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NHS Input and Productivity Growth 2003/4 – 2007/8

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NHS Input and Productivity Growth 2003/4 – 2007/8

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Background

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The new CHE Research Paper series takes over that function and provides access to current research output via web-based publication, although hard copy will continue to be available (but subject to charge).

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Notation

Notation	Interpretation
K	Capital
L	Labour
M	Intermediate inputs
ΔZ^{D}	Laspeyres input index, directly measured
ΔZ^{Ind}	Laspeyres input index, indirectly measured
z_{nt}	Volume of input of type *n* at time *t*
ω_{nt}	price of input type *n* at time *t*
E	Total expenditure
$\gamma = 1/\pi$	Rate of inflation γ and deflation π
θ_{nt}	Proportion of capital asset *n* used at time *t*
ΔTFP	Total factor productivity growth
ΔI	Index of output growth
ΔZ	Index of input growth

Executive summary

Productivity growth is measured by comparing the rate of output growth with the rate of input growth. In an earlier report we calculated output growth in the English NHS for the period 2003/4 to 2006/7 (Castelli et al., 2008). This report concentrates on input growth, detailing methods and calculating growth from 2003/4 to 2007/8.

The output of the health service is produced using factors of production which can be categorised into three main types: labour, intermediate inputs and capital. We use a variety of data sources to estimate growth in these input factors and present results separately for each major input category and according to organisational type – hospital, foundation and ambulance trusts, PCTs and the NHS as a whole.

The main observations from our analysis of input growth are the following:

- After a period of increased recruitment there has been a recent levelling off in the number of NHS staff.
- The last five years have seen reduced reliance on agency staff.
- There have been year-on-year increases in the volume of intermediate inputs employed by NHS organisations and in prescribing.
- The use of capital has increased over time.
- For the NHS as a whole, input growth averaged 4.7% per year between 2003/4 and 2007/8.

We estimate productivity growth for the NHS in England for the period 2003/4 to 2006/7. Improvements in the recording of community care activity between 2003/4 and 2004/5 give a misleading impression of output growth. To overcome this, our preferred estimates are restricted to the secondary and primary care sectors, which account for 75% of NHS expenditure. The main findings are that:

- Between 2003/4 and 2004/5 input growth was matched by output growth.
- Since 2004/5 there have been productivity gains with output growth exceeding input growth.
- These conclusions are robust to various assumptions about how the input and output series are constructed.

The primary factors driving these recent productivity gains are:

- Increases in the number of patients being treated,
- Improvements in the quality of care patients receive and
- A slowdown in staff recruitment and the use of agency staff.

1. Conceptual overview

1.1 Introduction

The National Health Service (NHS) accounts for a substantial proportion of public expenditure and there has been a significant increase in the resources devoted to the NHS in recent years. It is important for public accountability to measure how this money has been used in order to demonstrate that it has been well spent. Productivity measures are designed to show one aspect of what has been achieved. Put simply productivity is the ratio of outputs to inputs. If the rate of output growth is faster than the rate of input growth from one period to the next, productivity is said to have increased. Operationalising this simple concept, though, can be challenging because it requires accurate measurement of both outputs and inputs.

In a previous report, we considered how to measure NHS outputs and calculated output growth for the English NHS over the period 2003/4-2006/7 (Castelli et al., 2008). In this report, we consider input growth and productivity change over the same period. In future work we shall refine the way we measure the changing quality of NHS output and develop sub-national measures of productivity growth.

We start our analysis of input growth with a brief overview of methods and, then, in chapters 2 to 4 we calculate input indices for three broad input categories: capital, labour and intermediate inputs. We outline the main measurement issues, describe data sources, and provide details of input growth for each category. These separate indices are combined and then compared with our earlier estimates of output growth in chapter 5 to provide estimates of total factor productivity.

1.2 Specifying indices of input growth

The output of any sector of the economy is produced using what economists term ‘factors of production’. For the purposes of calculating total factor productivity, these factors need to be measured comprehensively, capturing as accurately as possible all the inputs into the production process (Atkinson, 2005). Usually factors of production are categorised into three main types:

- Capital (K)
- Labour (L)
- Intermediate inputs (M)

The relative importance (or share) of each category varies from sector to sector, with service industries being relatively labour intensive (O'Mahony, 2003). As we shall see in chapter 3, the third category of intermediate inputs is quite varied, containing such things as catering, laundry, energy, prescriptions and purchased (or procured) services.

Total factor productivity requires calculation of the growth in the ***volume*** of inputs from one period to the next, not the growth in the ***value*** of inputs. There are two ways of making this calculation:

- Direct measures, as the label implies, are based on direct observation of the volume of inputs;
- Indirect measures are applied when information about volume is unavailable or partial. In such circumstances, expenditure data must be used, which necessitates applying price deflators to arrive indirectly at a measure of the volume of input growth.

Next we detail how these measures are constructed and show that they are equivalent.

1.2.1 Direct measurement

A direct measure of input growth can be calculated when data on the volume of inputs are available. For instance, the NHS workforce survey provides information about the number of staff employed (in terms of both headcounts and FTEs) in English NHS organisations as of 30 September each year. This information can be used to quantify how many people are employed by the NHS from one period to the next.

But over time there may be changes in the staffing mix, perhaps because of faster recruitment of nursing staff than hospital consultants, for instance. A crude count of the numbers employed will fail to capture such changes in the composition of staffing. An index of input growth overcomes this by weighting the number of staff of each type by their respective wages before aggregating. In this index, wages are held constant using base period wages (Laspeyres index), current period wages (Paasche index) or some combination of the two (Fisher and Tornqvist indices). By holding wages constant, the index measures ‘real’ changes in the (weighted) volume of staff, not changes in how much they are paid. The Laspeyres volume index, in which inputs are measured directly, takes the following form:

$$\Delta Z^{D} = \frac{\sum_{n=1}^{N} z_{nt}\omega_{nt-1}}{\sum_{n=1}^{N} z_{nt-1}\omega_{nt-1}} \tag{1.1}$$

Where z_{nt} is the volume of input of type *n* at time *t* and ω_{nt} is the price of input type *n* at time *t*.

As we shall see when we come to calculate labour input growth, populating this index gives rise to two main considerations which, unsurprisingly, concern the two main elements in the index:

- How to define the volume of input (for instance, competing definitions for labour are headcounts, full time equivalents, and hours worked).
- What to use as a measure of input price, which ought to reflect the input´s marginal product. This is particularly challenging when considering capital inputs.

1.2.2 Indirect measurement

For many types of input, volume details are unavailable or would be prohibitively costly to collect. However, expenditure on these inputs is usually more readily available. Expenditure is driven by both the volume and price of inputs:

$$E_1 = z_1 \times \omega_1 \tag{1.2}$$

Where E_1 is the total expenditure on input 1, z_1 is the volume of input 1 and ω_1 is its price. The growth in total expenditure from one period to the next is driven by changes in both the volume and price of inputs:

$$\Delta E_1 = \frac{E_{1t}}{E_{1t-1}} = \frac{z_{1t}\omega_{1t}}{z_{1t-1}\omega_{1t-1}} \tag{1.3}$$

Thus, expenditure growth comprises both a price effect and a volume effect. To isolate the volume effect it is necessary, therefore, to convert ‘nominal’ monetary values into ‘constant’ or ‘real’ expenditure using a deflator π. This deflator reflects the underlying trend in prices for the inputs in question, such that $\omega_{nt-1} = \pi_n \omega_{nt}$. So, for instance, if expenditure has risen by 10% and prices by 2%, then the volume effect is 8%, arrived at by applying the deflator $\pi = 1/1.02 \approx 0.98$. The challenge in applying indirect measurement, of course, is to find appropriate deflators for each input type. If these are available, the Laspeyres volume index can be specified as:

$$\Delta Z^{Ind} = \frac{\pi_n E_{nt}}{E_{nt-1}} = \frac{\sum_{n=1}^{N} z_{nt}\pi_n\omega_{nt}}{\sum_{n=1}^{N} z_{nt-1}\omega_{nt-1}} = \frac{\sum_{n=1}^{N} z_{nt}\omega_{nt-1}}{\sum_{n=1}^{N} z_{nt-1}\omega_{nt-1}} = \Delta Z^{D} \tag{1.4}$$

Thus, provided that there is an accurate means of deflating expenditure data, indirect and direct measurement of input growth will yield equivalent results. The key elements where information for indirect measurement is required are:

- Total expenditure for each input category
- The value of the deflator appropriate to each input type.

1.2.3 Direct versus indirect measurement

As equation 1.4 demonstrates, provided that the requisite data are available, the direct and indirect measures are equivalent. While direct measurement is often recommended (OECD, 2001a, Atkinson, 2005), this is not a strict preference. In practice there are pros and cons with each approach, so the choice will depend on what insights are sought and what information is available. These pros and cons are summarised in Table 1-1.

Table 1-1 Pros and cons of direct and indirect measurement

Direct method		Indirect method	
Pros	*Cons*	*Pros*	*Cons*
Able to estimate specific contributions of each factor type	May be costly to obtain accurate volume and factor price information for each factor type	More likely to measure full resource commitment	Need to find appropriate price deflators
	Danger that some input types will be overlooked	Expenditure data are more likely to be readily available	

If there is interest in evaluating the contribution of specific factor inputs to the production process or in exploring substitution possibilities among factors, direct measurement is to be preferred. For instance, there might be interest in calculating labour productivity or the contributions of doctors or of nurses, not just total factor productivity.

But there is a price to pay for such a disaggregated formulation, the main danger being under-estimation of the full resource commitment. In particular, routinely collected volume data on intermediate inputs is usually quite rudimentary. For instance, organisations do not report routinely how many computers they have, let alone their specification or what software they operate. In such circumstances, a single measure of input in the form of total expenditure may be preferable, with the indirect method being used to assess input growth.

Although the indirect method is likely to be a more comprehensive measure of resource use, it requires a judgement to be made about how the price of resources changes over time. These deflators should be sufficiently disaggregated to take account of changes in the mix of inputs and should reflect full and actual costs (Atkinson, 2005).

1.2.4 Quality adjustment of inputs

It has been recommended that improvements in the *quality* of input over time should also be taken into account, the argument being that inputs of a higher quality are more productive (OECD, 2001b, Atkinson, 2005). There are examples of such adjustments being applied to labour input. For instance, the ONS has developed a measure of quality-adjusted labour input (QALI) which attempts to measure the marginal productivity of labour for the economy as a whole by adjusting hours worked by employee characteristics using data from the Labour Force Survey (LFS) (Dey-Chowdhury et al., 2007).

This adjustment might be necessary if there is limited information available to differentiate between types of labour, so that the index recognises that "one hour worked by one person does not constitute the same amount of labour input as one hour worked by another person" (OECD, 2001b) (p41). If inputs are to be adjusted for quality, two issues must be addressed.

- First, how should quality be defined?
- Second, what value should be attached to a unit change in each quality dimension?

ONS uses the LFS to estimate hours worked for the economy as a whole, and applies quality adjustment because the specificity of the labour categories in the LFS is crude. To overcome this, ONS constructs 576 labour input categories based on qualifications, age, industry and gender of respondents to the LFS. The weights attached to these characteristics reflect their estimated marginal impact on wages (Dey-Chowdhury et al., 2007).

In the past, quality adjustment was applied to NHS labour inputs probably because categories were insufficiently refined to capture grading trends, with most volume measures “hiding considerable diversity across types of workers” (Dawson et al., 2005) (p167). But, as we shall see in chapter two, NHS workforce survey data allows for fairly refined categories of labour input. With sufficiently refined categories, if people with more qualifications are indeed more productive they will be promoted to higher grades and command higher wages. This appears to be the case in the NHS, with the average wage paid to NHS workers with higher degrees about four times higher than the average unskilled wage (Dawson et al., 2005) (p174). If people are promoted, all the index requires is that staffing types are sufficiently differentiated to capture changes in grading as the labour force becomes more qualified. Additional quality adjustment of these categories risks double counting the impact of quality, by capturing it both in grading trends and in the quality adjustment.

If higher qualifications are not generally rewarded with promotion, quality adjustment of labour input is redundant. The reason is that the lack of promotion implies that staff who stay on the same grade once gaining their qualification are not, in fact, more productive than other less qualified staff of the same grade.

In summary, rather than quality adjustment we adopt the recommendation made by the ONS that the key approach to adjusting for quality is a higher level of input differentiation (Camus, 2007).

1.3 Conclusions

We have demonstrated that the direct and indirect approaches to input growth are equivalent. Any differences that arise when implementing these approaches will be due to the data used to populate the indices. Indeed data availability usually drives the practical choice of one approach over the other.

We have also argued that quality adjustment of inputs is desirable only in circumstances where data do not allow different types of input to be distinguished with sufficient precision. But quality adjustment is imperfect, requiring assumptions about how quality should be defined and about its relationship to the marginal product of the input in question. A preferable approach, and the one that we adopt in considering labour inputs, is to ensure that input types are differentiated into sufficiently homogenous groupings. This allows the marginal product of each input type to be captured by its relative price and ensures that improvements in labour productivity over time will be captured by changes in the grading composition.

We now turn to measurement of input growth for the NHS, dealing with each of the main input categories in turn.

2. Labour input

2.1 Introduction

Like all service industries, the NHS is labour intensive. It is critical, therefore, for any measure of overall input growth that the contribution of labour is captured as accurately as possible. In this section we calculate two indices of labour input growth, distinguished by their data sources. We first apply the direct method to data on the number of employees in the English NHS contained in the annual NHS workforce census. We then apply the indirect method to convert data about expenditure on staff into a volume index. This section concludes with a comparison of the estimates derived from applying the two methods.

2.2 Direct measurement of labour input growth

For direct measurement of labour input growth we require information about z_{nt}, the volume of input of type *n* at time *t*, and ω_{nt}, the price of input type *n* at time *t*. To calculate our direct measure we combine volume and earnings data, which are derived from different sources. Combining these data requires that the staffing categories used in each data source can be mapped. Until recently, this was not straightforward, as workforce and earnings data categorised NHS staff in different ways. With the recent introduction of the Electronic Staff Record, mapping of earnings to workforce data is now more accurate, and allows for greater differentiation of the staffing categories than was previously the case.

In accounting for growth in labour input, we also have to take account of periodic changes in how staffing categories are defined. For instance, the Modernising Medical Careers programme, implemented progressively from 2005, has introduced changes to grading structure as doctors are trained, resulting in changes to the number of doctors classified to different grades. Similarly, Agenda for Change resulted in wholesale revisions to the grading structure and pay rates for non-medical staff. While the Workforce Census has retained a consistent classification system over time, surveys of earnings have not. We detail the assumptions made to ensure consistent mapping of earnings to workforce data.

2.2.1 NHS workforce data

Data on the number of NHS staff is taken from the annual Workforce Census, which comprises data collected by NHS hospital trusts and primary care trusts (PCTs) in England on the staff in post on 30th September each year. The data refer to staff directly employed by the NHS in Hospital and Community Health Services (HCHS) and by GP practices contracted to the NHS. The census excludes locums, agency staff, high street dentists and ophthalmic practitioners. However, expenditure on non-NHS staff is available from each organisation's financial returns, so it is possible to apply indirect measurement to account for the contribution of non-NHS employees and we address this in section 2.3.2.

After collating the census data, the Information Centre posts the headcounts and full-time equivalents by staff type, organised into three broad groups: medical and dental staff; general practice staff and non-medical staff.[1]

Headcounts are converted into full-time equivalents (FTE) such that the maximum FTE is 1. Thus the figures do not capture overtime working, an issue to which we shall return in due course. The method for calculating FTEs varies according to type of staff:

- For medical and dental staff working part-time, FTEs are calculated by taking account of the weekly number of hours or sessions in staff contracts.
- The method for converting part-time GPs into FTEs has been subject to periodic revision. In 2003, allowance was made for GPs on part-time contracts, according to whether they worked ¾ time (0.69 FTE), ½ time (0.6 FTE) or were in a job share (0.65 FTE). In 2004 and 2005, a

[1] http://www.ic.nhs.uk/statistics-and-data-collections/workforce/nhs-staff-numbers/nhs-staff-1997--2007-overview accessed 19/1/09

GP working part-time was considered equivalent to 0.6 FTE. Since 2006, FTE figures are based on the number of sessions or hours in their contract.

- For non-medical staff, FTEs are calculated by dividing the number of hours staff in a grade are contracted to work by the standard hours for that grade. The same calculation applies to staff working in general practice.

2.2.2 Earnings data

Earnings data are used to derive a price for each category of labour input (ω_{nt}). We rely on different sources of earnings data for those employed by the NHS and those working in general practice.

NHS staff

For 2006/7 and 2007/8, the Information Centre provided us with earnings data based on 'worked full time equivalents' corresponding to the categorisation used in the Workforce Census. These figures were derived from the Electronic Staff Record which is a new payroll and human resources system that was fully implemented in April 2008. This means that earnings data are based on all staff in every NHS organisation (with the exception of two Foundation Trusts).

For earlier periods, the 95 categories used in the NHS Workforce Census do not correspond to the 27 categories of staff reported in the NHS Earnings Surveys.[2] We extrapolated from the more recent data provided by the Information Centre and made a number of assumptions in order to derive estimates for previous years:

- An estimate of earnings for hospital consultants was available from the 2004 Earnings Survey. Using this estimate for 2004/5 and that from the Information Centre for 2006/7, we assumed that earnings changed at a constant rate between 2003/4 and 2006/7.
- For other types of medical staff, we assumed that the salary relativities across different types of medical staff observed in 2006/7 applied in previous periods. We also assume that the ratio of earnings to salary for each staff group in years prior to 2006/7 was the same as that observed in 2006/7.
- An estimate of earnings for nurse consultants was available from the 2004 Earnings Survey. Using this estimate for 2004/5 and the data from the Information Centre for 2006/7, we assumed that earnings for nurse consultants changed at a constant rate between 2003/4 and 2006/7.
- For the other types of nursing staff, we used Agenda for Change pay scales to estimate salaries for 2004/5 and 2005/6. To derive 2003/4 estimates, we assumed the rate of salary change between 2003/4 and 2004/5 was the same as that for nurse consultants. We assumed that the earnings:salary ratio observed in 2006/7 applied to previous years.
- For non-medical staff (other than nurses) we assumed that the rate of change in earnings between 2006/7 and 2007/8 applies to preceding years.

These assumptions may not accord precisely with how earnings actually changed over the period but in the absence of any better information it is impossible to assess what impact any inaccuracy might have on the calculation of volume growth. The introduction of the Electronic Staff Record means that mapping of earnings data to workforce categories is now much more accurate and also means that earnings data are comprehensive not just from an (admittedly large) sample.

GPs and practice staff

Data on earnings by GPs are drawn from the annual GP earnings and expenses reports, made available by the Information Centre.[3] We have assumed that the salary for practice nurses is equivalent to that for 1st level hospital nurses and the salary for other practice staff is equivalent to that for clerical and administrative staff employed by NHS organisations. We have also assumed that general practice staff do not receive payments in addition to their salary.

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[2] The 2004 earnings survey was based on a one month sample (August) of 51% of NHS trusts that use a specific common payroll system. http://www.ic.nhs.uk/webfiles/publications/earnings05/NHSStaffEarnings300805_PDF%20.pdf accessed 12/2/09

[3] http://www.ic.nhs.uk/statistics-and-data-collections/workforce/nhs-staff-earnings accessed 19/1/09.

2.2.3 Changes in the number of staff

Table 2-1 and Table 2-2 provide details of staff numbers recorded each year in the Workforce Census, aggregated into broad staff groupings, with numbers defined either in terms of headcounts or FTEs. Figure 2-1 to Figure 2-3 provide a summary of staff numbers aggregated into medical & dental staff; non-medical staff; and general practitioners and practice staff. The main features of these data are as follows:

- There have been year-on-year increases in the number of medical & dental staff, although the rate of increase has slowed over time.
- While there were increases in the number of non-medical staff between 2003 and 2005, there has been a slight reduction in numbers more recently.
- The number of GPs and staff working in general practice increased from 2003 to 2006, with a slight reduction in numbers in 2007.
- The greatest divergence between headcount and FTEs is for hospital practitioners, clinical assistants and practice staff working in GP surgeries. This is a reflection of the higher proportion of part-time working arrangements among these types of staff.

Table 2-1 Medical & Dental Staff by Headcount and FTE's 2003-2007

	Headcount					FTE's				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
Career grades	36,006	38,411	40,074	41,641	42,777	32,949	35,119	36,839	38,439	39,519
Consultant	28,750	30,650	31,993	32,874	33,674	26,341	28,141	29,613	30,619	31,430
Associate Specialist	2,001	2,294	2,554	2,830	3,048	1,780	2,029	2,260	2,495	2,650
Staff grade	5,255	5,467	5,527	5,937	6,055	4,828	4,948	4,966	5,325	5,438
Doctors in training	37,320	41,697	44,311	46,269	46,783	36,402	40,654	43,295	45,422	46,051
Registrar group	14,619	16,823	18,006	18,808	30,759	13,989	16,112	17,313	18,180	30,175
Senior House Officer	18,698	20,601	21,642	18,863	5,954	18,419	20,283	21,337	18,662	5,849
Foundation Year 2	.	.	.	3,693	4,830	.	.	.	3,690	4,823
House Officer	4,003	4,273	4,663	4,905	5,240	3,994	4,259	4,645	4,890	5,203
Other grades	7,525	6,888	6,245	5,410	5,078	2,909	2,689	2,435	2,114	1,964
Hospital Practitioner	1,034	1,048	1,017	929	908	221	228	215	193	185
Clinical Assistant	3,950	3,476	3,047	2,593	2,364	1,068	936	794	655	553
Other Staff	2,541	2,364	2,181	1,888	1,806	1,620	1,524	1,426	1,266	1,226
GP's & Practice Staff	110,091	112,254	112,094	119,642	117,375	97,072	100,573	102,456	108,171	106,406
Total Practice Staff	110,091	112,254	112,094	119,641	117,375	69,140	72,006	72,990	76,977	75,085
GP's	-	-	-	-	-	27,932	28,567	29,467	31,194	31,321
All Staff	190,942	199,250	202,724	212,962	212,013	169,332	179,034	185,025	194,146	193,939

Table 2-2 Non-medical Staff by Headcount and FTE's 2003-2007

	Headcount					FTE's				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
Total non-medical staff	1,063,846	1,101,797	1,130,949	1,092,886	1,085,524	855,799	889,973	916,548.01	899,091	893,087
Professionally qualified clinical staff	502,715	521,526	533,908	525,212	530,741	410,192	427,050	438,376	437,662	441,270
Qualified nursing, midwifery & health visiting staff	364,692	375,371	381,257	374,538	376,737	291,925	301,877	307,744	307,447	307,628
Total qualified ST&T staff	122,066	128,883	134,534	134,498	136,976	102,912	108,585	113,214	114,492	117,107
Qualified Allied Health Professions	62,189	65,515	67,841	67,483	68,687	50,478	53,311	55,133	55,711	57,065
Other qualified ST&T staff	59,877	63,368	66,693	67,015	68,289	52,434	55,274	58,082	58,782	60,042
Qualified ambulance staff	15,957	17,272	18,117	16,176	17,028	15,355	16,587	17,417	15,723	16,535
Support to clinical staff	360,666	368,285	376,219	357,877	346,596	277,178	284,394	291,663	283,198	274,608
Support to doctor & nursing staff	298,752	303,630	310,441	291,098	281,894	226,955	231,652	237,889	228,084	221,270
Support to ST&T staff	52,230	55,025	55,715	54,307	53,259	41,481	44,089	44,708	43,906	43,113
Support to ambulance staff	9,684	9,630	10,063	12,472	11,443	8,743	8,653	9,066	11,209	10,225
NHS infrastructure support	199,808	211,489	220,387	209,387	207,778	167,916	178,098	186,137	177,871	176,858
Central functions	92,257	99,831	105,565	101,860	100,177	78,784	85,498	90,387	87,856	86,772
Hotel, property & estates	72,230	73,932	75,431	70,776	71,102	55,323	56,593	58,201	54,975	55,131
Manger & senior manager	35,321	37,726	39,391	36,751	36,499	33,810	36,007	37,549	35,041	34,955
Other non-medical staff	657	497	435	410	409	512	432	373	359	351

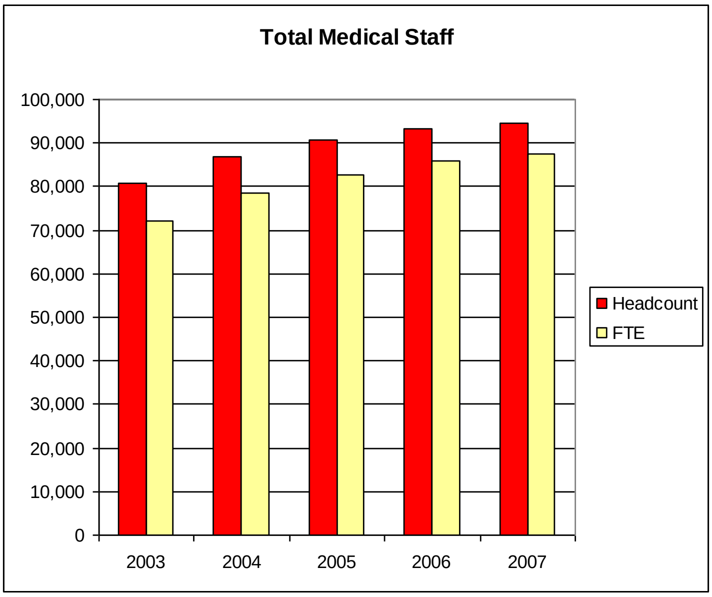


Figure 2-1 Comparisons of headcounts and FTEs, medical staff

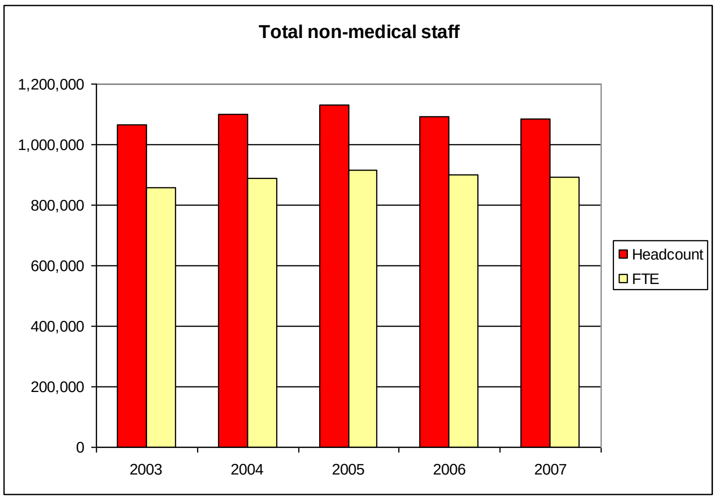


Figure 2-2 Comparisons of headcounts and FTEs, non-medical staff

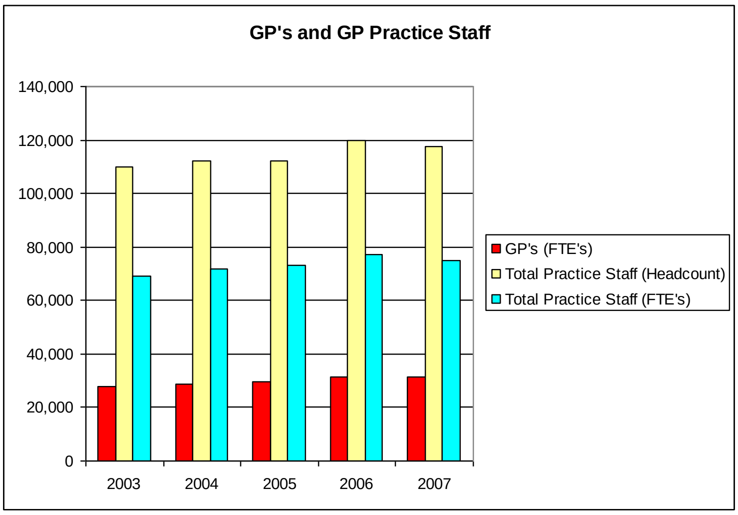


Figure 2-3 Comparisons of headcounts and FTEs, GPs and practice staff

2.2.4 Labour input growth – direct measurement

Data on FTEs and staff earnings are combined in an index of volume growth for each pair of years from 2003/4 to 2007/8. These figures are shown in the first column of Table 2-3 which shows that growth in the volume of labour input was stronger in the years 2003/4 through to 2005/6 but has slowed more recently. This reflects the slower rate of increase in staff numbers in 2007 and 2008 shown in the graphs presented in the preceding section.

Table 2-3 Growth in labour input, direct measurement

	CHE estimates	ONS estimates
2003/4 - 2004/5	4.76%	4.98%
2004/5 - 2005/6	3.44%	3.44%
2005/6 - 2006/7	0.64%	0.30%
2006/7 - 2007/8	0.66%	

For comparison the growth rates calculated by the ONS are reported in the second column of Table 2-3.[4] These are calculated slightly differently, most notably because in the ONS figures staff are

[4] Derived from Lee (2006) Figure 4.4 http://www.statistics.gov.uk/cci/article.asp?ID=1922

differentiated into just the 27 categories of the 2004 earnings survey rather than the 95 categories available in the Workforce Census. Nevertheless the two sets of growth rates are very similar.

These sets of estimates are based on FTEs. This is not an ideal measure of labour input because it excludes overtime working. Instead the preferred measure of labour input is hours actually worked, including overtime (Dey-Chowdhury et al., 2007). The definition of hours worked devised by the International Labour Organisation states that the measure should include:

- Productive hours
- Hours spent on ancillary activities
- Unproductive hours spent in the course of work
- Short periods of rest

But should exclude

- Hours paid for but not worked (eg annual leave, sick leave)
- Meal breaks longer than 30 minutes
- Time spent on commuter travel between home and employment

In practice it is difficult to adhere to this definition because data on actual hours worked are rarely observed in situations where working overtime is a common occurrence. Overtime working typifies the NHS, particularly the hospital sector where having staff work overtime has been crucial to efforts to reduce NHS waiting times. Nor can it be assumed that the proportion of overtime working to normal working hours is constant year on year. But NHS organisations do not report the amount of overtime hours worked by staff. They do, however, report total expenditure on NHS staff, which means that an indirect measure of staffing input may be more accurate than a direct measure. We turn to this approach next.

2.3 Indirect measurement of labour input growth

Total expenditure on salaries and wages is available from the financial returns made annually to the Department of Health by hospital trusts, ambulance trusts, PCTs and health authorities. When hospitals take on foundation status, they are exempt from making this financial return, thereby undermining the comprehensiveness of this source of information. However, foundation trusts still compile annual accounts which report less detailed information. We analyse aggregate data for FTs as a whole, derived from the consolidated annual reports compiled each year by Monitor.[5] The numbers of each type of organisation are reported in Table 2-4. Numbers have changed over time as more hospitals have taken on foundation trust status and some organisations, notably PCTs and SHAs, have merged together.

Table 2-4 Numbers of organisations to which each type of financial return applies

	Return	2003/4	2004/5	2005/6	2006/7	2007/8
Hospital and ambulance trusts	TFR3	234	223	235	210	178
FTs	FTC06	0	25	32	59	89
PCTs	PFR3	302	300	303	152	152
SHAs	HFR3	28	28	28	10	10

The financial returns record all payments made to staff directly employed by the organisation and to agency staff. We analyse payments to NHS staff first.

5 http://www.monitor-nhsft.gov.uk/sites/default/files/publications/Review_and_consolidated_accounts_of_NHS_FTs_2004_05.pdf accessed 27/2/09; http://www.monitor-nhsft.gov.uk/sites/default/files/publications/Monitor_Consolidated_0506.pdf accessed 27/2/09

2.3.1 NHS staff

Table 2-5 reports current expenditure on NHS staff according to whether staff are employed in hospital and ambulance trusts, foundation trusts, or PCTs. Data for foundation trusts are less detailed than for the other organisations, their accounts reporting only total expenditure on staff rather than breaking down expenditure according to staffing groups. Up to 2003/4 pension on-costs were shared equally between Treasury and the Department of Health, after which all costs were transferred to the DH. The expenditure on NHS staff reported by trusts and PCTs in 2003/4 has been adjusted upwards to allow for this policy change in order to ensure comparability over time.

As progressively more hospitals have taken on foundation status expenditure on NHS staff for this group of hospitals has risen from £2.5bn by the 25 FTs in 2004/5 to £9.6bn by the 89 FTs in 2007/8. It is notable, however, that this increase has not been completely offset by reductions in expenditure among hospital (and ambulance) trusts that have not taken on foundation status. Total expenditure has fallen from £23bn by 223 organisations in 2004/5 to £20bn by 178 organisations in 2007/8. The reason that the figures do not offset, of course, is that expenditure in each period comprises a mixture of volume and price effects. Hence the growth in total expenditure across all organisations from £28.7bn in 2003/4 to £36.5bn in 2007/8 is partly driven by increases in pay. When constructing our indirect measure of volume growth we remove the effects of pay inflation using the NHS pay index. This allows us to identify what proportion of increased expenditure is attributable to growth in the volume of staff rather than increases in their pay.

Table 2-5 Current expenditure on NHS staff salaries and wages (£000s)

	2003/4	2004/5	2005/6	2006/7	2007/8
Hospital and ambulance trusts					
Total Senior Managers & Managers	1,173,902	1,187,336	1,182,277	1,098,955	919,042
Total Medical Staff (including locums)	6,077,258	5,974,802	5,991,919	5,750,359	5,223,513
Total Dental Staff (including locums)	63,407	56,983	52,674	46,746	37,646
Total Nursing Midwifery & Health Visiting S	8,767,899	8,477,812	8,538,790	8,204,900	7,321,781
Total Scientific, Therapeutic & Technical S	3,020,549	2,942,535	2,994,992	2,904,196	2,581,216
Administrative and clerical	2,504,351	2,452,099	2,505,810	2,408,654	2,163,292
Healthcare Assistants and other Support S	1,176,027	1,115,684	1,166,179	1,130,289	1,017,431
Maintenance and works staff	233,171	219,448	210,717	195,169	173,882
Ambulance staff	555,659	662,651	737,866	773,365	832,961
Other employees	86,515	73,900	90,480	70,183	98,180
Chairman & Non-Executive Directors	20,523	16,125	15,226	12,232	11,560
Total staff - hospital & ambulance	**23,679,261**	**23,179,373**	**23,486,930**	**22,595,048**	**20,380,504**
Foundation Trusts					
NHS Staff		2,471,600	4,075,900	6,026,996	9,520,162
Chairman & Directors		14,800	26,000	41,969	74,859
Total staff - FTs		**2,486,400**	**4,101,900**	**6,068,965**	**9,595,021**
Total staff - all trusts	**23,679,261**	**25,665,773**	**27,588,830**	**28,664,013**	**29,975,525**
PCTs					
Total Senior Managers & Managers	599,322	780,970	863,892	825,938	808,074
Total Medical Staff (including locums)	294,357	340,367	359,456	386,793	379,779
Total Dental Staff (including locums)	62,661	76,315	81,672	79,642	93,216
Total Nursing Midwifery & Health Visiting S	2,197,615	2,389,454	2,652,729	2,714,685	2,720,984
Total Scientific, Therapeutic & Technical S	724,408	815,104	929,085	988,349	1,005,470
Administrative and clerical	638,785	772,569	910,954	1,004,588	1,079,280
Healthcare Assistants and other Support S	147,175	168,873	169,235	172,229	195,796
Maintenance and works staff	17,824	19,145	22,261	24,076	21,859
Ambulance staff	210	95	204	5,103	5,008
Other employees	40,873	31,311	49,201	49,731	84,346
Chairman & Non-Executive Directors	131,775	88,068	77,949	52,026	42,281
Total staff - PCTs	**4,855,005**	**5,482,270**	**6,116,638**	**6,303,160**	**6,418,594**
Total staff - SHAs	**155,084**	**186,209**	**221,279**	**210,336**	**145,865**
Total staff - NHS	**28,689,350**	**31,334,252**	**33,926,746**	**35,177,509**	**36,539,984**

2.3.2 Agency staff

Expenditure on agency staff by organisational type is reported in Table 2-6. Again the annual reports for foundation trusts report simply a global sum, while other organisations provide a detailed breakdown by staffing type.

What is most notable is that expenditure on agency staff fell markedly from £1.6bn in 2003/4 to less than £1.2bn in 2006/7. Expenditure increased to almost £1.4bn in 2007/8 but remains below the amount spent in 2005/6. As pay for agency staff is likely to have increased over time, these figures suggest that concerted efforts have been made to reduce reliance on agency staff since 2003/4.

Table 2-6 Current expenditure on Agency staff (£000s)

	2003/4	2004/5	2005/6	2006/7	2007/8
Hospital and ambulance trusts					
Medical	316,427	299,054	228,969	148,384	155,532
Dental	2,480	1,044	3,315	464	155
Nursing, midwifery and health visiting	464,333	320,967	246,376	134,055	147,889
Scientific, Therapeutic & Technical Staff	191,965	158,854	126,380	86,494	66,054
Administrative & Clerical	128,904	114,061	113,867	98,565	131,360
Healthcare Assistants & Other Support Staff	46,916	44,408	46,890	35,313	35,010
Maintenance & Works Staff	7,960	7,959	4,515	4,008	6,925
Ambulance Staff	934	198	696	97	1,008
Other Employees	38,970	37,739	45,306	36,632	40,355
Total agency - hospital & ambulance trusts	**1,198,888**	**984,283**	**816,314**	**544,012**	**584,288**
Foundation Trusts					
Total agency		**89,400**	**132,500**	**175,419**	**324,743**
Total agency - all trusts	**1,198,888**	**1,073,683**	**948,814**	**719,431**	**909,031**
PCTs					
Medical	28,255	29,963	27,989	28,571	28,186
Dental	1,218	1,121	1,703	1,417	1,537
Nursing, midwifery and health visiting	81,773	81,324	74,856	59,009	61,113
Scientific, Therapeutic & Technical Staff	53,656	57,490	58,500	39,831	41,938
Administrative & Clerical	53,722	61,626	72,329	73,640	115,109
Healthcare Assistants & Other Support Staff	8,265	11,141	10,339	10,486	7,672
Maintenance & Works Staff	1,053	857	793	866	2,859
Ambulance Staff	169	4	1	-	2
Other Employees	26,479	36,579	26,924	28,120	24,218
Total agency - PCTs	**254,589**	**280,105**	**273,434**	**241,940**	**282,634**
Total agency - SHAs	**170,869**	**203,494**	**237,688**	**223,873**	**162,855**
Total agency - NHS	**1,624,347**	**1,557,282**	**1,459,936**	**1,185,244**	**1,354,520**

2.4 Results – labour input growth

We apply a deflator to convert current expenditure into constant or real expenditure, thereby removing price effects. Expenditure on labour is deflated using the NHS pay index, which is reported in Table 2-7 re-referenced to 2003/4 (Barnes, 2008). Values for 2007/8 were not available at the time of writing, so it has been assumed that increases were equivalent to those experienced in the preceding year.

Table 2-7 NHS Pay, Prices and FHS drugs Indices

	2003/4	**2004/5**	**2005/6**	**2006/7**	**2007/8***
Pay	1.000	1.045	1.092	1.133	1.170
Prices	1.000	1.010	1.029	1.059	1.109
Pay & prices	1.000	1.033	1.070	1.107	1.148
FHS drugs	1.000	1.055	1.163	1.200	1.241
* estimate					

Table 2-8 reports expenditure on staff in constant prices, after deflating using the NHS pay index.

Table 2-8 Expenditure on staff, constant prices (£000s)

	2003/4	2004/5	2005/6	2006/7	2007/8
NHS staff					
Hospital, FTs and ambulance trusts	23,679,261	24,560,549	25,264,496	25,299,217	25,620,107
PCTs	4,855,005	5,246,192	5,601,317	5,563,248	5,485,978
SHAs	155,084	178,190	202,636	185,645	124,671
Total NHS staff	**28,689,350**	**29,984,931**	**31,068,449**	**31,048,110**	**31,230,755**
Agency staff					
Hospital, FTs and ambulance trusts	1,198,888	1,027,448	868,877	634,979	776,950
PCTs	254,589	268,043	250,397	213,539	241,568
SHAs	170,869	194,731	217,663	197,593	139,192
Total agency staff	**1,624,347**	**1,490,222**	**1,336,937**	**1,046,111**	**1,157,710**
Total staff	**30,313,697**	**31,475,153**	**32,405,386**	**32,094,222**	**32,388,465**

Labour growth rates are reported in Table 2-9. The first column reproduces the estimates from applying direct measurement previously reported in Table 2-3. Note that, because of data limitations of the Workforce Census, the direct method is unable to account for two important components of the contribution of labour, these being firstly overtime working by NHS staff and secondly the input of non-NHS staff. The impact of accounting for overtime working can be estimated by comparing the direct and indirect estimates for NHS staff reported in the first two columns. As would be expected, the growth rates are quite similar.

Table 2-9 Growth in the volume of labour inputs

	Direct measure	**Indirect measures**					
	NHS staff	NHS staff	Agency	Trusts	PCTs	SHAs	All staff
	1	2	3	4	5	6	7
2003/4 - 2004/5	4.76%	4.52%	-8.26%	2.85%	7.92%	14.41%	3.83%
2004/5 - 2005/6	3.44%	3.61%	-10.29%	2.13%	6.12%	12.70%	2.96%
2005/6 - 2006/7	0.64%	-0.07%	-21.75%	-0.76%	-1.28%	-8.82%	-0.96%
2006/7 - 2007/8	0.66%	0.59%	10.67%	1.78%	-0.85%	-31.15%	0.92%

Column 3 shows that over time there have also been substantial year-on-year reductions in the use of agency staff until 2006/7, when usage reached its lowest level over the entire period. The high rate of growth between 2006/7-2007/8 merely reflects a return to 2005/6 usage of agency staff.

Columns 4, 5 and 6 present estimates of labour input growth separately for trusts (hospitals, FTs and ambulance), PCTs and SHAs. Changes have been most pronounced among SHAs, which is largely a reflection of the smaller size of this organisational sector.

The final column shows the growth rate in the volume of labour input for the NHS as a whole. This indicates that growth was fairly strong in the earlier period, but this slowed to such an extent that there were recent reductions in labour input between 2005/6-2006/7 with a levelling out in 2007/8.

3. Intermediate inputs

3.1 Introduction

Intermediate inputs comprise a wide range of items used in the production of health, all of which can be attributed to a particular period of time (here, the financial year). In this section we sub-divide our discussion of intermediate inputs into three broad categories:

- Those inputs employed by hospital, ambulance and primary trusts
- Prescriptions dispensed in pharmacies and by GP dispensers
- Other inputs into the production of NHS care not captured elsewhere, such as expenditure on general medical services, DH administration and services provided at a national level

For most intermediate inputs we have expenditure data only, so growth is calculated by applying indirect measurement. For prescribing, details about the type and volume of medicines are available, enabling us to undertake direct measurement.

3.2 Intermediate inputs used by NHS organisations

Expenditure on intermediate inputs by hospital and ambulance trusts (but not foundation trusts) is derived from the Trust Financial Returns, for PCTs from the Primary Care Trust Financial Returns and for SHAs from the health authorities returns. These returns detail expenditure under various headings, some of which relate to capital expenditure which we deal with in the next section. We summarise expenditure on intermediate inputs into the following broad categories:

- Drugs and gases
- Clinical supplies and services, including dressings and x-ray film
- General clinical supplies and services, including catering and hotel services, uniforms, laundry and bedding
- Establishment costs, including stationary, telephones, advertising and transport
- Energy and premises, including energy, rent and engineering
- External purchasing, including purchase of healthcare from non-NHS bodies and external contracts such as consultancy
- Miscellaneous, including auditing fees

Summarised data for all FTs are reported by Monitor in the consolidated accounts each year. The accounts report expenditure under general headings, most of which correspond to those listed above. However, expenditure on clinical supplies and services and on premises comprises a mixture of intermediate and capital inputs. We have assumed that the proportionate mix of intermediate and capital expenditure within these two categories is the same for FTs as it is in the hospital financial returns.

Table 3-1 reports the amount of expenditure on intermediate inputs by organisational type for each year from 2003/4. Note that the first FTs were not established until 2004/5, with more becoming FTs over time. Expenditure prior to hospitals becoming FTs is included under hospitals and ambulance trusts.

Table 3-1 Expenditure on intermediate services, by type of NHS organisation (£000s)

	2003/4		2004/5		2005/6		2006/7		2007/8	
Hospitals and ambulance trusts										
Drugs & gases	2,227,972	33%	2,283,685	38%	2,128,698	32%	2,083,993	32%	1,974,347	31%
Clinical supplies & services	370,874	6%	238,156	4%	332,131	5%	352,184	5%	324,093	5%
General supplies & services	832,050	12%	666,426	11%	727,897	11%	717,857	11%	730,125	12%
Establishment	974,825	15%	870,471	14%	867,559	13%	815,330	12%	802,592	13%
Energy & premises	687,712	10%	704,235	12%	854,306	13%	886,484	13%	841,011	13%
External purchasing	565,953	8%	479,515	8%	477,508	7%	456,163	7%	450,463	7%
Miscellaneous	1,002,031	15%	761,677	13%	1,220,972	18%	1,290,530	20%	1,191,264	19%
Total hospitals and ambulanc	**6,661,416**		**6,004,167**		**6,609,071**		**6,602,541**		**6,313,896**	
Foundation trusts										
Drugs & gases			308,200	31%	518,900	32%	730,034	31%	1,141,034	30%
Clinical supplies & services			167,829	17%	262,558	16%	396,309	17%	618,049	16%
General supplies & services			77,000	8%	125,500	8%	193,647	8%	315,710	8%
Establishment			81,500	8%	114,000	7%	166,886	7%	283,042	7%
Energy & premises			95,727	10%	177,480	11%	274,979	12%	438,162	11%
External purchasing			129,700	13%	192,000	12%	282,760	12%	465,889	12%
Miscellaneous			126,900	13%	214,600	13%	322,041	14%	556,463	15%
Total FTs			**986,856**		**1,605,038**		**2,366,656**		**3,818,349**	
Total trusts	**6,661,416**		**6,991,023**		**8,214,109**		**8,969,197**		**10,132,245**	
PCTs										
Drugs & gases	79,735	2%	96,791	2%	113,846	2%	139,378	2%	170,870	2%
Clinical supplies & services	51,462	1%	56,528	1%	86,998	1%	73,611	1%	95,094	1%
General supplies & services	137,728	3%	115,960	2%	121,405	2%	114,887	2%	112,887	1%
Establishment	388,368	8%	399,522	8%	410,009	7%	396,311	6%	438,220	5%
Energy & premises	117,862	3%	137,190	3%	184,640	3%	228,225	3%	253,061	3%
External purchasing	2,999,056	65%	3,430,440	69%	4,241,018	71%	4,845,058	71%	5,972,476	72%
Miscellaneous	849,223	18%	735,741	15%	775,298	13%	994,558	15%	1,285,097	15%
Total PCTs	**4,623,434**		**4,972,172**		**5,933,214**		**6,792,028**		**8,327,705**	
Total SHAs	**58,945**		**58,721**		**67,368**		**72,493**		**94,749**	
Total NHS - current prices	**11,343,796**		**12,021,916**		**14,214,691**		**15,833,718**		**18,554,699**	
Total NHS - constant prices	**11,343,796**		**11,789,697**		**13,505,305**		**14,622,899**		**16,416,480**	

There are some noteworthy features of these data:

- Drugs & gases comprise the largest element of expenditure on intermediate inputs in the hospital sector.
- There is a marked difference between hospitals (ie non-FTs) and FTs in the proportions of expenditure classified under ‘clinical’ and ‘general’ supplies and services. This will be due to how specific inputs have been dealt with in organisational accounts, the conventions appearing to differ from those that apply to the financial returns.
- External purchasing of healthcare from non-NHS bodies is by far the most important category of expenditure by PCTs. This category includes care purchased from the voluntary sector and local authorities for older people and those with mental or physical disabilities, and acute care purchased from independent sector treatment centres. The amount of such expenditure has increased dramatically over time, as illustrated in Figure 3-1.
- There is some doubt as to whether all of these services are included in the output index, so in section 5.4 we undertake sensitivity analysis to assess what impact the exclusion of external purchasing has on estimated productivity growth.

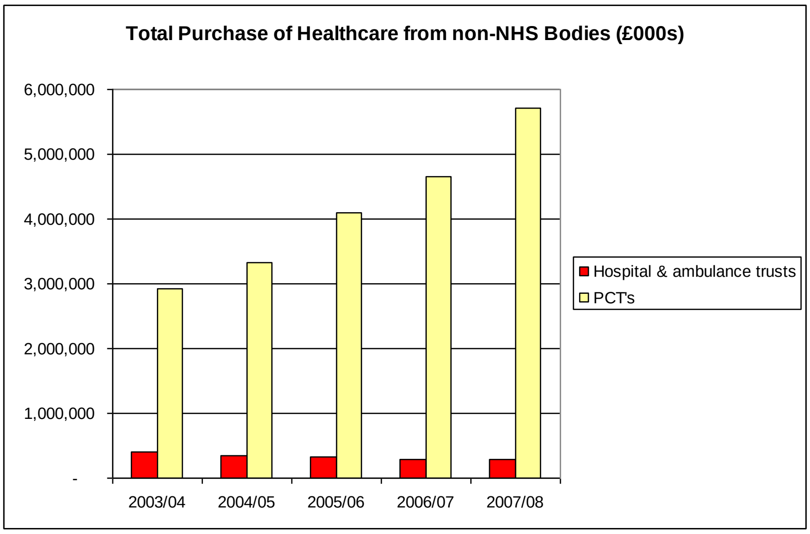


Figure 3-1 External purchasing of healthcare

The FHS drugs deflator is used to deflate expenditure on drugs and gases and the pay and prices deflator is used to deflate expenditure on all other inputs. These deflators are reported in Table 2-7. Expenditure in constant prices is reported in the final row of Table 3-1. From these figures we are able to calculate the growth in the volume of intermediate inputs over time. These growth rates are reported in Table 3-2 which show that the volume of intermediate inputs has increased year-on-year. The growth rate over time has been somewhat erratic particularly because of the slower rate of growth between 2005/6 and 2006/7.

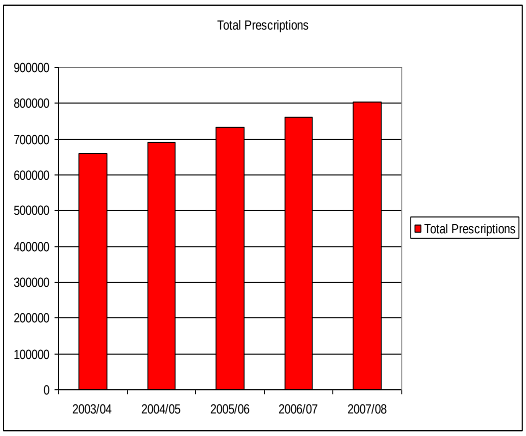
Table 3-2 Growth in the volume of intermediate inputs

	Trusts	PCTs	Total NHS
2003/4 - 2004/5	2.27%	6.39%	3.93%
2004/5 - 2005/6	12.83%	16.96%	14.55%
2005/6 - 2006/7	6.11%	11.21%	8.28%
2006/7 - 2007/8	8.36%	17.11%	12.27%

3.3 Prescribing

Prescribed medicines are an important input into the production of health care. While expenditure on drugs provided in hospitals and community settings is captured in the financial returns (under the drugs & gases heading), expenditure on prescriptions is not accounted for because payment for these items is made directly to pharmacies which do not file financial returns to the DoH. Hence we need to account for these inputs in their own right.

The volume and cost of prescribing is derived from Prescription Pricing Authority (PPA) data. The PPA data are collected in order to remunerate pharmacists and dispensing GPs. It is therefore a reliable and comprehensive measure of the volume of prescriptions dispensed. There has been growth over time in both the volume of prescriptions and in expenditure on them, as illustrated in Figure 3-2.



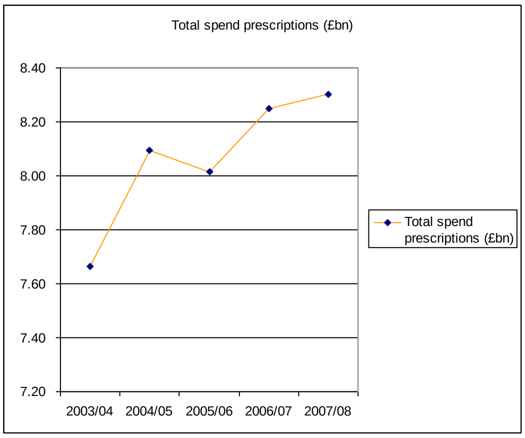


Figure 3-2 Volume of and current expenditure on prescriptions

In previous NHS productivity series medicines were described in terms of sub-chapters of the British National Formulary, resulting in some 200 categories of medicine. This is inexact for two reasons. Firstly the limited number of categories disguises considerable differences in the types of medicines within each category. Second, the volume of prescriptions in each category was weighted by prices (actually, net ingredient cost) to calculate prescribing growth. This is imperfect because drug prices are higher for branded than generic items. When drugs come off patent the NHS is able to secure better value for money by substituting from branded products to generic alternatives. In cases of substitution the branded and generic drugs are of equal value in terms of the health benefits they secure, despite their difference in price. But because the input index weights medicines by their price and not their value, any shift from branded to generic preparations would appear as a reduction in inputs (all else equal) even though there had been no real change.

To resolve this anomaly, the PPA, Information Centre and Office of National Statistics have developed a means of summarising prescribing data not by BNF sub-chapter but by chemical composition. This means that medicines of the same chemical composition are considered equivalent irrespective of whether they are branded or generic. The price attached to each category of medicine is based on the volume weighted average net ingredient cost of the items of the same chemical composition.

Rather than 200 sub-chapters, there are now more than 60,000 categories based on chemical composition. Not all of these highly differentiated categories are used – in some years there may be no prescriptions that correspond to the category in question. Indeed, over the period we consider, only a subset of categories are used, and there are significant year-on-year changes in categories, with prescribing data being recorded for an average of 8,000 categories per year.

The variability in which categories are used is a problem for traditional growth accounting methods. The problem is that, in a Laspeyres index[6], current and previous period volumes are weighted by previous period prices. If no medicines of a particular chemical composition were prescribed in the previous period, no previous price is observed. The traditional accounting method would simply drop this medicine from the overall index, despite there being a growth in volume from zero to some positive amount. This leads to biased estimates of input growth, the bias increasing in the proportion of input types where zero amounts are observed in one or other period (Castelli et al., 2008).

We avoid dropping input categories where zero amounts are observed by imputing prices for the period where prices are unavailable. To do so, we use observed prices in other periods. Our imputation assumptions depend on what price data are observed and what price data are missing:

- If current prices are unavailable but prices are observed in earlier and later periods we assume that prices changed in the intervening period at a constant rate.
- In the remaining cases missing current (previous) period prices are imputed from previous (current) period prices by inflating (deflating) using the FHS drugs deflator (see Table 2-7).

[6] Analogous problems arise when constructing a Paasche index.

The table below shows the impact of applying our method of imputation (CHE) rather than the traditional method (Trad). When considering a Laspeyres index the result is higher rates of input growth than if some types of medicine were not included in the index. Estimates are similar for the Paasche index.

Table 3-3 Growth in the volume of prescribing, direct measurement

	Laspeyres		Paasche		Fisher	
	Trad	CHE	Trad	CHE	Trad	CHE
2003/4 - 2004/5	9.83%	10.10%	9.65%	9.63%	9.74%	9.87%
2004/5 - 2005/6	9.56%	9.80%	9.53%	9.47%	9.54%	9.64%
2005/6 - 2006/7	6.46%	6.58%	5.75%	5.73%	6.11%	6.15%
2006/7 - 2007/8	7.19%	7.34%	4.03%	4.02%	5.60%	5.67%

For comparison, growth in prescribing based on BNF chapters is reported in Table 3-4. This shows that year-on-year growth rates are higher when using chemical composition, but trends over time are similar, as are the relative differences according to whether Laspeyres, Paasche or Fisher indices are calculated.

Table 3-4 Growth in the volume of prescribing based on BNF chapters

	Laspeyres	Paasche	Fisher
2003-04 – 2004/05	7.70%	6.96%	7.33%
2004-05 – 2005/06	8.02%	7.56%	7.79%
2005-06 – 2006/07	5.92%	5.58%	5.75%

At present, analysis of prescribing based on chemical composition is probably best regarded as experimental, particularly given the volatility in which categories are used from one year to the next. In view of this, and to retain consistency with the output series, we use estimates of prescribing growth based on BNF chapters in our baseline assessment of input and productivity growth. In section 5.4 we assess the sensitivity of the estimates of productivity growth to estimating growth in prescribing based on chemical composition.

3.4 Other intermediate inputs

Significant amounts of expenditure do not appear in the financial returns made by NHS organisations, particularly because they are made centrally. Such expenditures are on the following inputs:

- General medical, dental and ophthalmic services (GMS, GDS, GOS)
- New general medical services (nGMS)
- Other family health service expenditure, such as DoH initiatives
- DoH administration

Expenditure on these inputs, in constant prices, is reported in Table 3-5. The pay index (see Table 2-7) is used to deflate expenditure on medical, dental and ophthalmic services while the pay and prices deflator is used for other family health service expenditure and DoH administration. The pay index, which is based on the paybill within the hospital and community health service sector, may fail to remove all effects of pay inflation because pay has increased at a faster rate for GPs than those working in the hospital and community sectors.

Table 3-5 Other forms of expenditure on intermediate inputs (£000s)

	2003/4	2004/5	2005/6	2006/7	2007/8
GDS, PDS, GOS	2,136,279	2,140,325	2,377,203	2,283,907	2,347,936
nGMS	5,050,185	6,691,187	7,475,266	7,130,343	7,043,762
Other FHS	424,764	330,015	376,864	490,584	617,902
DoH Administration	295,000	269,119	244,860	206,865	196,864
Total	7,906,228	9,430,647	10,474,193	10,111,700	10,206,465

3.5 Results – intermediate input growth

Volume growth for each group of intermediate inputs is reported in Table 3-6 followed by figures showing growth for the NHS as a whole. This combined figure is derived by combining the growth rates in the preceding columns by the share of expenditure in these areas. The figures show that early strong growth in the use of intermediate inputs was followed by a slowing in the rate of growth between 2005/6-2006/7, followed by an increased rate subsequently.

Table 3-6 Volume growth in intermediate inputs

	Intermediate inputs Trusts & PCTs	**Prescribing**	**Other intermediate inputs**	**Total NHS**
2003/4 - 2004/5	3.93%	7.70%	19.28%	9.51%
2004/5 - 2005/6	14.55%	8.02%	11.07%	11.63%
2005/6 - 2006/7	8.28%	5.92%	-3.46%	3.84%
2006/7 - 2007/8	12.27%	6.27%*	0.94%	7.29%
* estimate				

4. Capital inputs

4.1 Introduction

For accounting purposes capital is defined as an asset with a useful life of more than one year. Of course a wide variety of inputs satisfy this definition, including buildings, machinery, medical equipment, computers and furniture. Irrespective of their type, accounting for the contribution made by capital inputs to the production process is complicated because, by definition, capital is deployed across multiple time periods, generating a stream of services that spans more than one accounting period (Wallis, 2005). This makes it difficult to apportion its use to any particular period. In this chapter we shall review the issues involved in calculating the contribution of capital to the production process at any specific point in time and the approaches adopted to address these issues before estimating the growth of capital inputs for the NHS.

4.2 Issues involved in accounting for capital inputs

Recall that for direct measurement of input growth we require information about z_{nt}, which captures the volume of input of type *n* at time *t,* and about ω_{nt} the price of input type *n* at time *t*. These elements are particularly difficult to measure for capital inputs because of their deployment over multiple time periods. Measurement of the value of the contribution that these assets make to the production process in any particular period must address two problems:

1. Asset lives differ, as might the productivity of an asset over the course of its lifetime. A building may have a useful life of 50-100 years but a computer may need replacing after just two or three years. The question is: how much does each asset contribute to the production process in each period?
2. The current price of each type of asset is not readily observed. An estimate of the current price is required to assess the relative value of different capital assets and their value relative to other inputs. But the timing at which payments for capital are made does not usually correspond to the time at which capital is deployed. This implies that some means is required to estimate a current price equivalent.

4.2.1 Determining the current contribution of capital

For direct measurement we need to know the amount of each capital asset used in production at a specific point of time, ie z_{nt}. Typically what we might observe, however, is the asset itself, such as a building or computer. Call this stock Z_n for asset *n*. In order to arrive at a value for z_{nt} we need to consider what proportion θ_n of the asset is employed in each period and over how many periods it is deployed T. This allows us to move from Z_n to z_{nt} because we have:

$$Z_n = \sum_{t=1}^{T} \theta_{nt} Z_{nt} = \sum_{t=1}^{T} z_{nt} \qquad (4.1)$$

Where Z_n is the stock of asset *n*, *t*=1…*T* are the time periods over which the asset is deployed and θ_{nt} is the proportion of the asset employed at time *t*. Hence, in order to apportion use of the asset to a particular point in time we need to consider two questions.

Firstly, what is the lifespan of the asset? In other words, over how many years will the asset be deployed? This will differ according to the asset under consideration. The last UK review of capital assets for national accounting purposes was conducted in 1993, with asset lives estimated to range from 50-100 years for buildings to 5 years for computers and software (Office for National Statistics, 2008). Technological innovations since then have probably reduced the asset life of computers. Note that it makes no difference for accounting purposes if the asset disintegrates at the end of its lifetime or simply becomes obsolete and can be ‘written off’ (Oulton, 2001).

Secondly, what is relationship between the age of the asset and its productive contribution? This is referred to as the age-efficiency profile of the asset (Oulton, 2001). There are two related but subtly distinct concepts to consider when assessing this age-efficiency profile:

- Depreciation, which measures how the price of an asset declines as it ages and
- Decay, which measures how the contribution to productive output from the asset declines over time.

While measures of depreciation are appropriate in most circumstances, it is the second concept that we are interested in for the purposes of measuring input growth.

The difference between these concepts can be brought out when considering the purchase of a new vehicle by a business. The business would apply straight-line depreciation in its accounts, depreciating a fixed proportion of the value of the vehicle each year. This would accord with the straightforward arithmetic assumptions that $\theta_{n1} = \theta_{n2} = ... = \theta_{nT}$ with $\sum_{t=1}^{T} \theta_n = 1$ and $\theta_{nt} = 1/T$. Straight-line accounting remains current practice for some elements of the UK national accounts, such as the health component (Office for National Statistics, 2008).

Although straightforward to apply, the problem with straight-line accounting is that it rarely accords with reality. Rather than falling as a fixed proportion of the initial value, most of the value of the vehicle is lost as soon as it is driven off the garage forecourt. A hyperbolic function would provide a better fit to the actual pattern of depreciation in the vehicle's value.

Irrespective of changes in the value of the vehicle, though, its performance probably deteriorates progressively over time at a fairly steady rate, implying that the reduction in the 'flow of services' from the vehicle differs from the reduction in its value. This progressive rate of deterioration – or 'decay' – can be captured as a geometric function. This makes the assumption that the productive contributions that flow from capital assets decrease at a constant *rate* over time.

The geometric function has two main attractions. Firstly, it accords more closely than other age-efficiency profiles to empirical evidence suggesting that most assets are more productive when first acquired, with their contribution declining at a constant rate as they begin to wear out (Oliner, 1996). Secondly, if a geometric pattern of decay can be assumed, then depreciation is also geometric (Oulton, 2001, Oulton and Srinivasan, 2003). The slight drawback of the geometric approach is that an infinite time horizon is required for it to be completely accounted for (Oulton and Srinivasan, 2003), implying that, at some point, it is simply written off.

The straight-line and geometric age-efficiency patterns can have quite different implications for what amount of the asset is considered available at any particular time. Table 4-1 provides an example. If, as under a straight-line approach, the contribution of the asset is assumed to amount to a constant *proportion* of 25% each year, it will be used up after four years. If the contribution follows a geometric pattern and falls at a *rate* of 25% per year, almost a third of the original asset is considered to remain available after the fourth year.

Table 4-1 Comparison of straight-line and geometric decay functions

	Straight-line		**Geometric**	
Year	Proportion of the asset used	% of original asset remaining	Rate at which the asset is used	% of original asset remaining
1	0.25	75	0.25	75
2	0.25	50	0.25	56
3	0.25	25	0.25	42
4	0.25	0	0.25	32

4.2.2 Determining the current price of capital

The second major technical challenge is to establish a current period price of capital that reflects its marginal product, ie an estimate of ω_{nt}. For capital assets that are rented this is straightforward – the rental price reflects the marginal revenue product of the asset (provided rental markets are competitive). However many capital assets are not rented but owned by organisations that may have purchased them many years previously. This gives rise to a problem, in that the price of an asset may not provide a true indication of the user cost of capital. This has been particularly problematic in the public sector where, in the past, organisations often treated capital as a 'free good' because it was wholly or highly subsidised. This provided weak incentives for the efficient use of capital.[7] Attempts have been made to make organisations more aware of the opportunity cost of capital, but it probably remains the case that asset prices observed in practice are lower than those that would pertain if assets were rented and not bought. These price differences mean that the 'capital consumption' method of accounting which uses asset prices might yield different estimates to the 'capital services' method, which is based on (nominal) rental prices (Oulton and Srinivasan, 2003).

What, then, is the current opportunity cost of these purchased assets? The (current period) rental price of an asset comprises two elements:

1. Allowance for depreciation, which describes how the value of the asset falls over the course of its useful life.
2. Allowance for risks, such as asset destruction, breakdown, or unanticipated obsolescence. The return on capital must be sufficient to compensate for these risks because, if not, investors would choose to invest in alternative projects.

This raises the question of what constitutes an appropriate rate of return for capital deployed in the public sector. Rather than a market interest rate, it has been argued that the rate of return in the public sector should reflect the social rate of time preference (Pearce and Ulph, 1995, Oulton, 2005). The social (or, sometimes, 'test') discount rate is currently 3.5% and is held to reflect the opportunity cost of public sector investment and to be close to the rate of time preference (HM Treasury, 2003).

4.2.3 Indirect measurement of capital growth

In practice we tend to observe neither the stock of each capital asset (Z_n) nor (nominal) rental prices (ω_{nt}), thereby ruling out direct measurement of volume growth. Instead, (historical) expenditure on capital is usually observed, from which an indirect measure of the contribution of capital can be calculated. This requires application of a capital price deflator so that price effects can be removed from the expenditure data, as is standard procedure. Recalling our earlier definition of the indirect index of volume growth in equation 1.4, we have:

$$\Delta Z^{Ind} = \frac{\pi_n E_{nt}}{E_{nt-1}} \tag{4.2}$$

But in the case of capital assets there are two complications to indirect measurement of volume growth. Firstly, the contribution of capital in any given period will be a function partly of current expenditure on the asset (E_{nt}) and will also draw on previous investments $E_{nt-1}, E_{nt-2}, \ldots$ The question is: what proportion of past expenditure is devoted to current production? Secondly, some proportion of current expenditure represents investment in the future and, again, this proportion must be accounted for in the current period.

These proportions, of course, are the same as those that reflect the rate of decay of the asset, namely θ_n. Hence, if we consider an asset deployed across just two periods, our indirect volume index would take the following form:

[7] Rather than over-utilisation of capital as would have been expected from organisations facing a zero price, capital may have been under-utilised because central controls were highly effective at restricting access to capital markets.

$$\Delta Z^{Ind} = \frac{\pi_n \;\; \theta_{nt}E_{nt} + \theta_{nt+1}E_{nt-1}}{\theta_{nt}E_{nt-1} + \theta_{nt+1}E_{nt-2}} \qquad (4.3)$$

Where $\theta_{nt}E_{nt}$ captures the proportionate contribution of current expenditure and $\theta_{nt+1}E_{nt-1}$ captures the proportionate contribution of expenditure in the previous period to current production. In the denominator, $\theta_{nt}E_{nt-1}$ captures the proportionate contribution of the previous period's expenditure on production in that period and $\theta_{nt+1}E_{nt-2}$ captures the proportionate contribution of expenditure two period's earlier to production in the previous period. Note that the decay rate θ_n that applies to each period's expenditure relates to how old the asset is (its vintage) at the time that (some proportion of) it is used. The expressions in equation 4.3 need to be extended back over all the periods from which past investments are drawn in the current use of the asset.

Finally, to derive estimates of volume growth from these expenditure series we need to remove the price effects (Office for National Statistics, 2008). To do this, we require a price deflator π_n, preferably specific to each capital asset. As with ω_n, in order to derive an accurate estimate of the *flow* of services deriving from the asset (not merely the *consumption* of these assets), the deflator should reflect changes in the rental price of assets not in asset prices.

Using appropriate deflators is therefore crucial to the calculation. It is probably inappropriate to apply a single deflator to capital assets, because price changes are likely to vary considerably across different asset types, driven primarily by differences in product life-cycles (Chesson & Chamberlain (2006)). Most obviously the rapid speed of technological advancement in information technology (IT) means that a specific IT deflator that accounts for both price and quality changes should be used for these assets (Wallis (2007).

4.3 Measurement of capital expenditure

Having considered the theory, we need to know to what extent best practice in estimating the contribution of capital is restricted by the nature of the available data. As for intermediate inputs, we use the financial returns made by hospital, ambulance and primary care trusts to measure expenditure on capital, drawing on the accounts consolidated by Monitor in order to derive estimates of capital spend by foundation trusts. Broadly speaking, information about capital expenditure is subdivided into:

- Current expenditure on various types of equipment and
- Past expenditure shown as depreciation on assets.

It ought to be possible to estimate equation 4.3 using only the data about current expenditure. But there are two major deficiencies with this information. Firstly, it is not comprehensive. In particular, assets for which outlays are infrequent, such as buildings, are under-represented. Secondly, to account correctly for current usage of existing assets it would be necessary to have an historical series of current expenditures dating sufficiently far back to capture outlays on assets with long asset lives. Such a series cannot be constructed readily.

Instead, then, we are forced to supplement information on current expenditure with the estimates of depreciation that organisations report. These estimates of depreciation have the advantage that they are based on the particular composition and vintage of capital in each organisation. But these estimates have to be taken as given, the disadvantage being that we have to accept the accounting rules that each organisation applies, with straight-line depreciation probably being the norm.

Making the best of this information we adopt the following approach to assessing the contribution of capital:

1. We assess what proportion of current expenditure on assets is employed in the current period. This involves making assumptions about the asset lives of particular types of asset.

2. We assume that the figure for depreciation is an accurate estimate of the usage of existing capital assets in the current period.
3. We apply asset-specific capital deflators in order to convert current expenditure into constant expenditure.

The assumptions we have made about asset lives and the most appropriate deflator to apply are reported in Table 4-2.

Table 4-2 Assumptions about asset lives and deflators

	Asset life	Deflator
Medical, surgical, x-ray and laboratory equipment	10	Medical equipment deflator 9414033000
Appliances	3	Medical equipment deflator 9414033000
Furniture, office and computing equipment and hardware	4	Computers & other data processing equipment deflator 3002000000
Building and engineering equipment	10	Electrical machinery 9414031000

Our assumptions about asset lives are drawn from what organisations report in their annual accounts. Each organisation quotes a single figure for depreciation which reflects the particular bundle of assets it possesses but their accounts usually provide information about the assumptions they have made in arriving at this figure. As might be imagined, there is diversity among organisations in the lives of their assets. Table 4-3 reports the range in asset lives for various capital items as detailed in the annual accounts for a small selection of NHS hospitals. Our assumed asset lives are at the mid-point of the relevant range reported.

Table 4-3 Asset lives as reported in selected trust accounts

Asset type	Asset lives
Buildings	25-40
Structural	*40*
Engineering	*25*
Plant & machinery	5-15
Short term	*5-7*
Medium term	*10*
Long term	*15*
Furniture & fittings	5-10
Medical & surgical equipment	5-15
Transport & vehicles	7
Information technology	
Mainframe	*5-8*
Computers	*2-7*
Software	*2-5*
Intangibles	2-5

We apply different price indices to deflate expenditure according to the type of asset. These indices are constructed by the ONS and we use those reported under the Plant & Machinery section of MM17 Price Index Numbers Current Cost Accounting (Office for National Statistics, 2009). The deflators, re-referenced to 2003/4, are reported in Table 4-4. Of particular note is the deflator for computing equipment that reflects both price reductions and quality improvements. Applying this deflator implies that, for a given amount of expenditure, it is possible to purchase much more computing equipment in 2007/8 than was possible in 2003/4.

Table 4-4 ONS capital deflators

	2003/4	2004/5	2005/6	2006/7	2007/8
Medical equipment	1.00	0.99	1.01	1.02	1.03
Computing equipment	1.00	0.86	0.80	0.75	0.70
Electrical machinery	1.00	0.99	1.01	1.00	1.01

Details of current expenditure on capital by NHS trusts are summarised in Table 4-5 with expenditure increasing year on year for most of the period.

Table 4-5 Current expenditure on capital items by NHS trusts (£000s)

Hospital and ambulance trusts	2003/4	2004/5	2005/6	2006/7	2007/8
Equipment					
Medical & Surgical Equipment - Purchase	1,546,803	1,111,881	1,362,224	1,339,694	1,355,021
Medical & Surgical Equipment - Maintenance	104,759	96,787	106,021	112,531	114,218
X-Ray Equipment - Purchase	32,469	26,298	27,600	29,187	33,498
X-Ray Equipment - Maintenance	62,412	57,223	55,030	56,133	51,721
Appliances	292,608	263,890	285,000	281,882	292,970
Laboratory Equipment - Purchase	298,137	270,876	288,360	282,818	268,995
Laboratory Equipment - Maintenance	27,229	25,023	27,197	29,163	27,917
Furniture, Office & Computer Equipment	186,277	152,182	141,995	134,995	165,375
Computer Hardware-Maintenance & Data Proces	176,759	153,909	153,539	144,839	135,976
Premises					
Building and Engineering Equipment	103,365	88,141	85,151	86,569	95,776
Building & Engineering Contracts	221,215	186,380	197,368	210,435	243,097
Business Rates	175,753	157,516	163,147	183,930	157,402
Total Depreciation & impairment	1,366,168	1,325,015	1,309,402	1,466,516	1,945,926
Total - hospital and ambulance trusts	**4,593,955**	**3,915,121**	**4,202,034**	**4,358,692**	**4,887,892**
Foundation trusts		2004/5	2005/6	2006/7	2007/8
Equipment					
Supplies and services - capital items		222,471	348,042	525,340	819,274
Other operating lease rentals		12,900	41,500	87,670	121,731
Hire of plant and machinery		7,400	9,500	24,845	37,298
Premises					
Premises - capital items		91,973	170,520	264,196	420,980
Total Depreciation & Impairment		171,600	275,500	432,071	689,397
Total - foundation trusts		**506,344**	**845,062**	**1,334,122**	**2,088,680**
Total - all trusts	**4,593,955**	**4,421,465**	**5,047,096**	**5,692,814**	**6,976,572**

Comparable figures are reported in Table 4-6 for PCTs, followed by capital spending as reported by SHAs. The final row shows the total capital expenditure by Trusts, PCTs and SHAs.

Table 4-6 Current expenditure on capital items by PCTs (£000s)

PCTs	2003/4	2004/5	2005/6	2006/7	2007/8
Equipment					
Medical & Surgical Equipment - Purchase	122,033	114,262	141,134	149,264	184,400
Medical & Surgical Equipment - Maintenance	9,320	9,179	10,449	13,611	15,587
X-Ray Equipment - Purchase	230	605	483	310	2,061
X-Ray Equipment - Maintenance	705	875	971	1,931	1,476
Appliances	75,127	76,628	92,845	93,524	119,113
Laboratory Equipment - Purchase	1,658	1,817	2,566	3,878	5,345
Laboratory Equipment - Maintenance	198	45	352	240	774
Furniture, Office & Computer Equipment	80,747	70,654	80,094	71,944	125,367
Computer Hardware-Maintenance & Data Processir	39,778	36,223	43,287	46,088	68,799
Premises					
Building and Engineering Equipment	21,944	29,255	24,040	26,888	48,240
Building & Engineering Contracts	42,025	39,315	46,128	37,675	77,803
Business Rates	40,897	41,416	49,829	62,083	65,901
Total Depreciation & Impairment	231,834	255,030	286,343	352,475	459,975
Total - PCTs	**666,498**	**675,303**	**778,521**	**859,911**	**1,174,841**
Total - SHAs	**19,619**	**18,746**	**14,048**	**15,600**	**15,196**
Total - NHS	**5,280,072**	**5,115,514**	**5,839,664**	**6,568,325**	**8,166,609**

4.4 Capital input growth

Estimates of the contribution of capital to current production expressed in real terms are reported in Table 4-7.

Table 4-7 Current contributions of capital expenditure in constant prices (base 2003/4), £000

Constant prices	2003/4	2004/5	2005/6	2006/7	2007/8
NHS trusts	2,476,477	2,543,923	2,728,042	3,181,156	3,978,021
PCTs	424,574	450,590	518,423	602,225	818,427
SHAs	15,146	15,378	13,028	13,933	11,856
Total	**2,916,197**	**3,009,891**	**3,259,493**	**3,797,314**	**4,808,304**

These figures yield estimates of the growth rate in the volume of capital services as reported in Table 4-8. This implies that the rate at which capital assets are employed has been rising at an increasing rate over time. As with intermediate inputs, the figures for SHAs are erratic, this being a reflection of small numbers.

Table 4-8 Growth in capital input

	Trusts	PCTs	SHAs	Total NHS
2003/4 - 2004/5	2.72%	6.13%	1.53%	3.21%
2004/5 - 2005/6	7.24%	15.05%	-15.28%	8.29%
2005/6 - 2006/7	16.61%	16.16%	6.95%	16.50%
2006/7 - 2007/8	25.05%	35.90%	-14.90%	26.62%

While these figures are based on the best available data as reported by all NHS organisations, it is worth re-iterating the concerns raised in section 4.3 about the quality of these data. Most notably expenditure on infrequently purchased capital assets (such as buildings) is likely to be under-represented. Moreover expenditures may not be spread accurately over the asset's entire life but rather 'front-loaded' to the present. Such practice may partially explain the high rates of recent growth apparent in Table 4.8. The extent to which such accounting behaviour occurs, however, cannot be readily ascertained.

5. Overall input and productivity growth

5.1 Introduction

In this section we construct measures of total factor productivity growth for trusts, PCTs and the NHS in England as a whole. With the exception of prescribing, these growth rates are amalgamated from the indirect measures for each factor type. We then report output growth and combine these figures with those for input growth in order to derive estimates of total factor productivity.

5.2 Input growth

Table 5-1 brings together the material in the preceding sections, reporting expenditure in real terms (ie after removing price effects) by type of NHS organisation and separately for labour, intermediate and capital inputs. Prescribing is omitted from this table because we use the direct method to account for volume growth of this input.

Table 5-1 Expenditure in real terms by organisation and input type (£000s)

	2003/4	**2004/5**	**2005/6**	**2006/7**	**2007/8**
NHS Trusts					
NHS staff	23,679,261	24,560,549	25,264,496	25,299,217	25,620,107
Agency staff	1,198,888	1,027,448	868,877	634,979	776,950
Intermediate inputs	6,661,416	6,812,689	7,686,566	8,156,332	8,838,196
Capital inputs	2,476,477	2,543,923	2,728,042	3,181,156	3,978,021
Total	34,016,043	34,944,608	36,547,981	37,271,684	39,213,274
PCTs					
NHS staff	4,855,005	5,246,192	5,601,317	5,563,248	5,485,978
Agency staff	254,589	268,043	250,397	213,539	241,568
Intermediate inputs	4,623,434	4,918,868	5,753,270	6,398,113	7,492,847
Capital inputs	424,574	450,590	518,423	602,225	818,427
Total	10,157,603	10,883,693	12,123,407	12,777,126	14,038,820
Total NHS					
NHS staff	28,689,350	29,984,931	31,068,449	31,048,110	31,230,755
Agency staff	1,624,347	1,490,222	1,336,937	1,046,111	1,157,710
Intermediate inputs	11,343,796	11,789,697	13,505,305	14,622,899	16,416,480
Capital inputs	2,916,197	3,009,891	3,259,493	3,797,314	4,808,304
GDS, PDS, GOS	2,136,279	2,140,325	2,377,203	2,283,907	2,347,936
nGMS	5,050,185	6,691,187	7,475,266	7,130,343	7,043,762
Other FHS	424,764	330,015	376,864	490,584	617,902
DoH Administration	295,000	269,119	244,860	206,865	196,864
Total (exclu prescribing)	**52,479,918**	**55,705,387**	**59,644,378**	**60,626,135**	**63,819,714**

Table 5-2 provides details of the mix of labour, capital and intermediate inputs, by organisational type. The secondary care sector (comprising hospitals, FTs and ambulance trusts) is mostly labour-intensive, this factor comprising 71% of total factor input. The proportion accounted for by labour has fallen over time, though, with the use of both intermediate and capital inputs increasing at a faster rate than labour inputs.

Intermediate inputs account for some 48% of total inputs for PCTs. But note that this category is quite diverse and the largest component for PCTs is 'purchase from non-NHS bodies'. If this expenditure is excluded, the average proportionate spend on labour, intermediate inputs and capital by PCTs amount to 70%, 23% and 7% respectively.

Table 5-2 Proportionate split between labour, intermediate and capital inputs

Trusts	2003/4	2004/5	2005/6	2006/7	2007/8	Average
Labour	73%	73%	72%	70%	67%	71%
Intermediate	20%	19%	21%	22%	23%	21%
Capital	7%	7%	7%	9%	10%	8%
PCTs						
Labour	50%	51%	48%	45%	41%	47%
Intermediate	46%	45%	47%	50%	53%	48%
Capital	4%	4%	4%	5%	6%	5%
NHS						
Labour	58%	57%	54%	53%	51%	54%
Intermediate	37%	38%	40%	41%	42%	39%
Capital	6%	5%	5%	6%	8%	6%

When taking the NHS as a whole, the intermediate category also includes spending on general medical, dental and ophthalmic services and the elements of central funding, as reported in section 3.4.

Our approach to measuring the contribution of capital implies that this factor comprises around 6% of total input use in the NHS. This is more than the 2% estimated by the ONS, based on a data series that is not specific to the NHS and which the ONS recognises as being imperfect (Lee, 2006).

Growth in the volume of total inputs, as estimated using the indirect method, is reported in Table 5-3. Columns 1 and 2 report growth rates respectively for Trusts and PCTs while column 3 also includes expenditure on all other intermediate inputs as reported in section 3.4. Column 4 includes prescribing growth, incorporating the direct estimates based on BNF chapter according to the share of total expenditure accounted for by prescribing. Finally, column 5 reports input growth in secondary and primary care. This includes expenditure in trusts, on general medical services and other family health services, and prescribing. Taken together this accounts for around 75% of total NHS expenditure.

Table 5-3 Growth in total inputs

	Trusts	PCTs	NHS exc px	Total NHS	Secondary and primary care
	1	2	3	4	5
2003/4 - 2004/5	2.73%	7.15%	6.15%	6.34%	6.50%
2004/5 - 2005/6	4.59%	11.39%	7.07%	7.19%	6.16%
2005/6 - 2006/7	1.98%	5.39%	1.65%	2.15%	1.89%
2006/7 - 2007/8	5.21%	9.87%	5.27%	5.39%	4.72%
Average	3.63%	5.26%	4.32%	4.67%	4.82%

5.3 Output growth

Estimates of output growth for the period 2003/4 to 2006/7 are taken from our earlier report (Castelli et al., 2008) and reproduced in Table 5-4 below. Key findings are the following:

- Growth in hospital (inpatient and day case) activity has averaged 6% per year. Improvements in survival rates and waiting times account for 2.4% of this annual growth.
- Growth in outpatient activity averages 4.5% per annum. There is a fall in output between 2005/6 and 2006/7: even though more patients were seen, they were of lower ‘complexity’ than previously.
- Growth in mental health care has averaged 8.7%.
- Growth in primary care consultations has averaged 3.2% over the full period, of which 0.5% is accounted for by the improvements in the management of blood pressure.

- The very high growth rate for community services between 2003/4 – 2004/5 is driven by much improved data collection intended to ensure that these activities were recorded comprehensively. Hence the figure of 315% is more a reflection of data collection than it is of true output growth.
- Data collection has also improved over time with respect to activities categorised under “all other NHS activity”. Hence, the growth rates will reflect both changes in data collection and actual increases in output.
- The growth rates for the Total NHS are aggregated from the figures across all settings, and suggest annual output growth of 14% per year. As mentioned above, though, this figure is contaminated by improvements in data collection.
- The final row presents growth rates for the secondary and primary care sectors only. This captures activity in hospitals, outpatient departments, in mental health and in primary care. Data collection has been consistent and comprehensive over the full period. This means that they measure output growth accurately. These imply that output growth has averaged 5.5% per annum.

Table 5-4 Quality-adjusted output growth, Laspeyres index

Setting	2003/4 - 2004/05	2004/5 - 2005/6	2005/6 - 2006/7	Average
Hospital activity	5.66%	7.48%	4.88%	6.01%
Outpatient activity	10.23%	9.96%	-6.81%	4.46%
Mental Health care services	11.83%	9.42%	4.82%	8.69%
Primary care consultations	0.34%	6.06%	3.21%	3.21%
Prescribing	7.70%	8.02%	5.92%	7.21%
Community care services	315.53%	10.25%	-0.65%	108.38%
All other NHS activity	17.13%	3.14%	22.07%	14.11%
Total NHS	**28.82%**	**7.11%**	**6.08%**	**14.00%**
Secondary & primary care	**6.44%**	**7.90%**	**2.30%**	**5.55%**

5.4 Productivity growth and sensitivity analysis

Taking 2003/4 as the base year, we construct different indices of output growth and of input growth. These indices are reported in Table 5-5. The indices vary according to the following:

- Whether we consider just the secondary and primary sectors or take the NHS as a whole. Given that estimates of output growth in community care are contaminated by improvements in data collection during 2003/4-2004/5, there is a preference toward the figures for secondary and primary sector.
- Whether prescribing growth in the input series is based on BNF chapter or chemical composition. Given the observed year-on-year volatility in how prescriptions are categorised under the latter method, our preference is toward remaining with the approach based on BNF chapter at present.
- Whether expenditure by PCTs on care from non-NHS bodies is included in the input series, as there is some debate about whether the output arising from this expenditure is captured accurately in the output series. Our preference is to include this expenditure, as this has been historical practice and PCTs are under an obligation to report what the money has been spent on. Whether captured fully or partially, these outputs are recorded under the “community care services” and “all other NHS activity” headings, so our estimates for the secondary and primary care sector are not sensitive to the choice of how care purchased from non-NHS bodies is handled.

Table 5-5 Output and input growth indices, 2003/4=1.00

	2004/05	2005/6	2006/7
Output growth			
Secondary and primary care	1.06	1.49	1.78
Total NHS	1.29	1.38	1.46
Input growth			
Secondary and primary care			
- prescribing based on BNF chapter	1.07	1.13	1.15
- prescribing based on chemical composition	1.07	1.14	1.16
Total NHS			
- prescribing based on BNF chapter	1.06	1.14	1.16
- prescribing based on chemical composition	1.07	1.15	1.17
Total NHS excluding purchasing for Non-NHS bodies	1.06	1.13	1.15

Total factor productivity growth is calculated by dividing the index of output growth by the index of input growth:

$$\Delta TFP = \left[\frac{\Delta I}{\Delta Z} - 1 \right]$$

Where ΔTFP is total factor productivity growth, ΔI is the index of output growth and ΔZ is the index of input growth. Results, converted into percent change, are reported in Table 5.6.

Table 5-6 NHS Productivity growth 2003/4 – 2006/7

	Secondary and primary care		Total NHS		
	1	2	3	4	5
2003/4 – 2004/5	-0.06%	-0.42%	21.14%	20.79%	21.54%
2004/5 – 2005/6	1.64%	1.36%	-0.08%	-0.29%	0.61%
2005/6 – 2006/7	0.40%	0.30%	3.85%	3.77%	4.37%

Our preferred set of estimates of productivity growth appears in column 1. These figures are derived by comparing the output index in the first row of Table 5-5 with the input series for secondary and primary care where prescribing is based on BNF chapter. The resultant estimates of productivity growth imply that from 2003/4 to 2004/5 inputs and outputs grew at virtually the same rate. Subsequently outputs have grown faster than inputs, resulting in positive productivity growth.

Column 2 uses estimates of prescribing growth based on chemical composition in the input series, as reported in Table 3-3, rather than the estimates based on BNF chapter. This has a small effect on productivity growth in secondary and primary care, deflating the estimates by around 0.25% per year.

Column 3 reports figures for the NHS as a whole, derived by comparing output growth reported in the second row of Table 5-5 with input growth with prescribing based on BNF chapter. This shows the following:

- Productivity growth appears very strong between 2003/4 and 2004/5. However, this is driven largely by improved collection of data on activity, particularly in the community care sector.
- After 2004/5 estimates of output growth are much less contaminated by changes in data collection. Both inputs and outputs grew at a similar rate between 2004/5 and 2005/6.
- Input growth was slower than output growth between 2005/6 and 2006/7, delivering positive productivity growth.

Column 4 again considers the total NHS but bases prescribing growth on chemical composition rather than chemical composition. The estimates of productivity growth are not particularly sensitive to this choice, changing by 0.2% on average.

Finally column 5 reports the sensitivity of the estimates for the whole NHS to the exclusion of expenditure used in the purchase of healthcare services from non-NHS bodies from the input series. Given that this expenditure has been rising in real terms over time it is unsurprising that its exclusion results in higher estimates of productivity growth. The exclusion of this expenditure adds an average of about 0.5% a year to the estimates of productivity growth.

6. Conclusions

6.1 Overview

Productivity growth is measured by comparing the rate of output growth with the rate of input growth. In an earlier report we calculated output growth in the English NHS for the period 2003/4 to 2006/7 (Castelli et al., 2008). This report has concentrated on input growth, detailing methods and calculating growth from 2003/4 to 2007/8. The two series are then combined to derive productivity growth for the NHS.

6.2 Summary of methods

The output of the health service is produced using factors of production which can be categorised into three main types: labour, intermediate inputs and capital. To calculate total factor productivity growth we need to measure growth in the ***volume*** of inputs over time not growth in the ***value*** of inputs. Volume growth can be calculated using direct or indirect measurement which, in theory, are equivalent. In practice, data availability will drive the choice between approaches.

Direct measurement relies on direct observation of the physical inputs into the production process. Inputs of different types are combined into a single index according to their relative prices.

Indirect measurement is based on what is spent on inputs. This makes it necessary to assess what proportion of expenditure growth is due to volume growth and what proportion is due to changes in prices. Hence a key requirement in applying indirect measurement is to find a price deflator for each input type so that price effects can be removed from expenditure growth. This allows 'nominal' monetary values to be converted into 'real' expenditure that reflects volume growth alone.

Data allow both direct and indirect measurement of growth in the volume of labour. In applying direct measurement quality adjustment of labour inputs has been suggested by other commentators in recognition that some people are more productive than others. However we argue that differential productivity is best captured by finer differentiation of staffing grades. Our direct measure of the volume of labour growth employs more categories of labour than have been used hitherto.

Direct measurement of labour input growth suffers a serious shortcoming though. The nature of the data mean that the measure fails to capture the volume of labour input comprehensively. In particular overtime working by NHS staff and the contributions made by non-NHS staff (eg locums and agency staff) are not accounted for. Until reliable and accurate measures of these two components are available, indirect measurement is to be preferred to assess the growth in labour inputs.

For most intermediate and all capital inputs data about physical inputs are unavailable, so we are forced to rely on information about how much is spent on these inputs. The exceptional class of intermediate inputs are prescribed medicines where accurate and comprehensive information on the volume and type of prescriptions is available. We use direct measurement to measure growth in prescribing and indirect measurement to measure growth in all other intermediate and capital inputs.

There are particular challenges in assessing the current contribution of capital to the production process, the problem being that capital assets are deployed across multiple time periods. We discuss the methodological issues that this gives rise to and describe how these can be addressed with the data that are available.

6.3 Summary of results

We use a variety of data sources to estimate input growth and present results separately for each major input category and according to organisational type – trusts, PCTs and the NHS as a whole.

The main observations from our analysis of input growth are the following:

- After a period of increased recruitment there has been a recent levelling off in the number of NHS staff.
- The last five years have seen reduced reliance on agency staff.

- There have been year-on-year increases in the volume of intermediate inputs employed by NHS organisations and in prescribing.
- The use of capital has increased over time.
- For the NHS as a whole, input growth averaged 4.7% per year between 2003/4 and 2007/8.

We estimate productivity growth for the period 2003/4 to 2006/7. Improvements in the recording of community care activity between 2003/4 and 2004/5 give a misleading impression of output growth for the NHS. To avoid this, our preferred (and more conservative) estimates are based on the secondary and primary care sectors, which account for 75% of NHS expenditure. The main findings are that:

- Between 2003/4 and 2004/5 input growth was matched by output growth.
- Since 2004/5 there have been productivity gains with output growth exceeding input growth.
- These conclusions are robust to various assumptions about how the input and output series are constructed.

The primary factors driving these recent productivity gains are:

- Increases in the number of patients being treated,
- Improvements in the quality of care patients receive and
- A slowdown in staff recruitment and the use of agency staff.

6.4 Future work

Once data are available we shall calculate the amount of NHS output produced during 2007/8, allowing us to extend the productivity series. In subsequent reports we shall attempt to refine the way we measure the changing quality of NHS output. We shall also explore the possibility of producing sub-national (SHA) estimates of input, output and productivity growth. Sub-national estimates of productivity growth will not only be interesting in their own right but will also aid our understanding of the drivers of productivity.

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