lower intensity but eventually lead to higher intensity. Finally, we hypothesise that complexity and size have jointly reinforcing effects on intensity. So that, for example, an increase in size is likely to have an especially strong positive effect in organizations that have high complexity.

In past studies the issue of task complexity has largely been examined by focusing on the implications of alternative approaches to structuring the division of labour within organizations (see, for example, Hall et al. 1967). In particular, the number of different production units has long been regarded as an indicator of task complexity (Dewar and Hage 1978), and a potentially important influence on other organizational characteristics, including the relative intensity of central administrative activity (Kahn et al. 1964). According to the 'complexity-administrative growth

hypothesis' (Rushing 1967), high levels of task complexity lead to an expansion of the administrative function within organizations, as the need to monitor and manage disparate production units poses new and complicated coordination problems (Blau and Schoenherr 1971). Moreover, the complexity-administrative growth hypothesis suggests that the size of an organization is associated with a growth in administration due to the sheer number of employees to be managed.

The 'complexity-administrative growth' hypothesis stands in stark contrast to arguments on economies of scale and scope which suggest that complex large organizations benefit from the ability to spread administrative expertise across more functions and staff (Koshal and Koshal, 1999). Since most public sector organizations are big, divisionalized professional bureaucracies that employ large numbers of central administrative staff (Mintzberg 1978), these contrasting arguments about administrative intensity remain of considerable theoretical and practical importance. We evaluate the validity of these different perspectives on the administrative arm within public organizations by investigating the separate and combined effects of task complexity and size on the central administrative intensity of universities in the United Kingdom (UK) between 2003 and 2008.

Do structurally complex organizations devote more or less resources to central administration? Is central administrative intensity higher or lower in big organizations? What are the combined effects of task complexity and organization size on central administrative intensity? To answer these questions, we carry out statistical analyses of the relationship between the number of production units within UK universities, the size of those institutions and central administrative intensity. First, we review prior research, which suggests that the relationships between task complexity and central administrative intensity, and organizational size and central

administrative intensity, may take a variety of forms. In doing so, we develop arguments about the relationships that we expect to observe in our analysis, by synthesising competing views on whether complexity and size have positive or negative effects on intensity. Thereafter, we outline our statistical model and the measures of central administrative intensity, task complexity and organization size used for the analysis. We then present our findings, discuss the statistically significant effects that emerge, and draw theoretical and policy conclusions from the tests that we have conducted.

TASK COMPLEXITY AND CENTRAL ADMINISTRATIVE INTENSITY

Arguments about the relationship between task complexity and administrative intensity within the organization studies literature were originally dominated by the "complexity-administrative growth hypothesis" (Rushing 1967). According to this perspective, increased differentiation of organizational structures poses coordination challenges that can only be met through the expansion of the administrative function. Donaldson (2001, 105) summarises the traditional contingency theory view as follows: "administrative intensity is raised by the complexity of coordination required through having more departments and other subunits, so that horizontal differentiation positively affects administrative intensity". The relative degree of task complexity found within an organization is therefore likely to be connected to the demand for an extension of greater managerial control over the activities of a diverse range of units and employees. Kahn et al. (1964, 75) emphasise that as "the division of labour becomes more differentiated and specialized; [so] more levels of supervision are introduced to maintain coordination and control; and more people become involved in

organizational planning". The number of occupational specialties and production sub-units within an organization are widely thought to be the principal indicators of the complexity of the task of coordination it faces (Hall, Johnson and Haas 1967). In particular, the relative divisionalisation of an organization is often regarded as the prime source of coordination problems (Mintzberg 1979), and this is sometimes said to be especially salient for the management of universities (Becher and Kogan 1992; Cyert 1978; Dearlove 1998). Indeed, an early study in US higher education provides some support for the complexity-administrative growth argument (Hawley et al. 1965), as does Raphael's (1967) study of local labour unions in Illinois.

Although the complexity-administrative growth hypothesis is a persuasive one, a negative rather than a positive relationship between task complexity and intensity is also a plausible outcome. Organizations with more production units may actually be able to realise internal economies of scope that are simply unavailable to their less complex counterparts. Given that it is necessary to develop an administrative function large enough to meet the demands of coordinating more than one sub-unit, it seems highly conceivable that an organization with more production units can spread fixed administrative costs more widely than a less complex organization. In fact, the fixed costs of having an administrative function for even the simplest organization can potentially be turned very quickly into a valuable resource for managing growth in the number of different sub-units (Williamson 1981).

While differentiated organizations may, theoretically, be able to distribute administrative capacity more effectively than those with fewer sub-units, it is also possible that at some point the realization of scope economies across horizontally differentiated organizations is exhausted as the number of divisions simply becomes too large to manage effectively from the centre – something that is again thought to be

especially characteristic of higher education institutions (Dearlove 1998). At this point, it is even possible that scope diseconomies will occur (and the complexity-administrative growth hypothesis gains support), especially in large divisionalised professional bureaucracies, such as universities, that provide very distinctive and specialized services.

Complex professional bureaucracies are frequently inflexible when confronting environmental change and may be plagued by internal conflicts between the centre and the sub-units, as well as between the sub-units themselves (Mintzberg 1979). This propensity for internecine conflict leads Cohen and March (1974) to liken universities to "organized anarchies". The problems of control that a high degree of departmental fragmentation can create in highly professionalised bureaucracies may therefore prompt the rise of excessive overheads as the centre seeks to obtain some kind of managerial grip on its errant divisions. Another way of thinking about this relationship is to consider the prospects for goal alignment in divisionalised bureaucracies.

Pondy (1969) highlights that initially task complexity may be associated with higher productivity, as organizations with more sub-units benefit from economies attributable to specialization. Similarly, for senior management, internal efficiencies can be achieved by spreading principal-agent hazards across multiple sub-units (Grant et al. 1988). Rather than having to confront a small number of very powerful and important departments, managers of a divisionalised organization may find it easier to 'divide and rule' in pursuit of organizational goals. Indeed, the distribution of production tasks into more and more specialized functions may be an especially efficient way for the corporate centre to monitor and manage operations. However, a strategy of divisionalisation may eventually lead organizations to invest too much of

their time and money in the administrative function (Pondy 1969). It is likely that at some point the deliberate extension of central control in pursuit of further efficiency gains will create excessive overheads in the effort required to manage and support sub-units. Thus, once the slack in the administrative function is picked up by initial growth in the number of sub-units, the administrative budget will then increase beyond the point necessary for optimising productivity and goal alignment. This leads us to offer our first hypothesis on the determinants of administrative intensity.

H1: There will be a u-shaped relationship between task complexity and administrative intensity.

ORGANIZATION SIZE AND ADMINISTRATIVE INTENSITY

In addition to the role that task complexity plays in determining administrative intensity, it is also important to consider the potential effects of the sheer number of employees to be coordinated (see Blau 1970). Organizational size has long been regarded as one of the most salient variables in the study of organizational behaviour, especially in terms of its relationship with organizational structure (see Hall, Johnson and Haas 1967; Kimberley 1976). Many scholars have suggested that the size of an organization has a direct positive link with the extent of bureaucratization, whether defined as formalization, specialization or centralization (e.g. Caplow 1957; Meyer 1972; Mintzberg 1979). In addition to identifying a connection between horizontal differentiation and administrative intensity, the "complexity-administrative growth hypothesis" suggests that coordination is more difficult in bigger organizations. As Donaldson (2001, 70-71) argues, "the conventional wisdom is that as organizations

grow in size they become top heavy....(and have) a rapid growth in managers and their associated administrative staff relative to the increase in operating personnel".

The number of possible social relationships within an organization increases as an exponential function of the organization's size (Caplow 1957). The size of the administrative function therefore seems likely to outpace the growth in the number of social relationships to sustain central control of front-line service provision. Indeed, several early studies of the size-administrative intensity relationship support this hypothesis (e.g. Chapin 1951; Meyer 1972; Terrien and Mills 1955). However, the application of the complexity-administrative growth hypothesis to the issue of organizational size and administrative intensity rests on a number of rather questionable assumptions, especially the notion that administrative mechanisms of control need to be tailored to each and every social relationship within an organization (Freeman 1973). In fact, it is one of the supposed virtues of the Weberian-style bureaucratic organization that it is able to develop and apply standard and impartial administrative rules and procedures suitable for the management of very large entities. This propensity for standardization is the potential source of scale economies in the size-administrative intensity relationship.

Several influential studies have suggested that bigger organizations can accrue internal scale economies, as the principal-agent challenges faced by the senior management within an organization remain essentially unchanged despite a growth in size (e.g. Blau 1972; Hall 1982; Pondy 1969). From this perspective, rather than adding to the challenge of coordinating a larger number of employees, being bigger can enable an organization to reap economies of scale as the same administrative practices can be applied across a larger number of individuals (Blau 1972). At the same time, larger organizations are better able to make cost-efficient use of

computerized management systems and techniques to handle routine administrative work. Bigger organizations are also equipped to make more complete use of any given level of administrative capacity, while smaller organizations may be plagued by the under-utilisation of human resources due to the indivisibility of labour and the fixed costs associated with providing core functions, which they may use less than their larger counterparts.

Although numerous studies offer support for the internal scale economies perspective (e.g. Lioukas and Xerokostas 1982; Melman 1956; Tosi 1967), there is a third argument about the likely relationship between size and administrative intensity. This suggests that, as for task complexity, the relationship between organization size and the scale of the administrative function may be nonlinear. In particular, size may initially produce economies of scale in coordination that are eventually replaced by diseconomies of scale that result from bureaucratic congestion in very big organizations (AUTHOR 2003; Williamson 1967). Thus, size can have both positive and negative effects on administrative intensity, and the balance between them may alter as an organization grows. This view is implicit in the organization studies literature, which assumes that all organisations require some functions to be carried out centrally (especially the governance functions). However, after a certain point is reached, the administrative function becomes an expensive overhead that feeds on the resources of the service delivery units. Tullock (1965: 51) argues that "it seems clear that the declining 'marginal efficiency' associated with increasing size would guarantee that a point would be attained at which further gains from expansion would be less than the added cost". In other words, at some turning-point the negative relationship between size and administrative intensity becomes positive. All of which implies the following hypothesis:

H2: There will be a u-shaped relationship between organization size and administrative intensity.

COMPLEXITY, SIZE AND ADMINISTRATIVE INTENSITY

Nonlinearity in both the task complexity-administrative intensity and size-administrative intensity relationships may take several forms. In particular, given the potential for both task complexity and organization size to exhibit a u-shaped relationship with administrative intensity, it might be anticipated that in combination the interactive effect of these two variables would offer the most stringent test of the "complexity-administrative growth hypothesis" (and, indeed, the internal scope and scale economies perspectives). That is, organizations that are both complex and big face the greatest coordination challenges and will therefore be most likely to require an especially concerted administrative effort.

As complexity and size simultaneously increase, so do the prospects of bureaucratic overreach and congestion. When functional departments become both more numerous and larger, the prospect of time-consuming and costly inter-departmental conflict is increased. To head off potentially damaging assertions of power by individual departments, the centre of an increasingly complex and growing organization will likely have to deploy extra central administrators. This implies the creation of additional work for managers responsible for furnishing departments with the human and material resources they require to remain well-integrated within the corporate organization. All of which is likely to add to the administrative burden on the centre (at least in the short term) (Cyert 1978).

Some early studies in private sector settings (e.g. Rushing 1967) uncover a complex array of interactions between task complexity, size and administrative intensity, but subsequent research has offered stronger support for the possible presence of a positive combined effect of the two variables on administrative intensity (Cullen, Anderson and Baker 1986; McKinley 1987). We therefore expect the interaction between size and complexity to have a positive relationship with the scale of the administrative function, leading to our final hypothesis:

H3: Organizational complexity and size have mutually reinforcing effects on administrative intensity.

RESEARCH CONTEXT, DATA AND MEASURES

The data set for our analysis consists of 114 UK universities (90 located in England, 12 in Scotland, 10 in Wales and 2 in Northern Ireland). We include only those universities that provide a broad range of courses for undergraduates and postgraduates. Thus, all twenty of those universities that were members of Russell Group in 2008 that together receive two-thirds of the research grant and contract funding in the United Kingdom are included in the sample. In addition, all but two (the Institute of Education, London and the School of Oriental and African Studies) of the nineteen '94 group of smaller-research intensive universities are included, and we exclude the Open University due to its distinctive and geographically dispersed teaching model and organizational structure. We are fortunate in being able to draw upon a comprehensive secondary data source from which all the dependent and independent variables necessary for the study can be drawn: the Resources of Higher

Education and Students in Higher Education data published annually by the Higher Education Statistics Agency (HESA).

UK universities represent an excellent context for examining whether task complexity and size have a statistically significant impact on administrative intensity. One consequence of the expansion and the marketisation of the HE sector in the UK, the United States and elsewhere is a widely reported rise in the numbers of managers in universities, which according to some estimates outstripped the growth of students and academics in the same period (Ginsberg, 2011; Morgan 2010; Ngok, 2008). To what extent does the ratio of administrative costs to those of production reflect the extent of task complexity? Does the size of the university influence this ratio? Do structurally complex big universities spend more on administration than their less complex smaller counterparts? In order to answer these questions, it is necessary to identify relevant measures of administrative intensity, task complexity, size, and other relevant explanatory variables that may influence the size of the administrative function within universities.

Dependent Variable

Our *administrative intensity* measure is derived from HESA figures on university expenditure, and is based on similar measures in prior studies of universities (Gumport and Pusser, 1995). We derive the measure by dividing the total expenditure on administration and central services – central administrative staff, general education expenditure (e.g. examinations) and staff and student facilities (e.g.careers advisory and occupational health services) – by the total expenditure on academic departments in each university. We use this measure rather than a staffing measure because elements of the central services provided by some universities are contracted out (e.g.,

occupational health, marketing), and so do not show up in the number of people directly employed by the institution. The expenditure measure captures this central use of resource, even if the expenditure is not on members of the university workforce. Nevertheless, we observed similar findings when using a ratio of the number of central administrative personnel to the number of academic personnel as our dependent variable (available on request).

Our measure is focused solely on the costs of administration in relation to the costs of production, and does not include the costs of technical services that are provided within universities, such as repairs and maintenance and catering. The measure therefore represents a good proxy for the administrative intensity of universities, and is akin to indicators used in previous studies of administrative intensity in public sector settings (e.g. Andrews and Boyne 2009; Bohte 2004). Similar results to those we present were obtained when we constructed a measure of central administrative intensity using only the expenditure on central administrative staff set against the expenditure on academic departments.

Independent Variables

Our measure of *task complexity* is constructed by counting the number of academic cost centres (key subject areas) for which each UK university returns expenditure data to HESA. The number of production sub-units has been used as a measure of complexity in several previous studies (e.g. Blau 1970; 1972; 1973; Cullen, Anderson and Baker, 1986; McKinley 1987). In total there are 34 different academic costs centres in the HESA data, ranging from clinical medicine through to design and creative arts (see Appendix A for full details). It is quite possible that some of these cost centres are more complicated to manage than others and that some combinations

of cost centres may pose more coordination challenges. However, as our sample comprises 'full-range' universities, they all already had some experience of managing units in the main disciplinary groups (e.g., biological and life sciences, physical sciences and social sciences), so adding a unit from any of these was not a radical innovation. At the same time, functional structures vary somewhat across universities. Yet, even if in practice specific cost centres are part of broader faculties of, for example, physical or social sciences, the presence of a wider range of subject specialisms in a university is likely to reflect significantly greater complexity in the coordination of the production of teaching and research. Non-linear effects of horizontal differentiation are tested by adding a squared version of the sub-units variable in the equation.

The total number of staff employed by each university is used as the measure of *size* for the analysis. Although organizational size is a multidimensional concept (Kimberly 1976; Melman 1951), we focus on staffing levels because this is the variable that features in arguments about complexity in the organizational studies literature (see above). This measure also provides a clear and transparent proxy for the operational scale of the main types of university within the UK HE system. Moreover, in the specific context of universities, staffing is a variable firmly within the purview of senior management. Both linear scale effects (raw size measure on its own) and non-linear scale effects (raw and quadratic terms in the model together) are tested. As a robustness check we also tested a measure of size based on the number of students in each university, and obtained very similar results for the nonlinear and interaction models (available on request). The staffing and student number measures are highly correlated (.60), so including them in the same model induces collinearity between the independent variables. Thus, in line with the previous research on this

topic, we favour the measuring gauging the size of the workforce rather than the size of the client base (e.g. Blau 1973; Cullen, Anderson and Baker 1973).

Control Variables

We include several measures which seek to distinguish and control for important organizational characteristics of UK universities. First, we include a measure of expenditure per head of staff to control for the level of resources in each university. We also add a measure of the budget surplus in the current financial year to control for the level of slack resources. Next we add several measures which seek to control for the type of institution included in the sample. In terms of the staffing structure, we measure the percentage of academics involved purely in teaching; the percentage of academics involved purely in research; and the percentage of all staff carrying out technical duties in support of specialist research: laboratory, engineering, building, IT and medical technicians (including nurses). In terms of the scope of the educational provision on offer, we measure the total number of different undergraduate and postgraduate degree courses offered by each institution; and the ratio of undergraduate students to postgraduates. Each of these measures captures and controls for key elements of the pattern of core activities within universities: teaching focus; research focus; technical complexity and specialisation. The descriptive statistics for all the variables included in the statistical models are shown in Table 1.

INSERT TABLE 1 ABOUT HERE

The descriptive statistics illustrate that the average level of administrative intensity in UK universities increased by over 6 percentage points between 2003 and

2008. At the same time, the task complexity within universities expanded with on average half an additional department being added to the existing complement between 2003 and 2008. Moreover, the average number of employees within those institutions rose by about 15 per cent (from 2,618 to 3,012 members of staff). These data highlight the sharp expansion in the size of universities, the growth in complexity, and the rise in the percentage of resources devoting to managing them during the study period. At the sector level, these variables have clearly moved together in the same direction.

In the following analysis we proceed to evaluate the extent of the link between the growth in administrative intensity and changes in complexity and size when other variables are controlled. We also assess whether the connections between complexity, size and administrative intensity follow a nonlinear pattern, and whether these variables have mutually reinforcing effects.

STATISTICAL RESULTS

The pooled time-series used for the analysis is a balanced and complete panel data set for six years (2003-2008). The cross-sectional dominance, shortness of the panel and inclusion of dummy variables for each year of the analysis (minus one) minimize the threat of serial correlation (Stimpson 1985). White's (1980) test and the Breusch-Pagan test revealed that the models suffered from heteroskedasticity. To correct for nonconstant error variance, robust estimation of the standard errors clustered on each university is carried out. This also controls for unobserved heterogeneity between the cases. Aside from the high collinearity generated by inclusion of the quadratic terms for task complexity and size, and the interaction between the two, the average VIF

score for the independent variables is about 2.3. The results are therefore unlikely to be seriously distorted by multicollinearity (Bowerman and O'Connell 1990).

Fixed effects estimates derived to permit the systematic exploration of variations in administrative intensity are presented below in Tables 2 and 3. The fixed-effects within estimator models the temporal variance within universities and ignores cross-sectional variance between these organizations. It takes account of university-specific (unobserved fixed) effects and permits correlations between those effects and the (observed) effects of the explanatory variables, both of which can bias random-effects estimates (Halaby 2004). As a result, the fixed effects estimates capture university-specific influences on administrative intensity that may have changed very little during the study period, such as the academic reputation of a university.

Before applying a fixed effects model, it is important to establish its efficiency as an estimator in comparison with the random effects estimator. To do this it is necessary to compare the covariance matrix of the regressors in a fixed-effects model with those in a random-effects model which does not permit correlations between unobserved and observed effects (Greene 2003). Using the Hausman test, systematic differences were observed between the coefficients for fixed and random effects models of change over time within universities. As a result, the fixed effects estimates that we present below are more efficient than random effects estimates.

We present our statistical results in the following sequence. Three sets of estimates are presented in table 2: model 1 analyses the separate effects of task complexity and size on administrative intensity; model 2 adds squared versions of the task complexity and size variables to the model; while model 3 adds a variable interacting task complexity and size to model 2. Turning to the results presented in

Table 2, we can see that the first model provides a decent level of statistical explanation of within-variations in the administrative intensity in universities. The R^2 is 46% and is statistically significant. Aside from the ratio of undergraduate to postgraduate students, the control variables appear to have little effect on the administrative intensity measure. By contrast, the coefficients for both independent variables are negative and statistically significant. Thus, increased task complexity and size appear to result in a lower proportion of expenditure being allocated to administration than to service production, which provides some support for the internal economies of scope and scale perspectives, rather than the complexity-administrative growth hypothesis. However, to fully explore the influence of these measures on administrative intensity, it is necessary to include the squared versions of the complexity and size variables in the model.

INSERT TABLE 2 ABOUT HERE

Once the effects of the squared variables are also estimated, the statistical power of the model increases by about 8 per cent (the R^2 rises from 0.46 to 0.54). At the same time, two of the control variables achieve statistical significance. Turning to the independent variables of principal interest, the results for the task complexity and size measures reveal, as hypothesized, a u-shaped relationship between both variables and administrative intensity. This indicates that as the number of departments and staff in universities grows, so the relative spend on administration compared to the delivery of teaching and research falls, but that at a certain point these effects are reversed. Further analysis revealed that for those universities that had on average twenty-three or more departments for the study period, the task complexity-

administrative intensity relationship turned from negative to positive. Twenty-six UK universities averaged more than this many departments during the study period, suggesting that the rate of administrative expenditure may reflect the high transaction costs of the centre dealing with the growth of so many separate departments. The equivalent turning-point for the size-administrative relationship is about 8,978 staff. Only three universities in the UK averaged this many employees during the study period (Cambridge, Manchester and Oxford). This implies that it is not the norm for large universities to devote an especially high share of their expenditure to administration. Only the very biggest universities have unusually large administrative overheads.

To explore whether institutions with lots of departments *and* staff have a bigger administrative function we add a variable multiplying the complexity and size measures together to the statistical model. Inclusion of this variable leads to a statistically significant improvement of the model's explanatory power of about 2 per cent (see final column in table 2). The interaction term is positive and statistically significant, suggesting that increases in task complexity and size are likely to produce an increase in administrative intensity in UK universities. Thus, we find substantial support for our third hypothesis about the challenges of managing complex and large public service organizations: the combination of lots of sub-units and a large number of employees appears likely to prompt coordination problems, which require more expenditure on administration.

To fully explore interaction effects it is necessary to calculate the marginal effects on the dependent variable of varying levels of the key independent variables (see Brambor, Clark and Golder 2006). Graphing the slope and confidence intervals of the marginal effects is an especially effective way to present this information.

Accordingly, Figure 1 provides a graphical illustration of the moderating influence of increasing size on the relationship between task complexity and the growth of administrative intensity within universities during the study perod.

[Position of FIGURE 1]

The centre line in figure 1 illustrates the predicted values of administrative intensity on the basis of organizational size and task complexity, while controlling for all the other variables included in our model. The dotted lines represent the upper and lower bounds of the confidence intervals for those predicted values. The area above the upper bound and below the horizontal zero line indicates the presence of a statistically significant relationship. The figure therefore confirms that organization size is likely to have an important effect on the relationship between task complexity and the ratio of administrative to production expenditure.

Substantive interpretation of figure 1 suggests that as staffing levels rise from their minimum level the negative complexity-administrative intensity relationship becomes weaker until at about 6,800 employees (more than two standard deviations above the mean university size for the study period) any potential administrative scope economies associated with a large number of departments are entirely lost. This implies that the five universities with, on average, 6,800 employees or more during the study period devoted the same proportion of resources to central administration to manage the multiple production units that they coordinate as their smaller counterparts. To explore whether the reduction of scope economies associated with large size is simultaneously mirrored in a reduction of scale economies due to

increased complexity it is necessary to graph the moderating influence of task complexity on the size-intensity relationship.

[Position of FIGURE 2]

Figure 2 suggests that the relative degree of task complexity does have an effect on the relationship between size and the ratio of administrative to production expenditure. However, it is not strong enough to completely overturn the adminstrative scale economies that large universities are able to capture. As the number of departments rises, the negative size-administrative intensity relationship becomes progressively weaker right through the range of the data. Importantly though, the negative scale effect disappears at about 31 departments, which is beyond the range of the data for UK universities during the study period. Even so, this indicates that universities with a large number of departments are likely to assign fewer resources to the corporate centre for the purpose of managing increases in staffing than their less complex counterparts. Taken in combination, our results suggest that complex organizations may find it hard to effectively manage staffing increases, but that big organizations can more readily accommodate greater functional complexity.

CONCLUSION

In this article we set out to examine whether task complexity and the size of public organizations are related to the resources devoted to administration. Our statistical results indicate that these variables have statistically significant effects on administrative intensity. The relationship between both complexity and size and

administrative intensity is nonlinear. Separately, these variables exhibit a u-shaped relationship with administrative intensity (albeit only for very large universities), while in combination they have a positive impact on the growth of the administrative function. Our findings on administrative intensity therefore offer some corroboration of both the complexity-administrative growth and the internal economies of scope and scale arguments. As such, they represent an important contribution to the body of knowledge on the challenges of managing large and complex public organizations.

Our statistical evidence is consistent with a core proposition of contingency theory that organizations adapt their internal characteristics in response to changes in other aspects of their structure. Thus complexity and size can be seen as constraints that influence decisions on administrative intensity. Our analysis reveals a general and systematic pattern of links between how complex or large an organization is and the proportion of resources allocated to central administrative tasks. In this sense, administrative intensity is partly 'determined' by shifts in other organizational characteristics. This does not imply that organizational leaders have no freedom of choice about the level of intensity, but their decisions to alter the size of the central administration are clearly contingent upon changes in complexity and size.

Our evidence supports three general conclusions: (a) public organizations with a small number of departments and a small number of employees devote a bigger share of their financial resources to administration; (b) very complex organizations are likely to have higher administrative overheads, and are unable to absorb the administrative costs associated with organizational growth; and (c) very large organizations, for the most part, have lower administrative overheads than smaller institutions and are able to absorb the costs associated with increased task complexity.

Thus, changes in the number of tasks and in the number of staff that are employed appear to have major implications for the relative scale of the administrative function.

For decision-makers, our findings pose important questions about how to get the right balance between the functions and structure of their institutions. Our study does not offer a hard and fast solution to the question of the optimal level of horizontal differentiation nor the optimal size of an organization, but it does highlight that institutional expansion may have unanticipated administrative costs. For small and specialized organizations, growth appears likely to bring lower overheads as the potential for internal scope and scale economies is realised. For larger and more complex institutions, the task of central coordination of the organization's activities appears to be made more resource-intensive as expansion occurs, especially for those with a wide range of tasks.

The findings we present raise further questions about the relationship between task complexity, size and administrative intensity in public organizations that are worthy of systematic analysis. Firstly, the effects we observe may not emerge in a context of decline rather than expansion, when management is under greater pressure to balance efficiency and effectiveness (Cyert 1978). Freeman (1979) shows that the administrative function tends to grow especially quickly during periods of organizational growth, and to remain stable in times of decline. Secondly, we evaluate the effects of only task complexity and size. There are several other aspects of the internal structure of organizations that merit closer attention, especially vertical differentiation. Evidence on the impact of the number of layers of management on administrative intensity would offer valuable lessons for policy-makers seeking guidance about appropriate organizational design.

Thirdly, it is possible that the relationships between complexity and size and administrative intensity are a product of reverse causation. Or put differently, that a large central bureaucracy is the precursor to an expansion (or reduction) in the number of production units and the number of staff within public organizations. To further test the robustness of our findings, we therefore carried out Granger tests to ascertain whether complexity and size determine administrative intensity, or vice versa. These tests revealed that there is not a statistically significant relationship between the lagged administrative intensity measure and either task complexity or size. Still, much more could be done to fully tease out the causal mechanisms that underpin the relationships that we observe using both longer panels of data and qualitative case study methods based on interviews with key actors.

Finally, it would also be valuable in future quantitative studies to pay attention to the role of administrative intensity in determining the relative success or failure of public organizations. For example, research on the performance of local governments suggests that there is an optimum size for the administrative function (Andrews and Boyne 2011), while other studies point to the role of administrative capacity in buffering public organizations from challenging environmental circumstances (Meier and O'Toole 2009). It is also conceivable that other organizational factors, such as mergers with other institutions, governance structure or strategy, may play a role in determining the scale of the administrative function.

For now, our conclusion is that, on their own, neither arguments on the link between complexity and administrative growth, nor those on economies of scale and scope, tell the whole story on the bureaucratic component of public organizations. It is these theoretical perspectives in combination that offer the best understanding of administrative intensity. This means that, in line with contingency theory, there are

no adjustments to complexity and size that are likely to be 'just right' for all organizations. Rather, the outcome of decisions to become larger or smaller, or more or less complex, will depend on where organizations are starting from, and how adjustments to these organizational characteristics work in combination to influence the share of resources devoted to administration.

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Table 1. Descriptive statistics

Entire study period (2003-08)	Mean	Min	Max	S.D.
Academic depts spend (£'ooos)	66672.66	2155 Cumbria	319105 Manchester	49046.27
Admin services spend (£'ooos)	21258.27	1678 Lampeter	110826 Cambridge	12985.94
Admin /academic spend (x 100)	36.92	12.59 Nott'mTrent	124.25 Cumbria	14.41
Departments	18.51	5 Cranfield	30 Leeds	5.07
Staff	2820.56	205 Cumbria	10210 Manchester	1863.69
Budget surplus (£'ooos)	2385.53	-27504 Manchester	26446 LSE	5509.94
Spend per head of staff (£'ooos)	54.43	23.01 Birkbeck	128.02 Cambridge	12.83
% academic staff (teaching only)	22.44	.00 *Several*	95.45 Cumbria	18.07
% academic staff (research only)	16.66	.00 *Several*	66.40 Oxford	15.70
% technical support staff	6.93	.00 *Several*	17.12 Cambridge	2.61
Number of degree courses	90.86	15 Cumbria	193 Manchester	32.88
Undergraduate/postgraduate ratio	3.98	.00 Cranfield	41.00 Cumbria	2.96

Start of study period (2003)	Mean	Min	Max	S.D.
Academic depts spend (£'ooos)	54507.08	2155	176997	37374.06
Admin services spend (£'ooos)	15982.46	1678	58621	8674.24
Admin /academic spend (x 100)	34.15	12.59	102.92	12.49
Departments	18.01	5	28	4.86
Staff	2618.29	205	8195	1728.40
Budget surplus (£'ooos)	1897.58	-8857	16331	3592.01
Spend per head of staff (£'ooos)	47.73	24.20	80.33	9.31
% academic staff (teaching only)	20.47	.00	95.45	18.28
% academic staff (research only)	17.21	.00	63.20	16.11
% technical support staff	7.43	1.85	17.12	2.72
Number of degree courses	88.75	16	188	32.29
Undergraduate/postgraduate ratio	4.17	.08	41.00	4.07

End of study period (2008)	Mean	Min	Max	S.D.
Academic depts spend (£'ooos)	79749.51	6193	319105	57339.53
Admin services spend (£'ooos)	28042.26	4046	110826	15758.67
Admin /academic spend (x 100)	40.39	15.67	76.35	12.70
Departments	18.50	5	30	4.99
Staff	3012.54	320	9850	1985.88
Budget surplus (£'ooos)	3385.62	-15525	26250	7509.49
Spend per head of staff (£'ooos)	62.83	35.06	128.02	13.75
% academic staff (teaching only)	23.51	.00	87.31	18.44
% academic staff (research only)	16.07	.00	66.40	15.86
% technical support staff	6.54	1.56	14.29	2.49
Number of degree courses	91.91	27	193	32.81
Undergraduate/postgraduate ratio	3.85	.00	14.88	2.05

Table 2

Task complexity, size and central administrative intensity (2003/04-08/09)

Independent variable	Linear model	Nonlinear model	Nonlinear model (incl interaction)
Departments	-1.2368**	-4.0873**	-4.1377**
	(.486)	(1.2716)	(1.1108)
Departments^2		.0900**	.0652*
		(.0306)	(.0287)
Staff	-.0068**	-.0167**	-.0188**
	(.0023)	(.0053)	(.0047)
Staff^2		9.30E-07**	5.85E-07+
		(3.72E-07)	(3.20E-07)
Departments x staff			.0003**
			(.0001)
Budget surplus	-.00005	-1.49E-05	8.44E-06
	(.0001)	(.0001)	(.0001)
Expenditure per head of staff	.0982	-.1829	-.1484
	(.1078)	(.1154)	(.1094)
% academic staff (teaching only)	.1065	.0908	.0907
	(.0899)	(.0697)	(.0670)
% academic staff (research only)	.0634	.0745	.1003
	(.1299)	(.1125)	(.1065)
% technical support staff	-.6566	-.5974	-.4529
	(.6253)	(.4643)	(.4213)
Number of degree courses	.0252	-.0186	-.0250
	(.0666)	(.0488)	(.0469)
Undergraduate/postgraduate ratio	1.1804**	.6434*	.5188+
	(.2129)	(.2698)	(.2670)
Constant	71.7355**	132.6641**	133.8175**
	(13.0068)	(19.8959)	(18.3232)
F-statistic	17.94**	21.78**	18.47**
R^2	.46	.54	.56
N of observations	684	684	684

Note: significance levels: +p ≤ 0.10; *p ≤ 0.05; **p ≤ 0.01 (two-tailed test). Standard errors shown in parentheses. Coefficients for individual year dummies not shown.
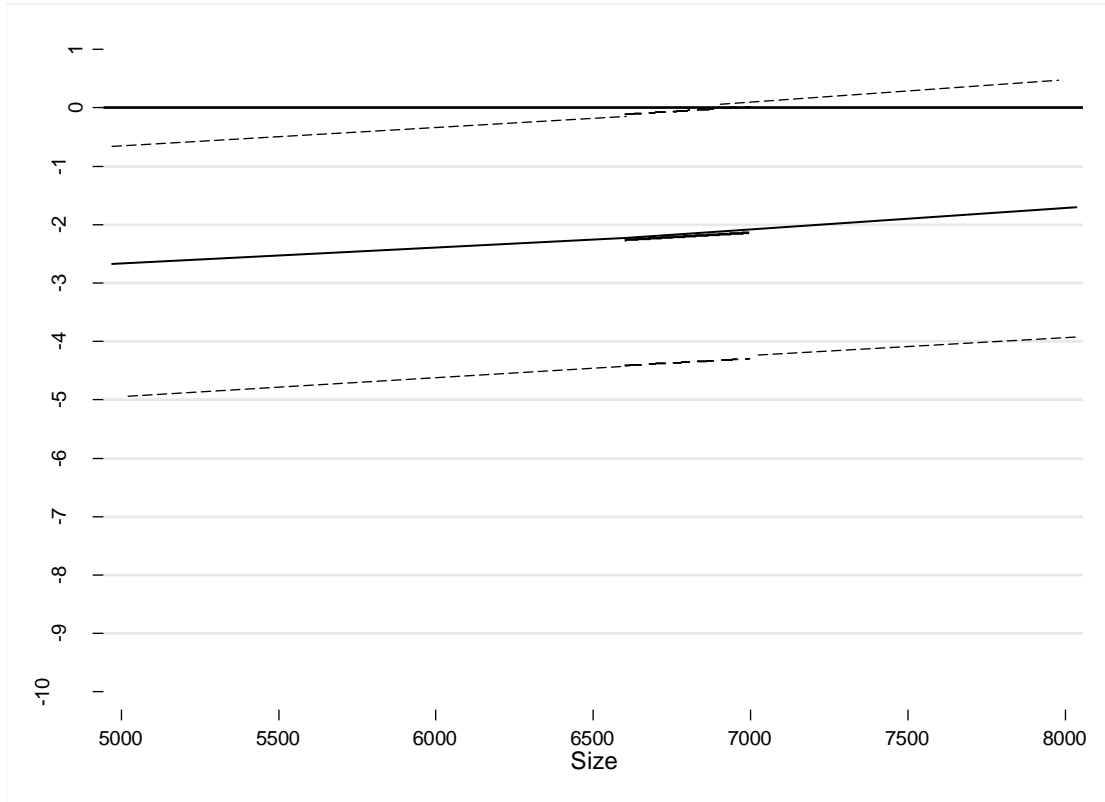
Figure 1 Marginal Impact of Departments on Ratio of Central Administrative to Academic Costs Contingent on Size
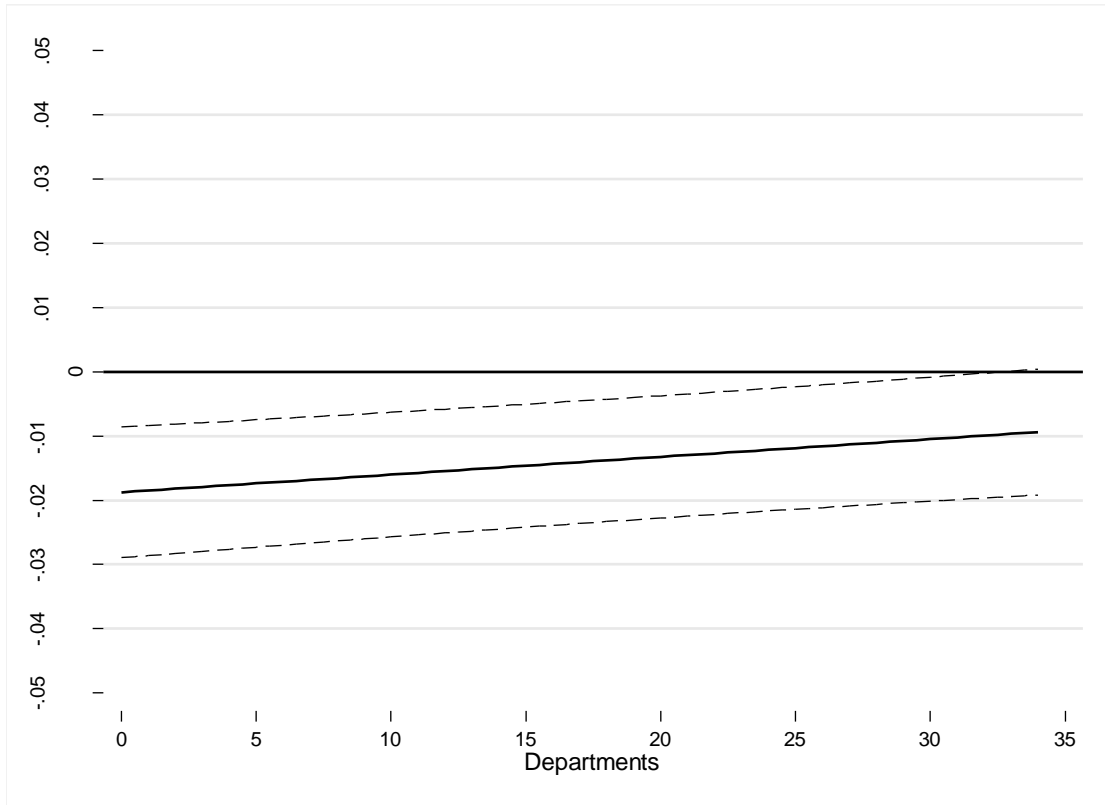
Figure 2 Marginal Impact of Size on Ratio of Central Administrative to

Academic Costs Contingent on Departments

Appendix A: Academic Cost Centres in UK Universities (incl. HESA coding)

01 Clinical medicine
02 Clinical dentistry
03 Veterinary science
04 Anatomy & physiology
05 Nursing & paramedical studies
06 Health & community studies
07 Psychology & behavioural sciences
08 Pharmacy & pharmacology
10 Biosciences
11 Chemistry
12 Physics
13 Agriculture & forestry
14 Earth, marine & environmental sciences
16 General engineering
17 Chemical engineering
18 Mineral, metallurgy & materials engineering
19 Civil engineering
20 Electrical, electronic & computer engineering
21 Mechanical, aero & production engineering
23 Architecture, built environment & planning
24 Mathematics
25 Information technology & systems sciences & computer software engineering
26 Catering & hospitality management
27 Business & management studies
28 Geography
29 Social studies
30 Media studies
31 Humanities & language based studies
33 Design & creative arts
34 Education
35 Modern languages
37 Archaeology
38 Sports science & leisure studies
41 Continuing education

Note: The HESA coding for the study period no longer includes certain categories of cost centre, but for the purposes of continuity has not been revised by HESA in light of those deletions.