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The Effect of Activity-Based Payment on Dentists' Activity: Evidence from a Natural Experiment in the UK National Health Service

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Abstract

The extent to which remuneration systems affect the behaviour of health care professionals is of considerable importance in the administration of publicly funded health care systems. Using data across two jurisdictions in the United Kingdom, in only one of which remuneration was changed, we compare the extent of measured dental activity at the dentist level in order to ascertain the impact of moving to activity-based remuneration. We find that there are large and statistically significant increases in activity as dentists moved to the activity-based system and that a dentist's previous form of contract is an important determinant of the magnitude of the effect. We also explore the extent to which dentists' professional attitudes can explain differences in their activity and find that some aspects of self-reported attitudes are associated with observable differences in activity.

1 Introduction

A recurring concern in considering the administration of publicly-funded health care systems is the impact that different payment methods have on the behaviour of health providers. Within the economics literature these issues are often analysed in terms of the Principal-Agent framework within which a distinction can be made between fixed payments, such as salaries, variable payments that are based on effort expended, which in a health care setting is often measured by the number and type of treatments given, and payments based on output, which in a health care setting corresponds to the throughput of patients. Fixed salary payments, for example, are deemed useful when the providers of a service already have objectives that are closely aligned with those of the purchaser or employer. In such circumstances the agent can be induced to behave in the principal's interest by simply ensuring that it is worth working. Treatment-based payment, which is often associated with the term *Fee-for-Service* in a health care setting, provides strong incentives to increase the complexity and cost of treatment given to each individual patient. Activity-based payment, which is associated with a number of terms, such as *Prospective Payment* in health care, provides incentives to increase the number of patients treated.

A characteristic of payments based on numbers of patients treated is that they require the measurement of patient flows and have thus given rise to a focus on measuring and assessing the cost of the output or *activity* of health care providers. A very large literature in Economics, of which McGuire (2000) and Chalkley & Malcomson (2000) provide useful summaries, has developed to consider the trade-offs between quality and cost of care that result from these different incentives whilst literatures have developed in management and administration to consider the practical implications of *activity-based* financing, examples of which are to be found in Biørn et al. 2003; Nørsgaard & Pallesen (2003) and Kennedy & Affleck-Graves (2006).

This paper is concerned with analysing data with a view to establishing how a shift towards activity based payments has affected the measurable activity of dentists in the UK National Health Service (NHS). The publicly administered NHS finances a substantial proportion of dental health care and has faced a number of difficulties regarding perceived or real restrictions on access to publicly funded dentists, and a consequent increase in private

dentistry. These concerns are documented, for example, by Boulos & Phillipps (2004) and Hancock, Calnan & Manley (1999). Whilst it is common to describe the UK as a single jurisdiction, the NHS is organised and administered separately in the constituent countries. For the purposes of the present study it is useful to consider Scotland and England & Wales² as two administrative units. Across all regions of the UK there have been concerns that a key reason for restricted access to publicly funded dentistry is the level and structure of the traditional, Fee-for-Service NHS dental contract, which operated throughout the UK from 1948 until 2006. In Scotland the traditional Fee-for-Service contract has continued to dominate whilst prior to April 2006 alternative funding mechanisms had been experimented with in England & Wales. Of particular relevance for the current study was a mechanism termed the Personal Dental Service (PDS) which rewarded dentists with a payment that was closer to a fixed salary than Fee-for-Service. As a consequence of continuing concerns regarding access to NHS services a major change occurred in April 2006: a new NHS dental contract was introduced specifically in England & Wales. Under the new contract the dentists were paid to deliver a fixed volume of dental treatment, measured by a weighted sum of the courses of treatment completed each year. Remuneration of deviations from the agreed volume is negotiated ex post with the effect that dentists' earnings will reflect their aggregate *activity* and the new contract specifies the measurement of *Units of Dental Activity* (UDA). In Scotland changes to the structure of the traditional Fee-for-Service dental contract are currently under consideration, but as at the time of writing dentists continue to be paid under the predominantly Fee-for-Service arrangement.

A key issue for policy makers when considering payment reforms is the extent of the impact that different purchasing mechanisms have on the quantity of services that are provided and, although the theoretical literature referenced above is vast, there remains a dearth of empirical evidence of the crucial policy "treatment effect". The RAND study, summarised for example by Newhouse & Group (1993), remains unique in scale as an example of a controlled experiment in the realm of health care finance. And whilst supply-side policy interventions of the kind considered in this paper are relatively commonplace, the most celebrated probably being the adoption by Medicare of Prospective Payment in the

2 Our grouping of England & Wales reflects the similarity in the arrangements for financing dental health care in these two countries rather than their NHS organisational structures which are now constitutionally separated.

1980's, they are seldom introduced with a view to establishing controls for the purposes of statistical analysis. The requirements to treat individuals, be they patients or health care practitioners, equitably means that “natural experiments” in the realm of health care financing policy are seemingly rare.

In this paper we utilise the natural experiment of the change in dental contract in England and Wales, with Scotland (where the contract did not change) as a control, to assess the impact of the resultant move to activity-based financing on both the overall volume of treatments and the measure of dentists' activity derived from the contractual arrangements – UDA. Our data provides the details of the number and UDA values of the treatments undertaken by a sample of 98 dentists who are practising in one or other of the two NHS jurisdictions of Scotland or England and Wales and covers a period from 6 months prior to the change of contract in England in Wales until 7 months after that contract change. We are thus able to adopt a *difference-in-differences* methodology to provide empirical estimates of the impact of this particular policy intervention. The institutional environment that we are studying offers a rich set of potential comparisons because we observe one region where a previously dichotomous financing regime changes to a new unified one, and a control region in which one financing regime persists.

In health care it is often suggested that institutional arrangements are diverse and instrumental in determining outcomes (see, for example, Gaynor, Rebitzer & Taylor, 2004). Hence, in Section 2 we provide a more detailed overview of the institutional setting and the changing contractual arrangements of our natural experiment. In Section 3 we consider the implications of a simple agency model in regard to the contractual change, and then in Section 4 we summarise our data and the empirical methods that we apply to those data, specifically by estimating a number of difference-in-differences models which allow for unobserved heterogeneity across the individual dentists whose treatments we observe. The results of the empirical investigation are reported in Section 5 and 6.

2 Remuneration of dentists in the UK NHS

Dentists in the UK NHS are predominantly self-employed professionals and thus rely on service contract, rather than an employment contract, to mediate their arrangements with the relevant NHS purchasing authority. It is convenient to abstract from the often intricate

realities of NHS provision and assume that for the period covered by our study there were essentially two contracts: the General Dental Service (GDS) and the Personal Dental Service (PDS) contract.

Dentists with a GDS contract were almost exclusively self-employed and could provide services both privately and for the NHS. The GDS contract specified a traditional Fee-for-Service arrangement wherein dentists billed the NHS (or, where they were subject to co-payment, their patients and the NHS) for each *item* of treatment carried out, and also contained some limited capitation payments for each patient registered. Historically fees for each treatment item were set so as to recompense a dentist for time and other inputs required to carry it out. Over time, however, technical progress and productivity changes have led to individual item fees becoming distorted relative to their original values and whilst there was active review of fees up until 1996, since then they have only been re-based in relation to the general price level. A small number of dentists in Scotland worked under the GDS but actually received a salary. For these dentists the items of treatment that they perform are still recorded but do not contribute to their remuneration. We refer to them henceforth as Salaried GDS.

PDS schemes were first established in 1998 and initially encompassed a number of different payment mechanisms but by 2004 a Department of Health paper (DH 2004) reported that PDS contracts were increasingly moving towards an arrangement in which dentists received a fixed annual contract value. There were various requirements in terms of dentists providing a commitment of time to the NHS and there was monitoring of the number of patients being cared for (the practice list size) and some patient outcomes, i.e. the time that patients waited for treatment. Whilst there was measurement of dentists' *activity* under PDS the link between activity and payment was relatively weak and in many cases PDS arrangements can be likened to a form of salaried employment – dentists received a payment provided they performed their NHS duties but the extent of that payment did not depend directly on the volume of those duties.

In understanding the NHS dental system and the contractual mechanisms that we study the *Course of Treatment* (CoT) is a key concept. Under the GDS, the treatment items (examinations, fillings, extractions etc.) required to restore the dental health of a particular patient were accumulated into the CoT. Dentists under the GDS were, and in Scotland still

are, paid for each item of treatment within a CoT but claimed for payment only once the CoT was complete. Thus, the administrative unit of account within NHS dentistry was the CoT and both GDS and PDS dentists had their CoTs recorded. Importantly for our study, the details of treatment items for each CoT were retained even when, as in the PDS contract, they did not impact on the dentists remuneration, the reason for this being that there is a substantial element of patient cost-sharing for NHS dental services and a patient's liability was determined in relation to the treatment items they received, however their dentist happened to be paid.

The existence of data relating to CoTs in part informed the movement to a new contracting regime in England & Wales. One measure of a dentist's activity that was readily available within the NHS was the number of CoTs that a dentist provided in a month or year. Of course some CoTs correspond to patients already in good dental health and represent only a little activity, whilst other CoTs record the treatment of initially dentally unfit patients and thus represent a great deal of activity. For the reform of contracting in England & Wales it was decided to categorise CoTs into four *bands* and to give them weights according to the treatments included in the CoT. The weights were normalised so that the simplest CoTs, where a patient's teeth are examined and cleaned but deemed not to require further treatment is assigned one Unit of Dental Activity (UDA) and more complex CoTs are given multiple UDA values according to, on average, how much extra activity they entail. The classification system and associated weights are summarised in Table 1.

Table 1: Course of Treatment, Bands and UDAs

CoT Band	Description of Treatment Item(s) within CoT	UDA Value
1	Routine examination, scaling and diagnostic procedures	1.0
1 (urgent)	One of a specified set of possible treatments provided to a patient in circumstances where: prompt care and treatment is provided because, in the opinion of the dental practitioner, that person's oral health is likely to deteriorate significantly or the person is in severe pain by reason of their oral condition; or care and treatment is only provided to the extent that it is necessary to prevent that significant deterioration or address that severe pain	1.2
2	Fillings and extractions	3.0
3	Treatment requiring laboratory work	12.0

Under what has become called the *New Dental Contract* dentists agree to deliver a number of

UDAs, each year in return for an annual income determined as the product of the price and number of UDAs they will supply. In a transitional period the price of a UDA for any dentists is determined so as to ensure that they are remunerated no less than under their previous contract, for the same level of activity. In future it is intended that local purchasers will negotiate prices with dentists and will reflect local conditions and priorities, i.e. may choose to set higher (lower) prices in areas of greater (lesser) need. The arrangements to adjust the overall contract value in response to over- or under-provision of UDAs by a dentist are complex and depend on the extent of any discrepancy. However, in essence the new system sets a price per UDA and with some degree of latitude the overall remuneration of a dentist will vary with the number of UDAs they provide. Both in terminology and in effect the new contractual arrangement in England & Wales is *activity-based*. In Scotland, dentists continue to work under treatment-based GDS contract.

The contractual basis of NHS dental provision in England & Wales and Scotland is summarised in Table 2.

Table 2: Contracts for NHS Dental Services

Contract	Basis of Payment	Period and Jurisdiction of operation
GDS	Items of Treatment, claimed by CoT	England & Wales: -- April 2006 Scotland: -- Present
PDS	Overall Service Delivery	England & Wales : 1998 – April 2006 Scotland: N/A
Salaried GDS		England: N/A Scotland: -- Present
New Dental Contract	Units of Dental Activity	England & Wales : April 2006 – Present

3 Agency theory and dental contracts

Agency models, for which Laffont & Martimort (2001) provide an overview of the relevant literature, analyse the impact of the incentives that are provided by different reward structures usually assumed to be designed by single decision maker – the *Principal*, on the behaviour of another decision maker – the *Agent*. Principal-agent theory has developed to a great degree of sophistication to account for different institutional constraints, complexities of task to be carried out and information structures but here we are only concerned with understand how different forms a dental remuneration contract may influence the amount of activity that dentists are observed to engage in. We thus use a very simple framework in the spirit of a

principal-agent theory without invoking the intricacies.

The approach we take is to consider from the perspective of a third party purchaser (principal) the implications for the extent of what we term the *effort* of a dentist (agent), of rewarding the dentist in different ways, corresponding to the different contracts that are summarised in Table 2. We consider a dentist determining the effort, henceforth denoted e , to devote to treating NHS patients over the course of a given time period – for example, a year. Following a long tradition in the application of agency theory in health economics (see, for example, McGuire, 2000) we assume that a dentist is altruistic at least to the extent that they derive some positive utility from providing treatment to their patients and that they also derive utility from money income which we will denote by Y . Hence, we write a dentist's utility as

$$U(e, Y)$$

and assume that the function $U(\cdot)$ is concave, increasing in Y and initially increasing (eventually decreasing) in e . For simplicity we will assume here that the only source of income for the dentist is their NHS contract and distinguish between the 3 alternatives in Table 2 by defining,

$$\begin{aligned} Y_G &= f(e) \\ Y_P &= \bar{Y} \\ Y_N &= pA(e) \end{aligned}$$

where: Y_G, Y_P and Y_N denote the incomes generated under the GDS, PDS and new contract respectively, \bar{Y} is a fixed sum, p is the price associated with delivering each UDA and $f(\cdot)$ and $A(\cdot)$ are increasing concave functions. The functions $f(\cdot)$ and $A(\cdot)$ capture the fact that by expending more effort the dentist will carry out more treatment items thus increasing payment under the GDS, or will generate more units of activity, thus increasing income from the new dental contract.

The optimal levels of effort under each of the three possible contracts are defined by the first order conditions

$$\begin{aligned}\frac{dU}{de} &= U_Y f' + U_e = 0 \\ \frac{dU}{de} &= U_e = 0 \\ \frac{dU}{de} &= pU_Y A' + U_e = 0.\end{aligned}$$

and we denote the corresponding levels of effort, e_G^* , e_P^* and e_N^* respectively.

On the assumptions thus far made it follows that $e_G^* > e_P^*$ and $e_N^* > e_P^*$ but that the relationship between e_G^* and e_N^* is ambiguous and depends on the details of the functions $f(\cdot)$ and $A(\cdot)$. The relationship between effort and *activity* is captured in the function $A(\cdot)$ and hence a formal consideration of incentives under the three possible contracts suggests the following: both the activity-based (new contract) and the fee-for-service GDS contracts provide a stronger incentive for increased activity relative to the fixed income PDS, but it is not clear which of activity-based or fee-for-service payment gives the strongest incentive.

The agency framework set out above has been couched in terms of a single dentist. In practice it would be reasonable to assume that each of the functions $U(\cdot)$, $f(\cdot)$ and $A(\cdot)$ is determined in part by a particular dentist's personal characteristics, motivation, economic circumstances and patient mix. Thus what might hold for dentist X may not hold for dentist Y, either in terms of the magnitude of any effect from switching contracts or in terms of the relative strength of incentives towards greater activity entailed in the GDS and new contract. The agency model suggests not only that the impact of activity-based financing is an empirical issue but also that any empirical assessment will need to take into account variations across individual dentists. Our empirical methodology is chosen so as to take note of these insights.

The framework considered here is simple and abstracts from many of the practical issues affecting the performance of a complex profession, such as dentistry, within a complicated institution such as the NHS. Dentists in practice may consider the impact of their treatment decisions over several time periods, they will face many dimensions to those decisions, such as quality of care, patient selection and so on and they will operate according to both personal and professional constraints. The contractual arrangements in the NHS do not in reality lend themselves to simple mathematical expressions such as those of equations . Nevertheless,

these additional complexities will not remove ambiguities but rather add to them. In this sense at least the simple agency model we have used is robust.

4 Data and empirical framework

Our study is concerned with a cohort of 98 dentists split across the jurisdictions of Scotland and England & Wales who are the subject of a long term investigation into the origins, development and impact of professional attitudes. Our sample dentists are all at a similar stage of their professional development, having recently completed the final stage of their training. They are a part of a study that is intended to achieve a better understanding of the effect of dentists' preferences, professional attitudes and beliefs on the numbers of patients treated and the treatments provided. These dentists have all responded to questionnaires and we utilise some of their responses in Section 6.

Whilst these dentists are subject to ongoing study in order to monitor their attitudes, they can also be identified for the purposes of linking to administrative records concerning the treatments that they perform in the NHS. These administrative data are described in greater detail by Chalkley & Tilley (2005; 2006) but as discussed in Section 2a a key unit of observation is the CoT. In particular for each dentist in each month we observe the number of CoTs for which that dentist was either eligible for payment or was credited with having conducted. Under GDS arrangements it is also possible to recover the precise details of which treatment items were included in each and every CoT. Following the adoption of the new contract in England & Wales the administrative system ceased to record this level of detail but does record the Band into which each CoT falls. As a part of our study we retrospectively 'banded' all CoT for all dentists by taking the definitions of Bands and running an algorithm to assign each CoT to a Band based on the included treatment items. The result is a data set that records the Band of every individual CoT delivered by each dentist.

The 98 dentists delivered a total of over 170,000 CoTs during October 2005 to November 2006 and Table 3 shows the distribution of those CoTs across jurisdictions and the dentist's basis of payment.

Table 3: Courses of treatment by contract³

	October 2005 - March 2006	April 2006 - November 2006	Total
Salaried General Dental Service (Scotland)	527	629	1,156
Non salaried General Dental Service (Scotland)	22,259	34,475	56,734
General Dental Service (England & Wales)	25,183	32,866	58,049
Personal Dental Service (England & Wales)	19,314	35,231	54,545
Trust led Dental Services (England & Wales)	0	740	740
Total	67,283	103,941	171,224

Our purpose is to examine the extent to which a change in contract, and specifically a move towards activity-based remuneration, impacts upon dentists' activity as measured by UDAs. Over any period of time changes in demand for dental services, professional standards and other factors might affect dental activity. In addition the agency framework that is summarised in Section 3 suggested that dentist specific characteristics will influence the activity of any particular dentist. In order to control for as many of these various factors as possible, given our data, we utilise the following regression model,

$$y_{it} = \alpha + \beta_s j_s + \gamma c + \delta_s (j_s c) + \lambda x + \mu_i + \varepsilon_{it}$$

where y_{it} denotes the UDA measure of dental activity provided by dentist i in month t ; j denotes the jurisdiction of the dentist (England & Wales is the omitted category); c is a dummy variable which takes the value 1 if the observation is after April 2006 and 0 otherwise; x is a vector of monthly dummy variables; μ_i denotes a dentist specific effect; and ε_{it} denotes an idiosyncratic error.

The coefficient on the interaction between the jurisdiction and contract change dummy variables, δ_s , is a *difference-in-differences* estimator of the change in contract. This difference-in-differences estimator accounts for changes in the dental activity measure over time that are unrelated to the change in contract such as a general improvement in oral health. In addition, it accounts for fixed unobserved differences between countries such as the level

3 TDS dentists are employed by PCTs. PDS dentists are typically paid a fixed annual contract value in return for a level of service.

of oral health. The difference-in-differences estimator, therefore, controls for both group-specific and time-specific effects, see Blundell & Dias (2002)

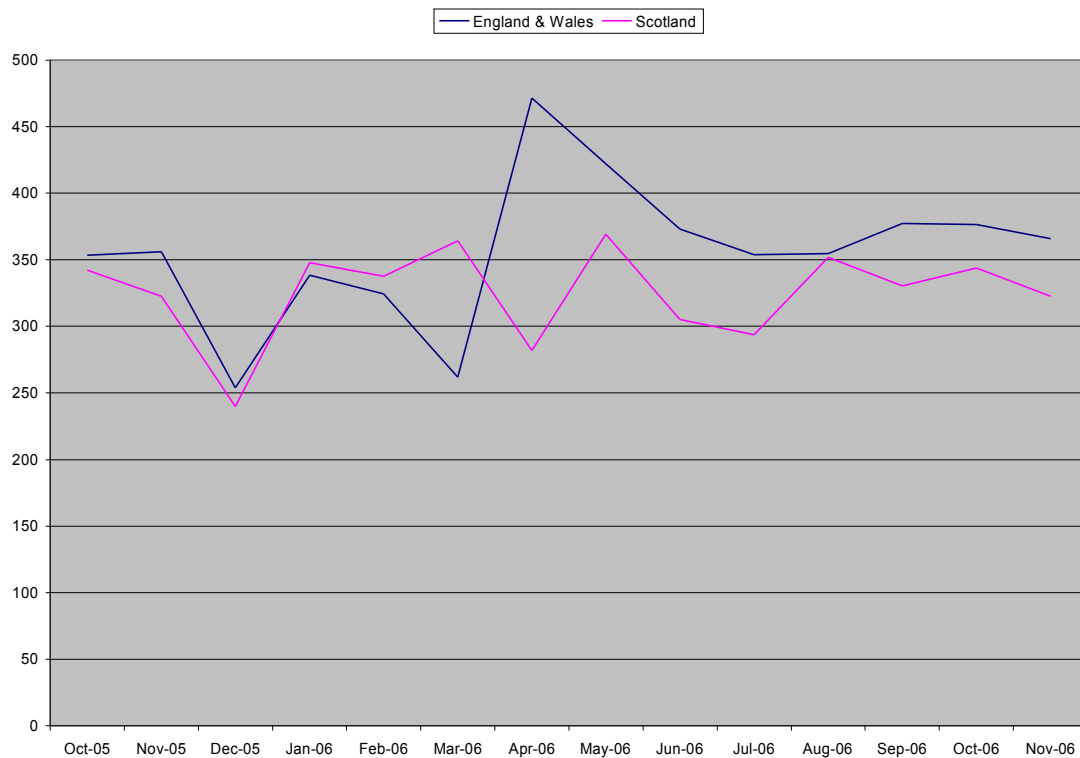
Under certain assumptions the difference-in-differences methodology enables us to identify the impact of the change in contract in England and Wales. For example, if we only had information from dentists in England, we would not be able to determine whether any change in UDAs per month was because of the new contract or because of a secular trend in treatment need such as improving oral health. Similarly, if we only had information after the change on contract, we would not be able to tell whether the difference between England & Wales and Scotland was because of the contract or because of some unobserved difference, perhaps in oral health, between the jurisdictions.

5 Results: the impact of activity-based pay

The difference-in-differences estimator in Equation (4) is only unbiased if the trend in the outcome variable is the same in England & Wales and Scotland. Figure 1 shows that the activity of dentists in England & Wales and Scotland is almost identical between October 2005 and February 2006. Thus, we can be reasonably confident that the difference-in-differences estimator will be unbiased.

Figure 1 also shows that the activity of dentists in Scotland, as measured by the mean number of UDAs per month, is about the same before and after the change in contract. However, the activity of dentists in England & Wales increases a little after April 2006. Thus the activity of dentists in England & Wales seems to have increased relative to the activity of dentists in Scotland after the introduction of the new dental contract in England & Wales.

Figure 1: Mean UDAs per dentist-month



The graphical analysis is formalised by estimating equation and Table 4 reports the results of this fixed effects panel regression model for the period October 2005 to November 2006. The difference-in-differences coefficient shows that, compared with dentists in Scotland, the activity of dentists in England & Wales increased significantly: the number of UDAs per month increased by 71 UDAs per dentist per month. This is equivalent to a 26% increase in the number of UDAs per dentist per month compared with the mean number of UDAs before the contract change.

Table 4: Regression results

	Coefficient	Robust SE	t	P>t
Nov-05	-5.811	13.189	-0.440	0.660
Dec-05	-100.570	14.266	-7.050	0.000
Jan-06	-8.802	16.640	-0.530	0.598
Feb-06	-17.526	16.347	-1.070	0.286
Mar-06	-49.550	18.581	-2.670	0.009
Apr-06	omitted category			
May-06	10.632	19.144	0.560	0.580
Jun-06	-40.431	20.644	-1.960	0.053
Jul-06	-62.166	21.028	-2.960	0.004
Aug-06	-30.696	25.114	-1.220	0.225

	Coefficient	Robust SE	t	P>t
Sep-06	-31.944	23.462	-1.360	0.177
Oct-06	-28.344	21.764	-1.300	0.196
Nov-06	-40.293	23.002	-1.750	0.083
β_s	omitted category			
γ	71.822	24.503	2.930	0.004
δ_s	-71.082	19.462	-3.650	0.000
constant	347.514	12.133	28.640	0.000
Sample size				
Number of dentists				
R-squared (overall)				
F(14,97)				
Prob > F				

The results in Table 4 assume that all dentists in England & Wales were paid in exactly the same way both before and after April 2006. However, by using the detailed information available to this project it is possible to estimate the impact of the introduction of activity-based pay on UDAs according to each dentist's contract before April 2006. The first row in Table 5 estimates equation 4 for all dentists and thus repeats the difference-in-differences estimate in Table 4. The second row estimates equation 4 for only GDS dentists. The third row estimates equation 4 for only PDS dentists.

Table 5 shows that the difference-in-differences estimates vary according to a dentist's previous contract. The introduction of activity-based pay had a much larger impact on the activity of dentists whose remuneration was salary-based (PDS dentists) rather than treatment-based (GDS dentists). The number of observations on which the estimates in Table 5 are based is relatively small but, nevertheless, the results for the PDS dentists are relatively large and significant: the activity of former PDS dentists increased by 128.2 UDAs per dentist-month, or 41.2% compared with before April 2006 (311.128). By contrast, the difference-in-differences estimator for former GDS dentists is not significantly different from zero.

Table 5: Difference in differences estimates by contract

		Coef.	Robust SE	t	P>t	Dentists	Observations
GDS, PDS, TDS	δ_s	-71.082	19.462	-3.650	0.000	98	1216
GDS	δ_s	-11.976	25.185	-0.480	0.636	55	706
PDS	δ_s	-128.207	22.670	-5.660	0.000	47	599

6 Results: an analysis of dentist specific effects

In order to reflect the Agency framework outlined in Section 3, the empirical framework used fixed effects regression models to account for unobserved dentist specific heterogeneity. This section explores these fixed effects in more detail. First, we assess the explanatory power and distribution of these fixed effects. Second, by linking these fixed effects to the responses obtained from the psychological questionnaire, we examine the extent to which these dentist specific effects reflect the attitudes of the dentists in the sample. In particular, we use a subset of these responses, which relate to the dentists' sense of professional identity, to try and explain the variation in the dentist specific effects.⁴ To our knowledge, this is the first time that such a multidisciplinary approach has been adopted.

In order to assess the explanatory power of the dentist specific effects, we compared the adjusted-R²s of regressions with and without fixed effects. An OLS regression of the number of UDAs per month on the set of monthly dummy variables yielded an adjusted-R² of 0.0387. However, accounting for dentist specific effects by including a dummy variable for each dentist in the sample increased the adjusted R² to 0.5953. An F-test that all the dentist specific effects were jointly equal to zero was rejected. Thus, dentist specific effects have a significant role to play in explaining variation in the number of UDAs per month.

⁴ A more complete analysis of those data is currently being undertaken.

Figure 2: The distribution of fixed effects

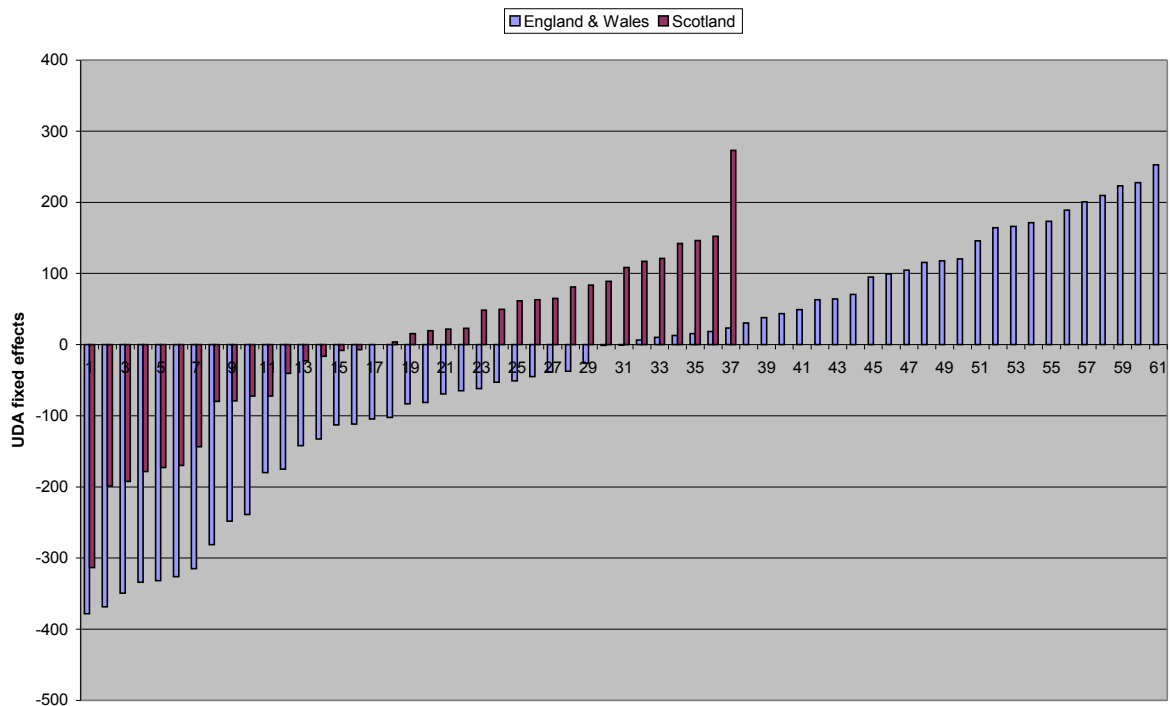


Figure 2 shows the distribution of these fixed effects (Table 4 reports the difference-in-differences results). This illustrates that, in general, there is more variation in the fixed effects from dentists in England & Wales than from dentists in Scotland.

The mean fixed effect is lower in England & Wales than in Scotland. This suggests that, other things equal, dentists in England & Wales tend to provide fewer UDAs per month compared with dentists in Scotland. This difference in the mean fixed effect per dentist may result from a number of factors such as the different types of patient treated by each dentist. As a result, a dentist who treats patients that require more UDAs will, other things equal, have a higher fixed effect.

The objective in the remainder of this paper is to examine the extent to which the variation in these estimated fixed effects is associated with each dentist's attitudes as measured by their responses to the psychological questionnaire.

One section of the psychological questionnaire examined how treatment impacts upon a dentist's sense of professional identity. In order to create a measure for the value of professional identity, dentists were asked to rank on a scale of 1 (not important) to 7 (very

important) how important it is to be:

- (a) someone who is doing what they need to do;
- (b) a caring dentist;
- (c) a competent dentist; and
- (d) an ethical dentist.

Then, dentists were asked to rank, on a scale of 1 (strongly disagree) to 7 (strongly agree), how strongly they agreed with the following statements

- If I provide a treatment that is best for the patient, no matter what the patient thinks, I will think of myself as
 - someone who is doing what they need to do
 - a caring dentist
 - a competent dentist
 - an ethical dentist
- If I provide a treatment that is best for my practice, no matter what anyone else thinks, I will think of myself as someone who is
 - someone who is doing what they need to do
 - a caring dentist
 - a competent dentist
 - an ethical dentist
- If I provide a treatment a patient wants, even if I do not believe they are right, I will think of myself as someone who is
 - someone who is doing what they need to do
 - a caring dentist
 - a competent dentist
 - an ethical dentist
- If I consider a patient's ability to pay when making treatment decisions, I will think of myself as someone who is
 - someone who is doing what they need to do
 - a caring dentist
 - a competent dentist

- an ethical dentist
- If I consider how and what I am paid when making treatment decisions, I will think of myself as someone who is
 - someone who is doing what they need to do
 - a caring dentist
 - a competent dentist
 - an ethical dentist

The value of professional identity was calculated by multiplying the strength of agreement for each statement by its importance. For example, a respondent who thought that doing what they needed to do was ‘very important’ (7 on the importance scale) and who strongly agreed (7 on the agreement scale) that they would think of themselves as ‘someone who is doing what they need to do’ for each of the 5 scenarios would have a score of 245 ($=7*(5*7)$).

The values associated with each of the four components of professional identity were used to explain the variation in the dentist specific effects. The results of this regression are reported in Table 6.⁵

Table 6: Fixed effects and dentists' preferences

Professional identity	Coef.	SE	T	P>t
Someone who is doing what they need to do	1.04	0.47905	2.17	0.03
An ethical dentist	0.48	0.94367	0.51	0.61
A competent dentist	-0.48	0.97792	-0.5	0.62
A caring dentist	-1.28	0.92926	-1.4	0.17
Constant	22.3	51.8053	0.43	0.67
N				81
F(4,76)				1.49
Prob > F				0.21
Adjusted-R ²				0.02

Table 6 shows that the components of professional identity were not jointly significant and that they explained only 2% of the variation in the fixed effects. However, one component

⁵ The responses used in the analysis were the post-intervention responses as this included the scenario: ‘if I consider how and what I am paid...’. The correlation between pre- and post-intervention component of professional identity was at least 0.96 for each component.

was significant and related to the value of what a dentist needs to do. The coefficient is positive which suggests that dentists who think that doing what they need to do is important have higher fixed effects i.e. provide more UDAs per month. Despite not being significant, it is noteworthy that dentists who think that being a caring dentist is important have lower fixed effects i.e. provide fewer UDAs per month.

In other work we have found that a regression between these same psychological factors and the fixed effects from a regression with the number of CoTs per month as the dependent variable is significant. These results, which are available from the authors on request, are qualitatively similar to the results in Table 6. Taken together, these results suggest that there is merit in adopting a multidisciplinary approach to the analysis of incentives in health care.

7 Conclusion

As health system administrators consider reforming the way in which health professionals are paid, it is important that they have evidence relating to the impact that different payment systems have in practice. Principal agent theory provides both a framework for understanding incentive effects and a guide to interpreting evidence and in this paper we have used that theory to interpret and assess data relating to a unique natural experiment in the UK NHS dental health care system.

Utilising a difference-in-differences methodology we have shown that the adoption of activity-based remuneration for dentists led to an increase in activity, as evidenced by a upward shift relative to the trend in activity exhibited by dentists in a part of the NHS that were not subject to the change in contractual terms. The magnitude of the increase in activity depends on the form of remuneration that was in place prior to the activity-based contract. It is largest, over a 40% increase, for dentists who were closest to a salaried arrangement and is small and not statistically significant for those dentists who were under a fee-for-service arrangement.

A distinctive feature of our data is that it enables us to link activity measures to questionnaire responses that elicit professional attitudes and identity. We utilise this additional information to assess how much of the variation in dentists' activity is capable of being explained by their stated attitudes. Individual heterogeneity is very substantial in our data and explains almost 60% of the variability in observed performance of dentists. We find

that relatively little of this heterogeneity can be explained by professional attitudes but that which can exhibits some potentially interesting avenues of future research. For example, dentists who see themselves as responding to need tend to exhibit greater activity whilst those who view themselves as acting ethically tend to have lower activity, other things equal. An understanding of how professional attitudes are formed and evolve and how they might be influenced by policy interventions would provide a potential further avenue by which the performance of health care systems might be influenced.

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