Chapter 5

Study sites, surgical procedures, and labour input to surgical production

5.1 Introduction

This chapter represents the first of two chapters dealing with the outcomes of the present research. It is dedicated to describing the technologies used in the intra-operative and perioperative phases of producing the six selected procedures and to analysing both the volume of human labour input to producing them and the changes that have occurred, between 1988 and 1998, as a result of new intra-operative artefact adoption. To a large extent, these results become part of the evidence contributing to the dominant (*naturalistic*) paradigm conclusion drawn in Chapter 6. However, some also constitute data in the analysis of the total labour input to surgical production undertaken in conjunction with the current Australian estimates of the human labour costs of producing the six procedures (as reflected in the National Operating Room Service Weights). The conclusions drawn represent the secondary (ie. *positivist*) paradigm outcome of the present thesis.

The chapter commences with a brief overview of the characteristics of the five study hospitals and their activity relative to each other and all NSW hospitals, and a discussion that demonstrates the representativeness of the six procedures selected for detailed study.

The six procedures are then described in order to highlight the diversity and complexity of the intra-operative artefacts and the associated techniques involved in their production. Along with being part of the response to the first research question concerning the technical and functional goals of new intra-operative artefact adoption and, hence, an important outcome of the research process in their own right, these descriptions provide the contextual background to the subsequent analyses. The perioperative technologies are then described in the course of presenting and discussing the quantitative data derived from the analysis of the *perioperative* (ie. *indirect*) human labour input to surgical production. These perioperative data pertain to all of the human labour contributing to all of the activities that are undertaken either before or after a procedure. They were collected using work time study techniques.

The focus then shifts back to *the intra-operative* phase for which data were collected from operating theatre records to derive the frequencies of the selected procedures at each hospital and their respective mean *intra-operative* times. The latter data were used as the basis for estimating the *direct* human labour input to each of the six procedures. The subsequent analysis of both the perioperative and intra-operative data results in the conclusion that, overall, since mid-1988, the net effect of new intra-operative artefact adoption has been an increase in the human labour input required to "produce" procedures within OTSs. This is

evidenced by the findings that: (1) the average operating time of all procedures has increased by more than 15 per cent; and (2) processing new intra-operative artefacts requires substantially more perioperative human labour input than those earlier technologies employed as therapies or diagnostics for the same medical conditions.

Finally, the grand mean perioperative and grand mean intra-operative human labour input data for each of the six procedures are analysed in conjunction with their respective weighted mean human labour costs estimated from the NORSWs data. Subsequently, the cost per minute of total human labour input to each procedure is estimated, and it is argued that the results do not correlate with the human resource costs represented in the NORSWs for each of these procedures. During the course of this discussion, I introduce an innovative measure, the *PI Ratio*, which serves as a way of demonstrating a fundamental flaw in the logic that was used to derive the NORSWs when they were developed in 1994 – a logic that has not come under scrutiny since that time.

5.2 Health services data

5.2.1 Hospitals

The purpose of this section is to briefly examine the surgical activity of the five hospitals selected for study to show how they are representative of hospitals within NSW.

Hospitals in this research were assigned codes in the sequence in which they were formally identified as study sites. Hence, the identifiers, Hospital A…Hospital E do not represent any hierarchy of relative size or perceived importance of the hospitals. Chapter 4 explained how each of the four public hospitals (A, B, D and E) represents a category of hospital based on the NSW Department of Health's classification of level and scope of services and geographic location, and that the fifth, Hospital C, is a metropolitan private hospital.

Appendix A1 Tables 1, 2 and 3 summarise several characteristics of the four public hospitals for the three sample periods in the ten years since 1988: annual hospital separations, average available beds, and (where available), number of surgical separations. (Data were unavailable for 1988/89, so the limited available data for 1989/90 are reported.) Overall, their relative share of the state's public hospital beds increased from 6.93 per cent in 1989/90 to 8.45 per cent in 1997/98. Meanwhile, they consistently accounted for approximately 8.5 per cent of all NSW acute public hospital separations and at least 10.8 per cent of all surgical separations in their combined peer group categories during the ten-year period.

Hospital activity data for the years prior to 1996/97 were not available for the private hospital (Hospital C) because the hospital had been purchased by another corporation not long before

this, and its activity data (excepting clinically relevant data in documents such as the *OTS Surgical Register*) for 1988/89 and 1992/93 were retained by the former owners. However, there was a wealth of "organisational memory" among the many long-term staff, and it was possible to ascertain that throughout the ten years since 1988, the average available beds numbered sixty and there were two operating rooms and an endoscopy room within the OTS. Based on data in **Table 5(a)** and Appendix A1 Table 4, it has been estimated that Hospital C accounted for about 1.35 per cent of the surgical procedures undertaken in NSW private hospitals during 1996/97.

5.2.2 Surgical Procedures

Attention now turns to the six surgical procedures, and this section discusses how, as representatives of four procedural specialties, they are performed in sufficient volume, both at each of the hospitals, and in NSW as a whole, to be considered representative of surgical procedures. Their frequencies in NSW during 1996/97 (representing the latest available comparative data for both public and private hospitals) and their total volume at the study hospitals during the three sample periods in 1988, 1993 and 1998, are presented.

Almost 98 per cent of the 4,656 separations at Hospital C during 1997/98 were surgical, and whilst this high level might be atypical of private hospitals, it is consistent with the fact that overall, surgical separations represent a much higher proportion of total hospital separations in private hospitals than they do in public hospitals. They performed about 56 per cent of the six selected procedures during 1996/97 in NSW (see **Table 5(a)**) – something that became apparent only after the present research was well advanced.

Table 5(a) summarises the 1996/97 NSW public and private hospital frequencies of the six categories of procedures. The data pertaining to similar procedures (detailed previously in **Tables 2(h)** and **2(i)**) are combined and referred to as "all colonoscopies", "all total knee replacements", and so on, and not by their various DRG codes. Chapter 2 discussed the clinical and managerial reasons for distinguishing similar procedures by DRG codes on the basis of clinical complexity and complicating factors present in the patient. Whilst I acknowledge that these issues can and do have an impact on the operative phase, any attempt on my part to identify and analyse these individual differences would fulfil no purpose in achieving the goals of the present thesis. I propose that, so far as the work of nurses and technical aides within OTSs is concerned, the shared characteristics of similar procedures have a far greater impact on the perioperative labour process than the characteristics that distinguish one patient/procedure from another.

The representativeness of these procedures is evidenced by the fact that the eleven DRGs representing the selected six procedures constituted 12.91 per cent of all public hospital surgical separations and 13.42 per cent of private hospital surgical separations in NSW in 1996/97, as shown in **Table 5(a)**.

Table 5(a): Summary table for all AN-DRGs (v3.1) NSW public and private acute hospitals, 1996/97

	No. of private hospital separations in NSW 1996/97	No. of public hospital separations in NSW 1996/97	Total separations in NSW 1996/97
All colonoscopies	32417	18404	50821
Open Cholecystectomies	768	1877	2645
Laparoscopic Cholecystectomies	4470	6388	10858
All knee replacements	3048	2367	5415
D&C and Hysteroscopy	3071	3583	6654
D & C only	1660	3165	4825
Total for these procedures	**45434**	**35784**	**81218**
Proportion of public/private location of surgical separations for above procedures	55.9%	44.1%	100%
Total surgical separations NSW 96/97	338597	277140	
Proportion of above six procedures of total surgical separations	13.42%	12.91%	

Sources: NSW Health (1998b; 1998c); Commonwealth of Australia (1998b).
Note: (i) Estimations of relative frequencies of open and laparoscopic cholecystectomies, and D&C with/out hysteroscopy are based on their relative frequencies in the 1997/98 Australian public hospital data reported in **Table 2(h)**. (ii) Total private hospital surgical separations have been calculated from NSW Health (1998b).

The data collected from the *OTS Surgical Registers* at each study hospital summarised in **Table 5(b)** reveal how the selected procedures (n=5,746) actually represented 18.94 per cent of all *surgical* procedures (N=30,345) over the three sample periods in 1988, 1993 and 1998, and accounted for 200,070 minutes (3,334.5 hours), representing 10.98 per cent, of all intra-operative time.

Table 5(b): Summary of surgical activity at the five study hospitals during the three sample periods in 1988, 1993 and 1998 – selected procedures and all surgical procedures

	TOTAL No. of procedures for all quarters at all hospitals	TOTAL operating minutes for all quarters at all hospitals
Open Cholecystectomy	299	31908
Laparoscopic Cholecystectomy	478	45368
Colonoscopy	2253	62933
D&C	2078	27678
D&C Hysteroscopy	531	16643
Total knee replacement	107	15541
Total of selected procedures in all sample periods	**5746**	**200070**
Total of all procedures in all Operating Suites in all sample periods	**30345**	**1822296**
No. of sample procedures as proportion of all procedures	**18.94%**	**10.98%**

Note: The data from each study hospital contributing to this table are contained in Appendix A3 Tables 1 and 2.

On the basis of these data, I contend that the representativeness of the hospitals selected as research sites, and the six procedures selected for study, is readily evident.

The remainder of this chapter focuses on the individual procedures – their technologies, the human aspects of their production at each hospital, and the practical implications of changes in their technologies for operating theatre services in Australia.

5.3 Intra-operative characteristics of selected procedures

This section is dedicated to describing the surgical technologies employed in the aforementioned procedures and to providing evidence from both the clinical literature and the present research about the changes that have occurred in them between 1988 and 1998. With its emphasis on the *technical characteristics* and *functional goals* of the *artefacts* employed during the *operative* phase of surgical production, it represents a continuation of my response (commenced in Section 2.5) to the first research question posed in Chapter 1.

5.3.1 Cholecystectomy

Cholecystectomy is the term used to describe the surgical removal of a gall bladder. The traditional method of gall bladder removal involves open surgery via a moderately large incision into the upper abdomen (Majeed et al. 1996; Olsen 1993). This was the only way to remove a gall bladder until the advent of laparoscopic cholecystectomy (National Institute of Health 1993; Prasad & Foley 1996), which is now the "gold standard". However, there are some clinical reasons why open cholecystectomy is still performed. Specialist general surgeons undertake both modes of cholecystectomy.

Laparoscopic cholecystectomy is performed with the abdomen inflated by carbon dioxide via an electronically controlled peritoneal insufflation apparatus. Four miniature ("keyhole") surgical incisions are made in the abdominal wall (Prasad & Foley 1996) and four cannulae, one inserted through each incision, provide the mode of access into the peritoneal (ie. abdominal) cavity for the special instruments used by the surgeon and his/her surgical assistant to perform the surgery using electro-coagulation/cutting or laser and other techniques, whilst watching what (s)he is doing on a television monitor, and possibly video-recording the whole procedure (Hobbs 1995). One of the special instruments that made laparoscopic surgery feasible is the solid-rod lens endoscope/laparoscope (approximately 8mm diameter and 40-45cms in length) through which cold light from an external light source is transmitted through flexible fibres into the abdominal cavity, and also through which real-time transmission of images of the operation site onto a television screen is achieved (Brune 1996a; 1996b).

Figure 5(a) shows some of the instruments used in laparoscopic cholecystectomy that are not used in open cholecystectomy. In the foreground on the left are four T-shaped instruments, the cannulae. Once inserted through the abdominal wall, the sharp-ended trocar is removed. In their heads they have a shifting valve below a rubber "washer" that ensures that instruments can be passed in and out of the abdomen through any cannula with minimal leakage of the carbon dioxide that has inflated the abdominal cavity, and then maintained at a safe intra-abdominal pressure by the electronically controlled peritoneal insufflation apparatus shown in **Figure 5(d)**. One cannula has a wider diameter than the rest, and it provides access to the abdominal cavity for the laparoscope, which stays in place for the duration of the operation.

Figure 5(a): Some of the special instruments used in laparoscopic cholecystectomy

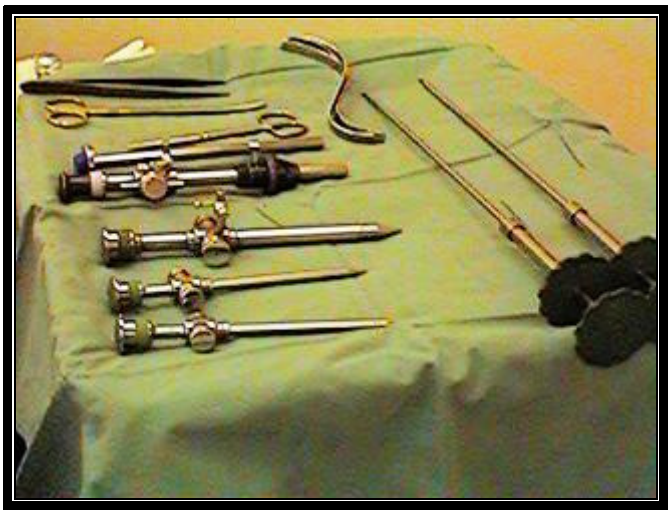


Figure 5(b) gives examples of the operating instruments (fine scissors and graspers) that are inserted as required down one or other of the cannulae. The black coating on them is insulation that is necessary because the technique of electrocoagulation/cutting of tissues employed frequently during the course of the operation, is powered by a diathermy machine (see **Figure 5(h)**) that is connected via electrical cables to selected instruments. The surgeon controls electrocoagulation/cutting by means of the double foot control pedal (shown stored in the bottom shelf of the trolley). In the background to the right of the diathermy machine is suction apparatus that is connected via sterile tubing to a long hollow suction instrument used by the surgeon to evacuate blood, irrigation fluid and electrocoagulation smoke from the abdominal cavity as required.

Figure 5(b): Examples of other special instruments used during laparoscopic cholecystectomy

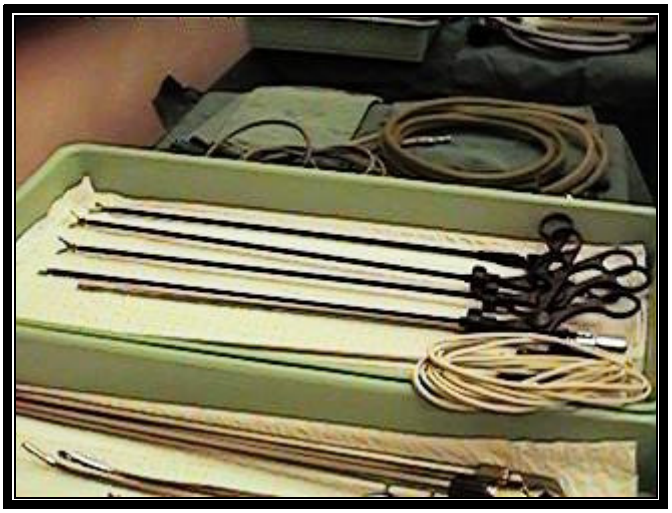


Figure 5(c) shows two examples of what are commonly referred to as laparoscopy "stacks", which are multi-level trolleys containing much of the dedicated electronic *enabling equipment* used during laparoscopy. **Figures 5(d)** and **5(e)** are close-up photos of individual components.

Figure 5(c): Two "stacks" of electronic equipment required for a range of minimum access surgical procedures

The electronically controlled peritoneal insufflation apparatus shown in **Figure 5(d)** is attached to a cylinder of carbon dioxide gas (or may be connected to central source of continuous-flow carbon dioxide via gas outlets in the wall of the operating room), and then connected at an outlet on the front panel via sterile tubing to the wide-diameter cannula. The apparatus can be pre-set to alarm if the intra-peritoneal pressure exceeds or falls below certain parameters determined by the surgeon, or if the gas source expires. On the left of the panel is a flow-meter, which indicates the rate of flow of gas. Despite the alarms, contingencies can and do arise during the course of the surgery that confound the self-monitoring of the apparatus, so it is necessary for the surgical team to be alert to the signs of problems that can arise and to know how to correct them.

Figure 5(d): The electronically-controlled peritoneal insufflation apparatus (bottom shelf)

Figure 5(e): Light source (top) and a video camera control box (bottom) for laparoscopy

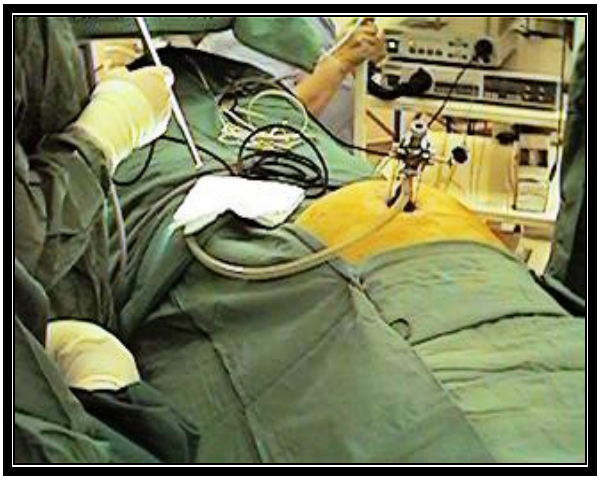
Figure 5(e) shows the electronic devices that combine to provide the light to the laparoscope and pick up and transmit the images of the operation site via an operating camera head and lead (shown in **Figure 5(f)**) and video recorder, to a television screen located at the top of the

"stack". Exclusive of the diathermy machine which is a general purpose item in each operating room, the 1998 purchase prices of the laparoscopic cholecystectomy artefacts pictured would range between AU$80,000 and AU$90,000, with the single most expensive item being the operating camera head and lead costing about AU$23,000.

Figure 5(f): The operating camera head and lead

Figure 5(g) pictures an early stage of the procedure. The abdomen has been "prepped" with an antiseptic solution and draped, and inflated with carbon dioxide gas via a fine instrument known as a Verres needle, after which the first cannula that "houses" the laparoscope is inserted through the umbilicus (as shown).

Figure 5(g): Commencing laparoscopic cholecystectomy – Cannula for laparoscope inserted through umbilicus



The picture shows the tubing carrying the carbon dioxide gas attached to the cannula, the laparoscopy "stack" in the background, and the surgeon on the left holding the laparoscope

and preparing to insert it into the cannula. After this, the camera head and light lead would be connected to the laparoscope, and the first intra-peritoneal images will appear on the television screen. Subsequently the other three cannulae are strategically inserted into the abdominal wall and the actual process of removing the gall bladder commences. Sometimes problems are encountered intra-operatively that necessitate the laparoscopic procedure being converted to an open cholecystectomy, and it is for this reason that the instrumentation dedicated to the latter must be assembled and ready to open quickly should the need arise.

Figure 5(h): Diathermy machine and suction apparatus

In 1996/97 in Australia, 33,833 laparoscopic cholecystectomies were performed compared to 8,260 open cholecystectomies (see **Table 2(g)**). Potentially a *replacement* technology (after Richardson 1990), laparoscopic cholecystectomy is, at its current stage of technological innovation and diffusion, an *alternative* technology to open cholecystectomy.

5.3.2 Colonoscopy

Colonsocopy refers to the examination of the colon (ie. the large bowel) using a flexible instrument known as a colonoscope. The colonoscope, shown in **Figure 5(i)**, uses similar enabling fibre-optic technologies as those employed in laparoscopic cholecystectomy, but it is a flexible instrument (about 15mm diameter and at least 100cms in length) that is directed through the colon by the procedural specialist. The proceduralist uses the hand controls at the "working end" to alter the direction of the 20cm tip of the instrument as it is slowly inserted, whilst watching what (s)he is doing on a television screen. Throughout the internal length of the colonoscope are the fibre-optics that transmit the light from an external light source and

return images to a television screen located on the colonoscopy "stack" (as pictured in **Figure 5(j)**), and three channels. Irrigating/flushing fluid is passed down one channel, liquid and semi-solid matter can be aspirated from the colon via a second channel, and the third channel accommodates a surgical instrument.

Figure 5(i): A flexible colonoscope

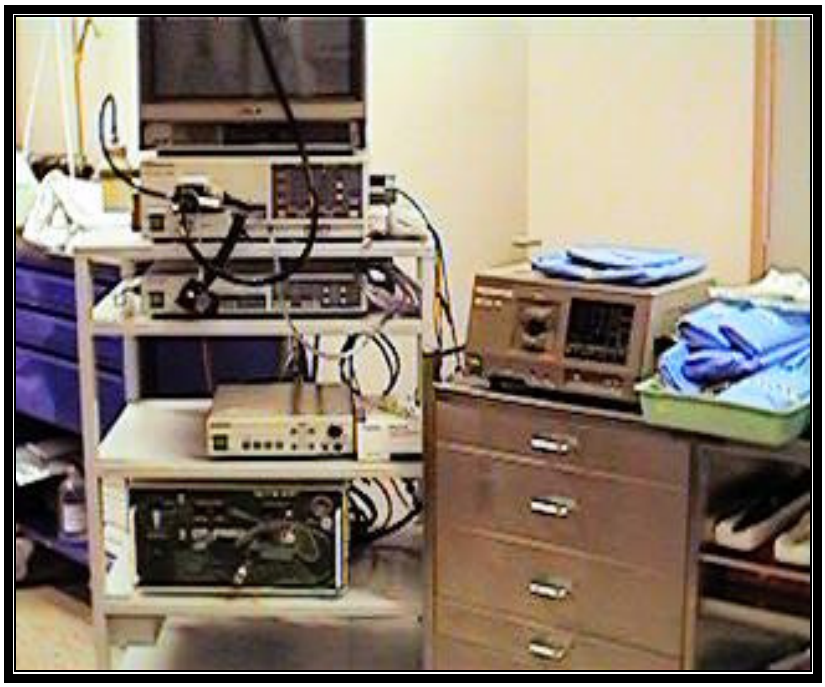
Colonoscopy is categorically a minimum access procedure because the colonoscope is inserted into the colon via the body's natural orifice, the anus. Colonoscopy is frequently undertaken for diagnostic/screening purposes, at which time biopsies are often taken for pathological examination (Rahman & Chagoury 1994; Macrae 1996; Frommer 1998). A number of therapeutic procedures can also be performed – procedures that are essentially surgical procedures such as removing polyps, treating bleeding vessels with cautery or laser (Ransohoff et al. 1991), and the insertion of stents 'for the palliation of malignant obstruction' (Alderson & Blazeby 1995:1441; cf. Fenton-Lee et al. 1995).

In 1996/97, in Australia, 151,282 colonoscopies were performed by general surgeons and specialist physician endoscopists (see **Table 2(g)**), and it was the most common procedure undertaken in private hospitals. Most are undertaken on a day case basis (Fenton-Lee 1995).

Categorically, colonoscopy is an *alternative* technology (after Richardson 1990) to, for example, barium enema and (non-procedural) faecal occult blood testing for the diagnosis of colonic disease (cf. Rahman & Chagoury 1994; Macrae 1996; Frommer 1998). It is also an *alternative* technology where it involves therapies (such as laser treatment to bleeding vessels) that are increasingly averting the need for open bowel surgery. The procedure's technologies have undergone continuous incremental change since it was introduced during the early 1970s, one of which was the advent in the late 1980s of video-colonoscopes.

Hospitals are progressively replacing their direct vision colonoscopes with video-colonoscopes, but the actual process of diagnostic colonoscopy has changed little since 1988 from the proceduralist's perspective.

Figure 5(j): The colonoscopy "stack" and other equipment required for colonoscopy



5.3.3 Diagnostic Curettage of Uterus and Hysteroscopy

Curettage of the uterus is a procedure performed by specialist gynaecologists on women for several reasons – diagnosis, the treatment of uterine dysfunction, or to evacuate the products of conception. This study focuses only on diagnostic curettage of the uterus which involves a surgeon using a range of instruments to first dilate the cervix (ie. the opening of the uterus) so that it will permit the passage of surgical instruments into the uterus, and then scraping (ie. curetting) samples of the endometrial tissue that lines the uterine wall for histological examination by a pathologist. Until the introduction of the procedure of hysteroscopy, dilatation of the cervix and curettage of the uterus (D&C) was the standard diagnostic procedure uterine dysfunction/disease (Chamber & Chamber 1992).

Hysteroscopy involves the endoscopic examination of the uterine cavity using a miniature version of the laparoscope and a variety of alternative liquid or gas media to inflate the uterus during the procedure. Therapeutic procedures such as hysteroscopic endometrial ablation or the hysteroscopic resection of submucosal fibroids (Ananthanarayan et al. 1996) render hysteroscopy an *alternative* technology (after Richardson 1990) to hysterectomy (ie. surgical

removal of the uterus). Gynaecologists can elect either to perform the procedure under direct vision or to use the video technologies similar to those employed in laparoscopic cholecystectomy, whereby the procedure can be observed on a television screen.

In Australia, hysteroscopy was among those MAS procedures that were adopted at around the same time as the widespread adoption of laparoscopic cholecystectomy. The procedure had been technically feasible prior to that, but hospitals had been generally hesitant to invest in the necessary high cost enabling equipment. However, following the adoption of laparoscopic cholecystectomy, gynaecologist not only had access to the additional equipment they needed for video-assisted diagnostic and therapeutic hysteroscopies, but they were now able to add video-optic technologies to the laparoscopies that they had been performing under direct vision for at least a decade.

Hysteroscopy is a procedure that can be safely performed in a gynaecologist's private rooms or clinic (Motashaw & Dave 1990; Ananthanarayan et al. 1996) but, in hospitals, the general trend has been for a gynaecologist to perform hysteroscopy in addition to D&C (see Goldenberg et al. 1997). This has resulted in hysteroscopy being largely a *complementary* technology (after Richardson 1990) so far as OTSs are concerned, but a *replacement* technology in cases where it is used in a gynaecologist's consultation rooms as a substitute for in-hospital D&C. This may explain the evidence from this research that the incidence of curettage of the uterus has declined as an in-hospital procedure since the advent of hysteroscopy. However, diagnostic D&C remains a common operation, accounting for 99,414 procedures in Australian acute hospitals during 1996/97 during which time 57,577 hysteroscopies were performed (see **Table 2(g)**) either independently or in conjunction with D&C.

5.3.4 Total Knee Replacement

Total knee replacement is often referred to in the clinical literature as *total knee arthroplasty*. It refers to an operation that restores function to a knee usually disabled by severe arthritis, by removing the ends of both the femur and tibia where these two long bones articulate at the knee joint, and replacing them with predominantly metal prosthetic components.

Total knee replacement (TKR) was adopted prior to 1988, but it has progressively become an accepted *alternative* technology (after Richardson 1990) to pharmaceutical treatment with anti-inflammatory drugs for arthritic knee joint disease. During the ten years since 1988, the procedure has undergone continuous *artefact* innovation by numerous biomedical companies, resulting in frequent changes in operative *techniques*. This situation is exemplified by a study conducted in the mid-1990s by Phillips, Tomlinson and Goddard (1996), in which they

surveyed British orthopaedic surgeons about the techniques they employed in TKR. They found that there were forty-one different prostheses in use, of which five prostheses represented 61 per cent of the total. The forty-one different prostheses represent a range of alternative intra-operative techniques and prosthesis designs and applications (cf. Campbell et al. 1993; Ritter et al. 1994; Laskin 1998; Rand 1998), such as in the case of a revision TKR (ie. a second operation, usually years later, on the same knee) (cf. Rorabeck & Smith 1998; Sculco & Choi 1998). Whilst a discussion of these clinical issues is out of the scope of this thesis, these data serve to highlight the potential diversity between individual TKR operations.

Figures 5(k) and **5(l)** show different perspectives of one example of the multiple boxes of specialist instruments that are required to perform a TKR. Because of the need to customise the procedure to individual patients (for example, due to their physical size and the clinical condition of their diseased knee), these instrument kits duplicate various components in a range of sizes. Furthermore, individual characteristics of patients might influence the orthopaedic surgeon to elect to use one brand of prosthesis (and, by necessity, the accompanying instrument kit) instead of another.

Due to the high cost of both the instrument kits and the prostheses, it is customary in Australia for biomedical companies to lend the kits to hospitals on demand, and to supply the full range of prosthetic implants on either a consignment or an ad hoc basis.

Figure 5(k): One view of the containers of special instruments for total knee replacement

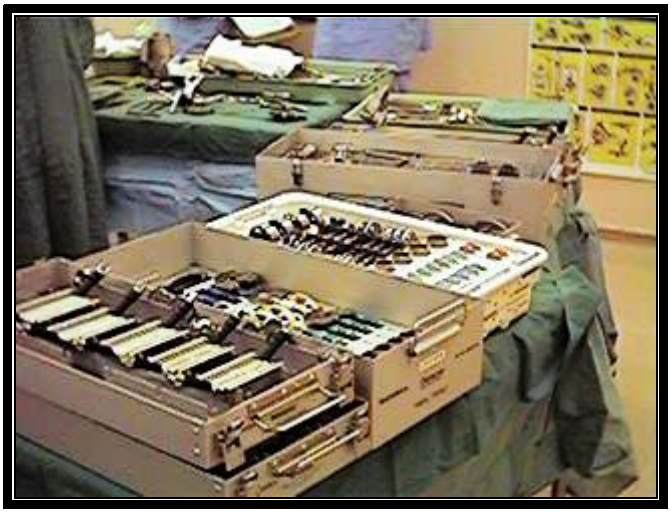


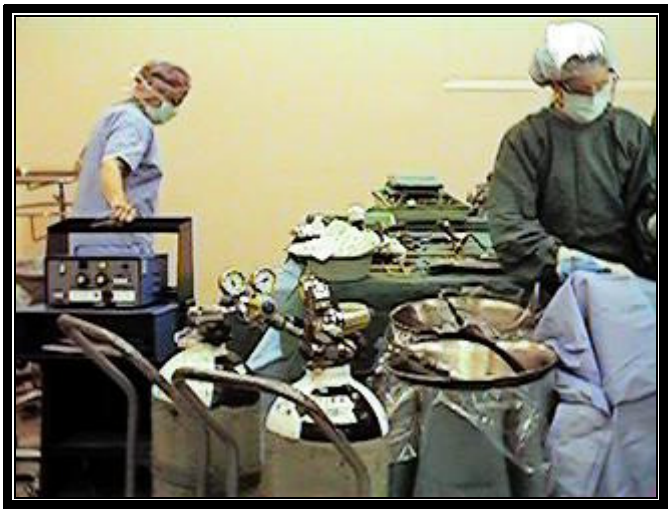
Figure 5(l) A closer view of some of the instruments in a total knee replacement kit

Figure 5(m) shows one example where 102 boxes of implant components, with a total value of about A$100,000, were on hand. Until the early 1990s, the custom of public hospitals was to own the instrumentation necessary for one or two types of prostheses, and to occasionally borrow instruments from a biomedical company if the surgeon had a strong clinical reason for using an alternative. Private hospitals, however, have a much longer and stronger history of using loan sets on the request of surgeons for specific patients. With so many types and brands available, the practice is now pervasive in public hospitals, and the hospital-owned instrument sets are rarely used.

Figure 5(m): A packed trolley of sterile prosthetic implants for total knee replacement

However, these instrument kits and the prosthetic implants do not represent the only instruments required to complete the operation. **Figure 5(n)** shows the instrument and circulating nurses with some of the necessary hospital-owned equipment, such as general surgical instruments, power tools for sawing and drilling and the gas cylinders to drive them, and the diathermy machine. Not on view is the pneumatic tourniquet apparatus that controls the pressure applied to the patient's thigh during the operation to produce a "bloodless field". I mention the tourniquet first, as an additional intra-operative artefact, but also because the safe application time of such an operating tourniquet is about 2 hours, which means that there are time pressures on the operative team to complete the operation within this safe period.

Figure 5(n): Nurses with other instruments and equipment used during total knee replacement



5.4 Perioperative technologies and work process time study

Chapter 4 detailed the strategies used to identify and quantify the time taken by various staff to undertake all of the pre- and post-operative activities associated with each of the six procedures. These activities constitute the *perioperative times* cited throughout this thesis. They are exclusive of any machine processing times. Collecting these data proved to be the most difficult and frustrating aspect of my research for several reasons: first, the discontinuous nature of the perioperative activities that contribute to a single procedure, secondly, the number of staff involved at different stages and periods of time and, finally, the "pot-luck" nature of the selected procedures being scheduled when it was convenient for me to visit the hospitals. Consequently, it is not surprising to me that there is no published record of any attempts to empirically quantify the perioperative human labour input (HLI) to surgical production.

As mentioned in Chapter 4, between two and six complete examples of the perioperative HLI to each procedure were collected at each hospital, contingent on the opportunities that arose during the research period. I personally recorded all of the data associated with colonoscopy and virtually all of the operating suite data. However, most of the data collected in the sterilising departments were recorded by the technical aides on log sheets that I customised to suit their work patterns. I explained in Chapter 4 how I collected a complete set of sterilising department data at a sixth site (Hospital V) for validation purposes.

Raw data from each OTS were transcribed into spreadsheets (examples are available in the Research Protocol). **Table 5(c)** (in Section 5.4.2) provides an example of the stages in the labour process involved in each procedure. Identification and classification of the various stages for each procedure at each hospital was necessary before the time study data could be collected. This was achieved via observation, preliminary interviews and informal discussions with OTS personnel. However, prior to presenting these quantitative data, I describe the main perioperative activities, and their associated technologies, that contribute to surgical production. The qualitative data contributing to this description of perioperative work are derived primarily from my interviews, conversations, and observations within OTSs.

5.4.1 Perioperative technologies

Perioperative activities can occur anywhere within the OTS – in the operating suite, the endoscopy unit and the sterilising department. For the five procedures performed under aseptic conditions (ie. excluding colonoscopy), the processes generally commenced with the *pre-operative* assembly of all the sterile instruments and other intra-operative artefacts within an operating suite. The person who does this, usually a nurse, is guided by a "preference card" for the particular procedure and surgeon. This card identifies all of the items that must be collected from numerous storage sites throughout the operating suite and stored, temporarily, in a case cart (or similar), in readiness for the operation. Preference cards are necessary for two reasons. First, there are many types of surgical operations, so documentation provides the only way that any member of staff can accurately assemble the artefacts required. Secondly, surgeons undertaking similar procedures are likely to use a number of different technologies and, hence, there is no standard set of preferred intra-operative artefacts (although there are many similarities).

Immediately prior to a procedure, the operating room furniture and other equipment must be customised to the requirements of the specific operation, and then the instrument nurse, supported by at least one circulating nurse, prepares (ie. sets up) the sterile instrumentation

and supplies. The operation can then commence. After it is finished, the operating room, its fixtures and furniture, must be cleared and cleaned, and most instruments are despatched to the sterilising department for re-processing. Finally, equipment and unused sterile materials are returned to their respective storage places within the operating suite, although these may be stored in an ante-room until the conclusion of the operating session.

The perioperative processes associated with endoscopies undertaken within endoscopy units vary slightly from what has been described in two main ways. The first is that the procedure rooms are dedicated to only one category of procedures (eg. flexible GI endoscopies) and so the enabling equipment and other items of furniture do not have to be changed between individual procedures. The second is that, in most instances, the post-procedure instrument reprocessing is completed within the endoscopy unit and not sent to the sterilising department.

Sterilising departments have a number of types of machines for (re)processing surgical instruments – ultrasonic and high-pressure instrument washers, dryers, and various types of sterilisers. During the period of 1988 to 1998, the overall trend was to acquire a new machine only when an existing machine needed to be replaced, either because it could not be repaired or because it was cost-inefficient to repair it. However, the new machines perform the same basic functions as their predecessors and have not changed the essential nature of sterilising department work.

Instrument reprocessing activities follow the same general pattern regardless of the size or role of the hospital, or the location within the OTS of those activities. Activities include sorting, possibly dismantling, washing, drying, reassembling, checking, sorting into sets and assembling onto sterilising trays, wrapping or containerising, labelling, and sterilising. Different stages of reprocessing are physically separated from each other. In the sterilising department, sorting and washing of contaminated items received from the operating suite are isolated from other stages of reprocessing, as are sterilised items that are ready for dispatch back to the operating suite. Items are conveyed from stage to stage, either by being carried by the worker, transported on a trolley, and/or, as in some larger sterilising departments, via conveyor belt. In the smallest of departments, a single worker will carry out all of the tasks, completing the available work in the “dirty” area before removing protective apparel to continue reprocessing in the various “clean” areas.

All of the SD technical aides interviewed described a general set of steps involved in reprocessing the instruments and miscellaneous equipment from a single case. A single case could involve up to several hundred items that need to be sorted, prior to machine or manual

washing and drying. During this preliminary sorting phase, instruments that belong to specific collections, such as "general instruments" (containing between 50 and 70 assorted instruments, depending on the hospital), "hysterectomy extras" (between 10 and 15 assorted instruments), and possibly as many as 230 instruments for some open heart operations (Informant DX005), are distinguished from the others and placed into separate baskets. Items that are reprocessed individually (such as MAS instruments) are separated from the others, but otherwise subjected to the same processes described here.

Mechanical high pressure and ultrasonic washers are used in most sterilising departments and operate on cycles of 5-10 minutes, although, to reiterate, these processing times are not included in the perioperative times cited throughout this thesis. Some sterilising departments have high-pressure washers that incorporate a drying cycle. Others have separate drying cabinets that necessitate staff having to manually move wet instruments from a high pressure washer to an ultrasonic washer (see **Figure 5(o)**) and then into the drying cabinet.

Figure 5(o): Technical aide removing instruments from ultrasonic washer

However, mechanical washers cannot be used for most MAS instrumentation, flexible endoscopes (such as colonoscopes), or delicate instruments such as those used in eye surgery, and the sterilising department at the largest of the study hospitals (Hospital D) actually had an area dedicated to manual handling of such instruments, which they referred to as "specials".

Mechanical washers tend to do an inadequate job of washing instruments such as those used in TKR operations, and technical aides commonly reported to me that instruments needed to be carefully inspected after mechanical cleaning, and often scrubbed to remove embedded

bone fragments and other tissue. **Figure 5(p)** shows a technical aide doing a preliminary wash of some of the equipment used in a TKR to remove all visible contamination.

Figure 5(p): Technical aide doing a preliminary wash of some Total Knee Replacement instruments

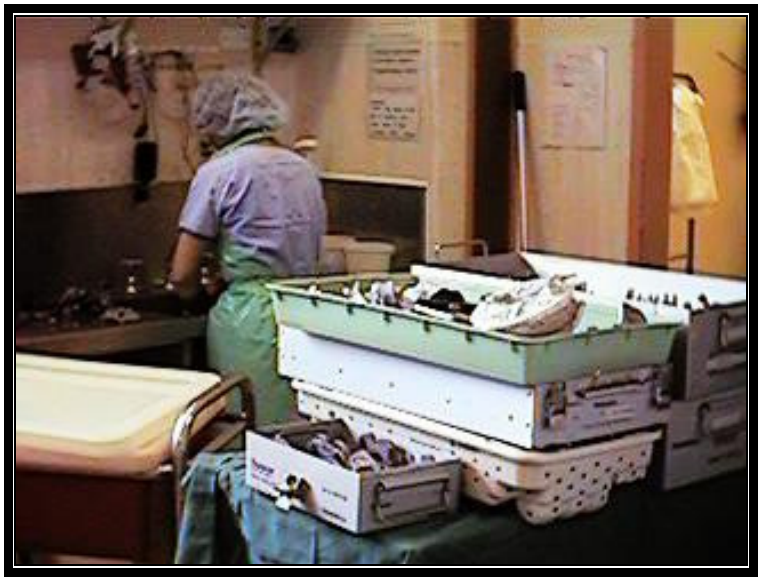


Figure 5(q) shows a SD technical aide at work in the first stage of instrument reprocessing. Here, instruments are checked and sorted into the metal baskets (located to the right of the worker) after they have been washed free of most visible contamination. Larger items such as bowls, basins and trays are placed into the crates that are stacked in the foreground of the picture. At all hospitals, these activities are totally manual. At Hospitals D and E, which were the largest of those studied, instruments and other items were conveyed to the next processing stage via a conveyor belt.

Figure 5(q): Technical aide working in Stage 1 instrument processing in a Sterilising Department

Technical aides are able to refer to procedure manuals (shown in **Figure 5(q)** to the left of the technical aide) to assist in the identification of instruments and/or for information on special processing requirements. One of the five hospitals has a SD computer information system that has the dual function of providing the information that would otherwise be in such a procedure manual, and a system of tracking instrument sets and printing the necessary labels and other paper documentation required during re-processing through the sterilising department. The system contains details of the names and numbers of every type of instrument in a set, possibly accompanied by photographs and/or details of the inventory numbers (ie. codes) etched on each instrument, along with assembly instructions where necessary.

After drying, instruments are individually inspected for any residual contamination and, if necessary, washed again by hand. Thorough inspection is also necessary to check that all the components of instruments are intact and that instruments are undamaged. Damage can take numerous forms, such as splits in the electrostatic coating on an instrument, improperly aligned opposing sides of forceps, and burred tips on fine instruments. Checking may involve testing on an electrical device or inspection under a magnifying glass or microscope and, if damaged, instruments must be removed from circulation for repair. Some instruments need to be reassembled because they were dismantled prior to washing.

Instruments are then sorted and reassembled into their respective sets on perforated trays or in purpose-specific metal sterilising containers. If perforated trays are used, the trays are wrapped in linen or other forms of material and sealed with adhesive autoclave tape. Metal containers are self-sealing, whilst numerous instruments are individually packaged in diverse ways. Prior to sterilisation, all items are labelled for future identification, proof of sterilisation and subsequent tracking.

Sterilisers of various kinds represent another category of machine processing that occurs within OTSs. Conventional surgical instruments are usually sterilised in high vacuum steam sterilisers (see **Figure 5(r)**), but the introduction of MAS technologies, combined with improved standards concerning the re-processing of the latter, has resulted in several other sterilising technologies becoming commonplace. This process has been evolutionary, with most of the modern era change occurring during the ten years covered by this research.

With conventional steam sterilisation, the prepared instruments are placed on a multiple-rack steriliser cartridge, which is pushed into the steriliser from its carrier (pictured in the foreground of **Figure 5(r)**) when it is fully loaded. After the sterilisation period is completed, it is removed, and the instruments allowed to cool. The instruments are then

moved onto trolleys for return to the operating suite sterile stock rooms. The processing cycle in a conventional steam steriliser varies between 50-90 minutes, depending on the nature of the load of instruments in it at the time. However, these machine sterilising times, like all machine processing times, are *not* included in the perioperative times cited throughout this thesis because they fall out of the scope of the research's interest in the human labour input to surgical production.

Figure 5(r): High vacuum steam sterilisers – 1990s technology (on left) and 1980s technology (on right)

When the first laparoscopic cholecystectomies were performed in Australia in 1990, the MAS instruments were sterilised by soaking in a liquid chemical called gluteraldahyde, which was contained in one of two large tubs (seen in the foreground of **Figure 5(s)**). Nurses were required to place the instruments into the tubs, to flush the liquid through the channels of the instruments before leaving them to soak, and then to remove the instruments from one tub prior to repeating the process using sterile water to ensure the removal of all traces of the gluteraldahyde.

However, convincing evidence was emerging that this chemical was harmful to users, both when it came into contact with the skin, and when its fumes were inhaled (cf. Commonwealth of Australia 1996). Mechanisms were devised to extract the fumes from work areas (eg. via the two wall-mounted fume cabinets shown in **Figure 5(s)**) whilst alternative means of decontamination were being devised and tested by biomedical companies. The alarm raised with HIV-AIDS during the late 1980s added another dimension to the decontamination issue, with the result that the Standards Association of Australia published a revised set of standards for sterilisation practices within hospitals (Standards Australia 1998). Consequently, it

became mandatory for hospitals to upgrade many of their instrument reprocessing technologies, particularly those associated with MAS, such as colonoscopy, hysteroscopy and laparoscopic cholecystectomy. The development of machines, such as the *Steris*^{TM} and *Medivator*^{TM} (pictured following) and, more recently, autoclavable MAS instruments, such as the operating telescopes, have been driven primarily by these occupational health and safety concerns.

Compliance with the new standards has had a number of consequences for perioperative work within OTSs, consequences that are discussed, where appropriate, in this and the following chapter.

Figure 5(s): Some reprocessing technologies in an Endoscopy Unit

All of the study hospitals now own one or more *Steris* ™ machines (**Figure 5(t)**) and/or one or more *Medivator* ™ machines (**Figure 5(u)**) to sterilise flexible endoscopes and other instruments for which there exists no alternative means of sterilisation. In the five study hospitals, these machines were not located in the sterilising department, but in the operating suite or the endoscopy unit, where they were operated by nurses. In the case of the *Steris*^{TM} being used to sterilise surgical instruments for invasive procedures, such as hysteroscopy, instruments must be delivered to the OR for immediate use. Surgical instruments sterilised by these machines are not wrapped or containerised like most other instruments and, hence, cannot be stored sterile, until required, like instruments processed using conventional sterilising department technologies.

The processing times of the *Steris ™* and *Medivator ™* machines vary between 20-30 minutes. The chief advance of these technologies over those which they are intended to replace is that the chemical sterilising fluid is contained within the machines. Consequently, personnel are no longer exposed to the toxic liquid or its fumes.

Figure 5(t): A *Steris ™* machine

Figure 5(u): A *Medivator ™* machine

Evidence is that there has been a slight increase in workload resulting from the introduction of the *Steris*^{TM} and/or the *Medivator*^{TM} machines (exclusive of the training involved at the

outset). No longer do nurses need to manually rinse the chemical decontamination liquid from instruments, but they believe that the time saved here is less than the additional work arising from pre-sterilisation machine and instrument assembly and post-sterilisation machine maintenance. Brewer (1986:182) described this latter phenomenon as 'the multiplier effect' of replacement technologies.

Whilst these are changes in *perioperative* rather than *intra-operative* technologies, I have adopted the position in the present thesis that these changes in instrument reprocessing are direct consequences of the adoption of new intra-operative artefacts and, hence, they should be included in the quantification of perioperative workload. I have adopted this position because I contend that, if innovations in MAS had not occurred, there would have been no demand for these alternatives to steam sterilisation in the first place.

However, some other quality assurance activities have been introduced since 1988, such as systems of monitoring the effectiveness of steam autoclaves, which have not been included in the present analyses. They, along with other new systems of documenting all sterilising activities, such as those designed to facilitate identification of the machine used and the date and time of sterilisation of instruments used in a specific procedure, are, nonetheless, sources of increased perioperative work within sterilising departments that cannot be ignored by managers. These types of quality assurance issues receive no further treatment in the present thesis because they are independent of the innovations that have occurred in intra-operative artefacts.

The final reprocessing stage is that in which re-sterilised instruments are returned to the operating suite and re-shelved for future re-use. I abandoned attempts to collect data for the six selected procedures on how long it takes to undertake these activities because of logistical problems. The main problem was that once instruments from particular procedures were put into the sterilisers it became impossible to track them without imposing on the SD technical aides to substantially alter their standard work practices – something I regarded as inappropriate because the quality of more important perioperative data would have compromised. I contend that the absence of these data simply means that all of the mean perioperative times, reported herein, will be slightly underestimated.

5.4.2 Perioperative work process time study

The pre- and post-operative activities associated with each of the six procedures constitute the *perioperative human labour input* cited throughout this thesis. The following table, **Table 5(c)**, is an example of the perioperative work process time study activities and data. It shows

that the mean perioperative HLI to laparoscopic cholecystectomy at Hospital E was 206 minutes.

Appendix A6 contains an example from each hospital of one of the other five procedures. Each table reports the mean perioperative minutes for HLI to the perioperative component of surgical production for each procedure. The summary perioperative data for all procedures at one hospital, Hospital A, is provided in Appendix A5.

Table 5(c) Perioperative human labour input to laparoscopic cholecystectomy at Hospital E

Activity	Average HLI (mins) to activity
Pre-operative equipment assembly in OS	16.17
Pre-operative non-sterile set-up in OR	8.29
Pre-operative sterile set-up in OR	43.0
Post-operative clear up in OR (all)	14.92
Disassemble & rinse in OS	18.7
Sort, wash, check & pack in SD	87.5
Pre- and post-sterilise in SD	5.8
Maintain laparoscope & accessories (average)	4.5
Maintain "disposable" stock levels (average)	2.7
Steris maintenance & QA activities (average)	4.5
Mean perioperative scenario	**206.08**

The perioperative activities associated with TKR surgery are more numerous than those shown in **Table 5(c)** largely as a consequence of "the loan set phenomenon" that was mentioned in Section 5.3.4. It has resulted in a duplication of instrument processing and other additional work because the loan set instruments must be individually checked both on receipt and before dispatch, and fully processed through the sterilising department as soon as they are received from the biomedical company, which, for medico-legal reasons, cannot supply the loan set instruments sterile and ready for use.

I found that at Hospital E, where perioperative times for four different loan sets contributed to the data set, the total perioperative time for TKR using loan sets ranged from 455.6 minutes to 854.4 minutes (see Appendix A6 Table 5) – data that serve to highlight how an orthopaedic surgeon's choice of brand and type of artificial knee joint for a particular patient can impact on the volume of perioperative human labour. In the Hospital E example, pre-operative instrument processing accounted for 229.5 minutes in the mean perioperative time of 622.3 minutes – time that is not required when only hospital-owned instruments are used. These and the corresponding data for Hospitals A, C and D are summarised in **Table 5(d)**, which shows that, on average, the perioperative human labour associated with TKR loan sets

is about 200 minutes longer than for hospital-owned sets. I propose that this is a good indicator of the increase that has occurred in public hospitals, in particular, between 1988 and 1998, in the perioperative human labour input to TKRs as a consequence of the changes in *within-technology alternatives* in TKR (described in Section 5.3.4). Based on a 1998 grand mean perioperative time of 542.8 minutes, I have estimated that the loan set phenomenon alone has resulted in an increase of at least 36.9 per cent in the perioperative labour requirements of TKRs since 1988.

Table 5(d): 1998 perioperative human labour input to total knee replacement showing extra processing time required when loan sets are used

	Hospital A	Hospital C	Hospital D	Hospital E	Grand Mean for loan sets
Mean total perioperative time (mins), loan sets	580.0	401.9	531.5	622.3	**542.8**
Extra processing time due to loan set (mins)	210.0	192.4	154.5	229.5	**200.5**
Perioperative time (mins) exclusive of extra processing time	370.0	209.5	377.0	392.8	**342.2**
% of total represented by extra processing time	36.2%	47.9%	29.1%	36.9%	**36.9%**

At two hospitals I was able to collect the perioperative times for hospital-owned TKR sets, and they are remarkably similar to the mean perioperative time for the loan sets *exclusive* of the addition workload just described. At Hospital A, the respective times were 341 minutes (hospital-owned) and 370 minutes (loan set), while at Hospital D they were 373 minutes and 377 minutes.

In this connection, it must be noted that the presence of perioperative data for both loan and hospital-owned instrument sets at Hospitals A and D explains why their mean perioperative times are different in **Table 5(d)** compared to **Table 5(e)**. For example, at Hospital A, the mean total perioperative time for TKRs using loan sets was 580 minutes but 514 minutes for all TKRs. Hence, the mean perioperative times for TKRs at both Hospitals A and D are actually grand means, calculated using the equation:

$$\textit{Mean perioperative time for TKR} = [(t_1)(n_1) + (t_2)(n_2)] \div [(n_1)+(n_2)] \text{ minutes}$$

where the mean time using loan sets is t_1 and using hospital sets is t_2, and the number of operations performed between April and June 1998 at each hospital using loan sets is n_1 and using hospital sets is n_2. The grand mean perioperative times for all procedures undertaken at all the study hospitals reported in **Table 5(e)** have also been calculated in a similar fashion using mean perioperative time (t_i) and total number of procedures performed (n_i) for each of the six procedures.

Table 5(e) reports the mean perioperative HLI to each procedure at each hospital, plus the grand mean perioperative HLI. Upon examination of these data, it is evident that substantial variation occurs between hospitals in some of the procedures but I propose that these are "normal variations" arising from a range of factors that distinguish one OTS or one similar operation from others. Unavoidably different and largely fixed characteristics of OTSs at individual hospitals are sources of some of this variation. They include their physical size and layout and the varying characteristics of the sterilising department reprocessing equipment. Other sources of variation are independent of these fixed characteristics. These include the particular intra-operative artefacts and techniques employed by a procedural specialist, the extent of use of single use instruments in MAS, the ready availability of the necessary surgical materials and, during instrument re-processing, the nature and volume of body tissue/fluids soiling the instruments.

The data in **Table 5(e)** provide the first stage of comparison between 1988 and 1998 technologies for the procedures of open and laparoscopic cholecystectomies, and D&C without and with hysteroscopy. The data reveal that the estimated 1998 grand mean total perioperative time for laparoscopic cholecystectomy (128.38 minutes) is approximately 45 minutes more than the 83 minutes it was in 1988 for open cholecystectomy. This represents an increase of about 54 per cent resulting from the adoption of the *alternative* (and potentially *replacement*) *technology*.

Table 5(e): Summary of 1998 mean perioperative human labour input (HLI) minutes for six procedures at five hospitals and the grand mean perioperative time of each procedure

	Hospital A Mean Periop HLI	Hospital B Mean Periop HLI	Hospital C Mean Periop HLI	Hospital D Mean Periop HLI	Hospital E Mean Periop HLI	**Grand Mean Perioperative HLI (mins)**
Open Cholecystectomy	74.00	82.99	83.45	80.92	107.34	**83.11**
Laparoscopic Cholecystectomy	139.36	110.11	145.13	110.27	206.08	**128.38**
Colonoscopy	56.59	68.12	85.15	101.52	66.35	**82.05**
D&C	42.34	28.09	36.45	34.97	37.24	**34.18**
D&C Hysteroscopy	73.50	85.13	60.42	79.62	75.83	**79.32**
Total Knee Replacement	513.61		401.88	452.25	622.32	**484.87**

Note: Total knee replacement is not performed at Hospital B.

The data also reveal that the estimated 1998 grand mean total perioperative time for D&C with hysteroscopy (79.32 minutes) is about 45 minutes more than D&C was in 1988. This represents a 130 per cent increase for every D&C in which the *complementary technology*, hysteroscopy, is also performed. Based on the fact that about 58 per cent of D&Cs in 1996/97 included hysteroscopy (estimated from NSW data in **Table 5(a)**), this represents a net

increase in the total perioperative HLI to all D&Cs, with or without hysteroscopy, of approximately 75 per cent.

It is not possible to use similar techniques to empirically quantify changes between 1988 and 1998 in the perioperative times for colonoscopies because the associated 1988 reprocessing technologies are obsolete. However, Hospital D, with a mean perioperative time for colonoscopy of 101.5 minutes, is a "leading edge" facility, and was the only hospital among those studied that had commenced the practice of routinely sterilising colonoscopes immediately prior to their first application on the day of use *in addition to* the sterilisation that was completed on the day that the instrument was previously used. The other four hospitals had not yet adopted this practice, although some nurses reported that it would soon become standard practice, and that it would increase their perioperative workload also.

By comparison with Hospital D, the grand mean perioperative time in 1998 for colonoscopy at the other four hospitals (using circa 1993 technologies) was 69 minutes – about 32 per cent less than at Hospital D using 1998 technologies. Interviews with all nurses involved with colonoscopies revealed that the perioperative (re)processing in 1988 was even less involved and less time consuming than both the 1998 and circa 1993 technologies, although it is only possible to quantify part of what "less" amounts to, as I now explain.

Nurses experienced in colonoscopy were able to identify several causes of increased perioperative HLI to colonoscopy that occurred between 1988 and 1993. One arose from the introduction of video colonoscopes, and another was a consequence of the changes in instrument reprocessing that were described in Section 5.4.1. Following two separate requests for nurses to replicate the standard 1988 reprocessing of a colonoscope so that I could time the activity, I have estimated that, between 1988 and 1993, perioperative HLI to colonoscopy increased by about 15 per cent. Consequently, based on best perioperative practice in 1998, it is estimated that there has been an overall increase of about 47 per cent in the perioperative HLI to colonoscopy since 1988.

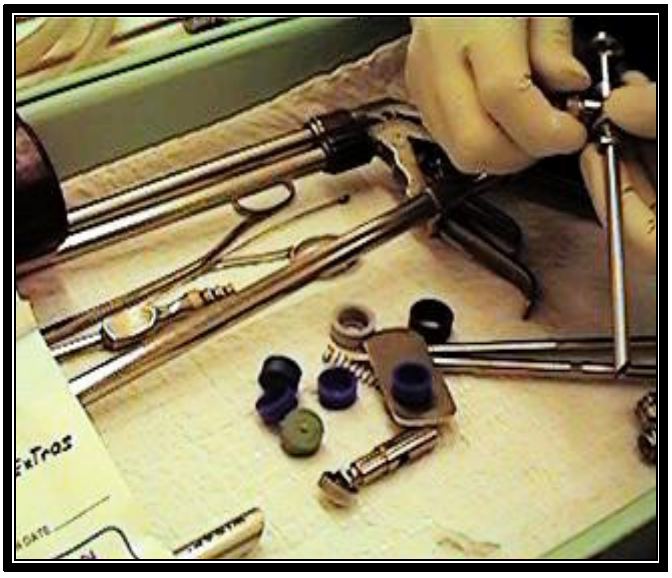
As mentioned in Chapter 4, I undertook to confirm the reliability of the sterilising department component of the data by personally observing and timing every activity contributing to the perioperative workload associated with one complete example of five of the procedures (ie. excluding colonoscopy) at a hospital that was not one of the five study sites. This "control" activity yielded the following results for total perioperative HLI:

- Open Cholecystectomy, 89 minutes
- Laparoscopic Cholecystectomy, 213 minutes
- D&C, 33 minutes

- D&C Hysteroscopy, 69 minutes, and
- Total knee replacement, 483 minutes.

With the exception of laparoscopic cholecystectomy, these results are congruent with the data in **Table 5(e)**. However, one study hospital (Hospital E) reported a similar mean perioperative time for laparoscopic cholecystectomy, and the most likely explanation of the substantial differences between these two hospitals and the other four, is that these two do not use the range of single use MAS instruments that can be employed in this procedure. A report to the Commonwealth by the Australian Health Technology Advisory Committee (Commonwealth of Australia 1996) explained that the high cost of disposable instrument acts as a deterrent to hospitals to widely adopt them. I observed that the alternative non-disposable instruments are time-consuming to dismantle and must be cleaned manually with repeated brushing and flushing through narrow channels, and so on, then reassembled to check that all components are present, and dismantled again with components "bagged" for re-sterilisation. Once in the OR, these instruments must be reassembled by the instrument nurse prior to use by the surgeon, as shown in the example in **Figure 5(v)**.

Figure 5(v): Example of instrument nurse assembling a special instrument used in laparoscopic cholecystectomy prior to use – small components are in centre of tray



Hospitals B and D shared the shortest mean perioperative time for laparoscopic cholecystectomy (110 minutes). Hospital D made maximum use of disposable instruments, whilst Hospital B used a mixture of disposable and non-disposable instruments, but had the practice of two nurses being specialist instrument nurses for laparoscopic procedures. Furthermore, because of the nurses' expertise at Hospital B, it was possible for the surgeon to

commence the procedure using already assembled instruments while the instrument nurse continued to assemble others, resulting in some savings in pre-operative preparation time – an outcome that is only feasible when nurses have the necessary expertise (cf. Kenyon, Lenker, Bax & Swanstrom 1997).

Table 5(f) summarises the estimated increases occurring since 1988 in *perioperative human labour input* to the production of the six procedures for which work process time study was undertaken. It provides convincing quantitative evidence that new intra-operative artefacts, as used in cholecystectomies, colonoscopies, D&Cs with hysteroscopy and TKR surgery, require significantly more HLI than their alternative, replacement or complementary technologies did in 1988. And because of the widespread adoption in most surgical specialities of MAS technologies similar to those employed in laparoscopic cholecystectomy and hysteroscopy (as discussed in Chapter 2), I propose that increases in perioperative HLI can be assumed to have occurred in a large proportion of surgical procedures such as minimally invasive joint surgery (Roth, Richards & MacLeod 1994) laparoscopic fundoplication (Vogt, Curet, Pitcher et al. 1997), laparoscopically-assisted pulmonary resection (Proot et al. 1996), laparoscopic adrenalectomy (Stuart et al. 1995), stereotactic neurosurgery, and many more. The extent of the increase overall is unknown but, using these data as a guide, I suggest that an estimate of between 40 and 50 per cent increase in the *perioperative* HLI to surgical production within OTSs since 1988 is not unrealistic.

Table 5(f): Estimated increases between 1988 and 1998 in perioperative human labour input to production of selected procedures

Procedures	Estimated change in mean perioperative human labour input between 1988 & 1998 technologies
Open Cholecystectomy compared to Laparoscopic Cholecystectomy	+ 54 %
All Colonoscopies	+ 47 %
D&C only compared to D&C with Hysteroscopy	+ 130%
Total Knee Replacement	+ 37 %

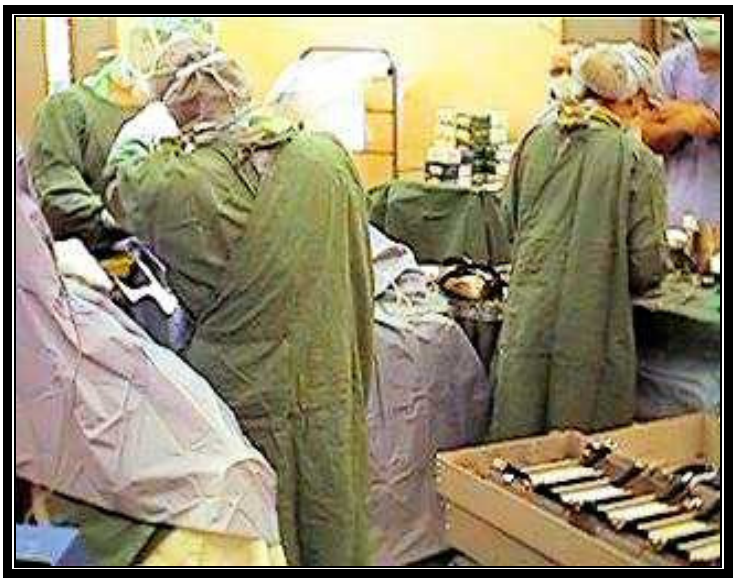
The following section examines changes in all surgical activity at each of the study hospitals between 1988 and 1998, and the *intra-operative* HLI to the six selected procedures at each.

5.5 Intra-operative data

The majority of people outside of the operating theatre service environment have a limited understanding of the nature and volume of the work that contributes to any surgical procedure – a phenomenon that was discussed in Chapter 2 in connection with the *closed workplace*.

However, aided by the media's portrayal of the operating suite, most people would likely envisage something akin to the activities shown in **Figure 5(w)** of nurses and doctors working together during an operation on a patient. However, this picture portrays only the *intra-operative* phase of surgical production – in this case, a surgeon, and surgical assistant, an instrument nurse, and a circulating nurse involved in a TKR operation.

Figure 5(w): A typical surgical team involved in the intra-operative phase of surgical production



The *OTS Surgical Register* contains summary details of all procedures performed within the operating suite. Data include the starting and finishing times of each procedure. From these data, I was able to derive the *intra-operative* times for each of the 30,345 procedures that were performed during the three sample quarterly periods (July- September 1988, April-June 1993, and April-June 1998) in order to calculate, for each hospital and for the five hospitals combined:

- total number of all cases/procedures
- mean and grand mean operating minutes (ie. intra-operative time) for all procedures
- total number of cases of the six selected procedures
- mean and grand mean operating minutes for each of the six selected procedures
- proportion of all cases represented by the six selected procedures
- grand mean operating minutes for the four categories of procedures represented by the six selected procedures.

Appendix A3 Table 3 summarises the mean operating time for each of the six procedures at each hospital, and **Table 5(g)** (following) presents the grand mean operating times for the six procedures for the three sample periods. Raw intra-operative times data collected at three of

the study hospitals for the six procedures are provided in Appendix A2. An example of the summary data from one study hospital (Hospital A) is provided in Appendix A4, and the comprehensive summaries for the five study hospitals are provided in Appendix A3. The differences between hospitals in the proportion of total procedures represented by the six selected procedures (evident in Appendix A3 Table 1) are inconsequential because they are simply a reflection of each hospital's classification relating to its designated level and scope of services. However, the combined activity of the five hospitals highlights the magnitude of the likely impact of the technological changes that have occurred in the six procedures (n=5,746) because they represented 18.94 per cent of all procedures and almost 11 per cent of recorded operating minutes at the five hospitals (summarised earlier in **Table 5(b)** from Appendix A3 Tables 1 and 2).

Table 5(g): Grand mean operating times (in minutes) for the six selected procedures

Procedure	1988/89	1992/93	1997/98
Open Cholecystectomy	98.61	113.56	130.73
Laparoscopic Cholecystectomy	0	96.20	93.96
All Colonoscopies	29.11	25.67	28.96
D&C	13.49	12.75	13.92
D&C Hysteroscopy	0	37.26	28.56
All total knee replacements	135.67	142.85	149.08

Attention is drawn to the fact that there were no cases of laparoscopic cholecystectomy or hysteroscopy in the 1988 data at any of the hospitals – confirmation that these technologies had not been introduced at that stage. Hospital B was a late adopter of hysteroscopy as is evidenced (in Appendix A3) by the fact that no cases were recorded in 1993. It is noticeable that the operating times for these two procedures were longer in 1993 than in 1998. The widely accepted explanation for this is that, by 1998, the "learning curve" of the procedural specialists during the early phase of new technology adoption was over (cf. Zucker 1992) and so the mean operating time reduced.

A reverse trend is evident in **Table 5(g)** for open cholecystectomies whose mean operating time has progressively increased from 98.61 minutes in 1988 to 130.73 minutes in 1998. This can be explained by several factors. First, in 1988 all complicated and uncomplicated procedures were represented in the data but, since the introduction of laparoscopic cholecystectomy, open cholecystectomies that are not attempted laparoscopically tend to be done because of complicating factors that make the operating time consistently longer than an uncomplicated open cholecystectomy performed in 1988. Secondly, and more significantly, approximately 50 per cent of open cholecystectomies performed at the study hospitals during

the sample quarterly period in 1998 were commenced laparoscopically and then converted to an open procedure due to unforeseen circumstances, thereby adding the time spent in the laparoscopic phase to the time taken to complete the open operation. This latter source of increased intra-operative time for open cholecystectomy is an indirect consequence of new intra-operative artefact adoption within OTSs whereby technical difficulties associated with individual patient characteristics or machine failure can necessitate a MAS procedure being converted to an open procedure, or the procedure being aborted altogether. The "snowball" effect of this on perioperative labour is discussed in Section 5.7.

Appendix A3 Table 3, summarised in **Table 5(h)**, shows that the mean operating time for *all* procedures undertaken within OTSs steadily increased over the ten-year period, resulting in a net increase for the five hospitals of 15.85 per cent. This result was unexpected. Indeed, there was a widely held perception amongst this study's informants that the average operating time would be less, or at least no greater in 1998 than it was in 1988. This increase is particularly evident in the example of the *complementary* technology (ie. D&C plus hysteroscopy) which has increased the mean intra-operative time for all D&Cs, with or without hysteroscopy, by 56.7 per cent (see **Table 5(h)**). It is evident, but to a smaller extent in the case of TKRs, which show a net increase of 9.88 per cent. However, the mean intra-operative times of all cholecystectomies (ie. open and laparoscopic cholecystectomies combined) and all colonoscopies are essentially unchanged.

Table 5(h): Summary of grand mean operating times (in minutes) for selected procedures and the extent of change since 1988

Procedure	1988/89	1992/93	1997/98	% change between 1988 & 1998
All Cholecystectomies	98.61	100.09	99.44	+ 0.86%
All Colonoscopies	29.11	25.67	28.96	- 0.52%
All D&C with or without Hysteroscopy	13.49	17.58	21.15	+ 56.7%
All total knee replacements	135.67	142.85	149.08	+ 9.88%
Grand mean minutes for all procedures in OS (N=30345)	**56.10**	**59.35**	**64.59**	**+ 15.85%**

In view of the fact that D&C Hysteroscopies and TKRs represent about 9 per cent of the procedures at the five study hospitals (calculated from **Table 5(b)**), it can be readily inferred that the overall increase of 15.85 per cent in the grand mean intra-operative time for *all* procedures (ie. from 56.1 minutes in 1988 to 64.59 minutes in 1998) cannot be accounted for by the increases in these two procedures alone. Hence, it must be concluded that operating times of many other procedures have also increased during this period, although the procedures involved and the extent of their respective increases or decreases in intra-

operative times are unknown to this researcher. Whilst some insights into these issues could have been interesting, the opportunity cost of the time and effort that would have been necessary to collect the required data from the totally hand-written (ie. non-computerised) records in each operating suite could not be justified.

Section 6.5.1 in the following chapter briefly discusses the inferred cause-effect relationship between the adoption of new intra-operative artefacts and the overall increase in mean intra-operative time. However, at this juncture, I propose that it is not unreasonable to conclude that, on the basis of evidence already presented, the adoption of new intra-operative artefacts has been an important contributing factor in the 15.85 per cent increase in mean intra-operative time reported here. An important consequence for OTSs of this increase has been the diminished maximum output potential of an average operating room (measured in numbers of procedures), *ceteris paribus*.

5.6 Operating theatre services' staffing data

This section introduces the variable, staffing levels, into the analysis of changes in the volume of work occurring between 1988 and 1998. Chapter 4 explained why only the hours worked by nursing and technical staff within operating theatre services were included in this analysis (ie. OTS employees such as porters and clerical staff were excluded). Staffing levels were measured as full-time equivalent (FTE) staff from OTS rosters at each of the five hospitals for the three sample quarterly periods between 1988 and 1998. This provided the means to compare workloads in terms of:

- mean number of cases per FTE per month
- mean intra-operative minutes per FTE per month.

The term, "case" has been used here to refer to one patient episode in the operating suite, during which one or more different *surgical procedures* might be performed.

Although staff rosters have a mandatory seven-year archival period, managers at four of the five operating theatre services had not destroyed older rosters. Consequently, I was able to access data for all three sample periods fairly readily. At the fifth hospital, I was able to retrieve the necessary 1988 staffing data from a hospital annual report. Typically, rosters use codes to differentiate shifts by starting time and duration, and the codes vary from hospital to hospital, so the process of calculating the FTE staffing levels involved the long-hand process of decoding each rostered shift to the number of worked hours that it represented before any calculations could be done. The working staff establishments expressed in FTEs are the mean number of OS nurses and SD technical aides working 38 hours per week over the 13 weeks

of each sample period at each of the five hospitals. The results are presented in **Table 5(i)** and summarised in **Table 5(j)**.

Table 5(i): Levels of staffing and relative workload for each quarterly period for the five hospitals

	Year	Full time equivalent (FTE) staffing levels	Total No. of procedures in OS for each sample period	Total operating minutes for all OS procedures	Cases per Full Time Equiv (FTE) OTS staff per month	Intra-operative minutes per FTE OTS staff per month
Hospital A	1988	23.58	1180	47160	16.68	666.67
B2: Major Non-Metropolitan	1993	26	1141	52285	14.63	670.32
	1998	26.6	1512	73280	18.95	918.30
Hospital B	1988	15	794	28142	17.64	625.38
C1: District Group 1	1993	15.53	918	37584	19.70	806.52
	1998	17.17	1078	42202	20.93	819.46
Hospital C	1988	15.2	1082	44810	23.73	982.68
Private Hospital	1993	16.8	1191	51071	23.63	1013.31
	1998	12.57	948	39076	25.14	1036.27
Hospital D	1988	137.6	5350	369868	12.96	896.02
A1: Principal Referral	1993	129.71	5113	384716	13.14	988.69
	1998	138.13	4957	414448	11.96	1000.14
Hospital E	1988	52.96	1461	63581	9.57	449.87
B1: Major Metropolitan	1993	54.74	1941	85921	11.82	523.24
	1998	46.55	1679	88152	12.02	631.20

Table 5(j): Summary of levels of staffing and relative workload at all hospitals for each sample quarterly period and the extent of change since 1988

	1988/89	1992/93	1997/98	% change between 1988 & 1998
Sum of all FTE at 5 hospitals	244.34	242.78	241.02	– 1.36%
Grand mean number of procedures per FTE per month	13.46	14.15	14.07	+ 4.53%
Grand mean operating minutes per FTE per month	755.19	839.70	908.86	+ 20.35%

The data reveal that all hospitals show significant increases in the *mean intra-operative minutes per FTE per month* – an increase of 20.35 per cent across the five hospitals since 1988 – and that the *mean number of cases per FTE per month* have increased at all hospitals except Hospital D. Hospital D, which undertakes the most complex surgery of the five hospitals, experienced an increase of 11.6 per cent in *mean intra-operative minutes per FTE,* and had a larger real increase in mean intra-operative time (14.5 minutes) than the other four hospitals (range, 0-9 minutes), so the marginal decrease in its *cases per FTE* is inconsequential. The overall increase in *cases per FTE* was 4.53 per cent, but when Hospital D is excluded, the increase in *cases per FTE* for the other four hospitals is approximately 14 per cent.

It can be concluded that, in 1998, proportionately more staff time was spent being directly involved in procedures, *ceteris paribus*, and that the "average nurse" was participating in more operations than (s)he was in 1988. Hospital managers might interpret these results as evidence of increased OTS efficiency in the same way that a production department manager would interpret an increase in finished products per FTE per day as improved production efficiency. However, I propose that the extent of this increased employee work volume might be underestimated, because *perioperative* workload has never figured in any hospital's OTS "efficiency equation". In other words, the 40 to 50 per cent increase in perioperative HLI, estimated at the conclusion of Section 5.4.2, represents additional employee work that is not reflected in the OTS output measures that have been calculated here using only *intra-operative* data.

However, none of this evidence of increased employee workload is sufficient in itself to support an argument that OTS staff are now *over*worked, because they might have been under-utilised in 1988. Rather, at this juncture these results must be viewed only as necessary pieces of evidence in the growing body of data converging on one of the dominant paradigm conclusions of this thesis. They will be discussed in detail in Chapter 6, particularly in Section 6.5, in connection with the topic of managerial expectations of increased employee output productivity resulting from new intra-operative artefact adoption.

That said, it is important to highlight that the preceding discussion has provided an important, but only partial picture of the impact of new intra-operative artefact adoption on the human labour input to surgical production within OTSs. The following section provides brief examples of other factors as they relate to cholecystectomy and D&C Hysteroscopy.

5.7 Changes in total labour input to surgical production

Earlier in this chapter it was mentioned that approximately 50 per cent of open cholecystectomies carried out in April-June 1998 at the study hospitals were converted from laparoscopic cholecystectomy. This means that all of the surgical instruments and equipment involved in each type of cholecystectomy will have been used in each "converted" case and require reprocessing. Hence, the total HLI to a laparoscopic cholecystectomy "converted" to an open cholecystectomy can be approximated to be the intra-operative and perioperative HLI estimated for an open cholecystectomy *plus* the perioperative labour of about 128 minutes associated with laparoscopic cholecystectomy (shown in **Table 5(e)**). At a national level, if 50 per cent of the 8,260 cholecystectomies carried out during the 1996/97 year (see **Table 2(g)**) were "converted", an estimated 8,810 hours of human labour will have been

utilised in accommodating this otherwise unrecognised consequence of technological change in cholecystectomy.

The unrecognised human labour consequences of hysteroscopy carried out in conjunction with D&C are more significant. The data detailed in **Table 5(l)** (in the following section) reveal that hysteroscopy, as a *complementary technology* to D&C, has increased the total HLI per case by about 75 minutes, representing an increase of 123 per cent. For this procedure alone, this would have amounted to an increased national labour requirement of about 72,205 hours for the 1996/97 year during which time 57,557 hysteroscopies were performed in acute public and private hospitals throughout Australia (see **Table 2(g)**).

The following section discusses some of the ramifications of inadequate estimations of the total HLI to producing specific procedures within OTSs. At this juncture, however, I draw attention to the data in **Table 5(k)** (in the following section) which show how the Australian Government's estimated human resource costs for open and laparoscopic cholecystectomy were identical (at $445.79), as were D&C with and without hysteroscopy (at $161.08). The error of such estimates is obvious from the evidence presented in this and the preceding section.

5.8 Critique of National Operating Room Service Weights for selected procedures

This section brings together the previously reported 1997/98 perioperative and intra-operative data for the principal purpose of drawing the secondary (ie. *positivist*) paradigm conclusion of the present thesis. The goal here is to explore how effectively the OTS human resources required to produce the six procedures would be funded, should current cost estimates in the NORSWs be used to do so.

The *perioperative* work process time study data are combined with the *mean intra-operative* HLI for the six procedures to calculate the *mean total HLI* to each at the five hospitals, as well as a *grand mean total HLI* for each procedure at all five hospitals. The resultant data are subsequently analysed in conjunction with the NORSWs' estimated human resource costs to derive a measure of mean funding/budget per minute of HLI to each procedure.

First, the NSW public and private hospitals' data on the frequencies of procedures, provided in Appendix A7 (NSW Health 1998b; 1998c)**,** and the NORSWs and human resource costs data in **Table 2(i)** in Chapter 2 (CDHSH 1995a), were used as the raw data to calculate both the grand mean NORSWs and the Australian Government's deemed average human resource cost of producing each of the six procedures listed in **Table 5(k)**. (The method used to do this was explained in Section 4.8.2 and expanded in Appendix A7.) Because comprehensive

NORSW tables were not published in 1998 to reflect the reduced mean total cost per OR procedure from $1,190 in 1995 to its 1998 value of $973, these data were proportionally adjusted to reflect that change. The results, which are subsequently used to estimate a mean funding/budget per minute of total HLI, are tabulated in **Table 5(k)**.

Table 5(k): Grand mean OR service weights and estimated 1998 OTS human resource (HR) costs for the six selected procedures at all five hospitals

Procedure	Grand mean OR service weight estimated from 1995 data	Estimated HR costs in SD adjusted to reflect lower 1998 average cost	Estimated HR costs in OS adjusted to reflect lower 1998 average cost	Total estimated operating theatre services HR costs in 1998
Open Cholecystectomy	**1.613**	$80.64	$365.15	**$445.79**
Laparoscopic Cholecystectomy	**1.210**	$80.64	$365.15	**$445.79**
All colonoscopies	**0.628**	$41.10	$87.71	**$128.80**
D&C only	**0.520**	$80.95	$80.13	**$161.08**
D&C Hysteroscopy	**0.520**	$80.95	$80.13	**$161.08**
All knee replacements	**6.045**	$104.94	$391.67	**$496.62**

The grand mean *actual* funding per minute of OTS human labour for each of the six procedures were then calculated (as explained in Section 4.8.2). **Table 5(l)** presents the results along with the data used to compute the grand mean funding/budget per minute of HLI to each procedure across the five hospitals. Mean *perioperative* HLI minutes were in a form ready to use in these calculations, but mean *intra-operative* times were doubled to reflect the fact that, for most cases, two nurses (an instrument nurse and a circulating nurse) are involved in each of the procedures for the full intra-operative period.

Table 5(l): Summary of data contributing to the estimated funding/budget per minute of human labour input to the six selected procedures at the five hospitals in 1998

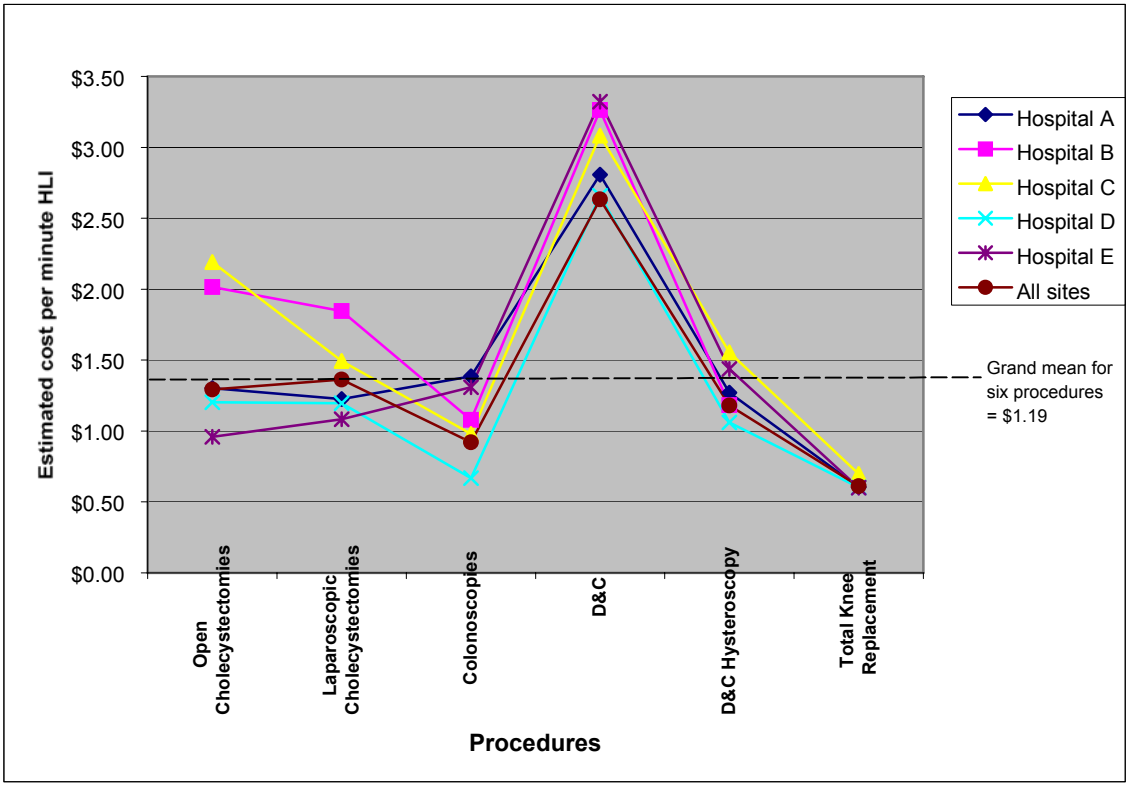
	Open Cholecystectomy	Laparoscopic Cholecystectomy	All Colonoscopies	D&C only	D&C Hysteroscopy	All Total Knee Replacements
Grand mean intra-operative time (minutes)	130.73	99.44	28.96	13.49	28.56	149.08
Total *intra-operative* human labour input (minutes) per procedure	261.46	198.88	57.91	26.98	57.11	298.17
Grand mean *perioperative* human labour input (minutes)	83.11	128.38	82.05	34.18	79.32	514.68
Sum of *perioperative* & *intra-operative* human labour input (minutes)	344.57	327.26	139.96	61.16	136.43	812.85
Estimated National OTS human labour costs per procedure	$445.79	$445.79	$128.80	$161.08	$161.08	$496.62
Grand mean funding/budget per minute of total human labour input to each procedure for all hospitals	**$1.29**	**$1.36**	**$0.92**	**$2.63**	**$1.18**	**$0.61**

For example, the grand mean intra-operative time for open cholecystectomy in 1998 was 130.73 minutes (from **Table 5(g)**), which is doubled to derive the grand mean total intra-

operative HLI to the procedure of 261.46 minutes. This was added to the perioperative time of 83.11 minutes (from **Table 5(e)**) to produce a grand mean total HLI to the production of open cholecystectomy of 344.57 minutes. Then, based on the NORSW-based OTS human resource cost of $445.79 in **Table 5(k)**, the potential funding/budget has been calculated as $1.29 per minute of HLI. **Table 5(l)** summarises the results for each procedure.

Table 5(l) reports that potential funding/budget per minute of HLI across all five hospitals for each procedure ranges from $0.61 to $2.63, and **Figure 5(x)**, using data for each procedure at each hospital presented in **Table 5(m)** (following), provides graphic evidence of fairly consistent results for each procedure at each of the five hospitals.

Figure 5(x): Trend comparison of estimated mean funding/budget per minute of human labour input to the six selected procedures within operating theatre services at five hospitals



The least variance between hospitals occurs for TKR. However, at potential funding per minute HLI for all hospitals of $0.61, TKR would be seriously under-funded if the grand mean value for the six procedures of $1.19 was actually the appropriate level of funding per minute of HLI for all surgical DRGs. On this assumption, the procedure that emerges most favourably for potential funding is D&C (estimated at $2.63 per minute of HLI), whilst potential funding for D&C with hysteroscopy (at $1.18 per minute of HLI) would be quite appropriate.

However, due to the absence of any prior studies on the *total* HLI to surgical procedures, there is no empirical basis against which to compare these results. Hence, the grand mean value of $1.19 must not be interpreted as a benchmark for all surgical DRGs, but rather, only as a basis of demonstrating the variances occurring in the six procedures studied in the present thesis. In other words, I cannot present these results in terms of potential under-funding or over-funding.

A similar approach was used to estimate the grand mean funding/budget per minute of HLI required to produce each hospital's sample casemix (ie. their individual volume of the six procedures reported in Appendix 3 Table 1) during April-June 1998. **Table 5(m)** presents the results of that analysis and reveals potential funding/budget at each hospital ranging from $0.97 to $1.77 per minute of HLI. These results serve to reinforce the anomalies already discussed.

Table 5(m): Grand mean funding/budget per human labour minute for each hospital's casemix of the six procedures in 1998

	Hospital A	Hospital B	Hospital C	Hospital D	Hospital E
Open Cholecystectomies	$1.30	$2.01	$2.19	$1.20	$0.96
Laparoscopic Cholecystectomies	$1.22	$1.85	$1.49	$1.20	$1.08
Colonoscopies	$1.39	$1.08	$0.98	$0.67	$1.31
D&C	$2.81	$3.26	$3.08	$2.66	$3.32
D&C Hysteroscopy	$1.27	$1.18	$1.56	$1.06	$1.44
Total Knee Replacement	$0.60		$0.70	$0.60	$0.60
Grand mean funding/budget per human labour minute at each hospital for six procedures	**$1.43**	**$1.77**	**$1.06**	**$0.97**	**$1.23**

In each of the six procedures, at least one hospital's mean funding/budget per minute is statistically different at Crit t = ±2.7765 (p=0.05 and 4 df). For example, for laparoscopic cholecystectomy, Hospital B's value of $1.85 per minute is significantly different to the mean value of $1.36 ($t$ = +3.53), and Hospital C's result for D&C Hysteroscopy of $1.56 per minute is significantly different from the mean value of $1.18 ($t$ = +4.25). In my view, these and other statistically significant differences are most likely the results of efficiencies achieved by the hospitals concerned arising from some economies of both scope and of scale (cf. Folland et al. 1993). This is achieved, for example, in the case of laparoscopic cholecystectomy at Hospital B, by its high volume (n=112, or 10.4 per cent of all procedures) and the expertise of the staff resulting from their frequent participation in the procedure. I propose that this is another example of the normal variation that I discussed earlier.

The very important observation, however, is that there is an overall trend for different procedures to be funded for their actual minutes of HLI at significantly different rates. Yet, in practice, the cost of an "average minute" of human labour for one procedure is the same as any other. From an OTS management perspective, human labour costs per minute do not vary from operation to operation, and so, for the human resource costs represented in the NORSWs to be deemed reliable, the range of the variation evident in these results, should not exist. Erroneous estimates for very low volume DRGs might be of little consequence in most OTS human resource budgets, but these six procedures accounted for 20.3 per cent of all procedures at the five hospitals between April and June 1998 (calculated from Appendix A3 Table 1), and the budget implications could be substantial. Consequently, I propose that a situation in which one of these procedures (eg. D&C) is potentially funded at a rate that is 430 per cent higher than another (eg. TKR) demands further investigation.

This leads me to what I propose is a probable source of the error. In Chapter 2, I outlined the history and purpose of the NORSWs, and highlighted that the process engaged by the consultancy firm that undertook the study was essentially a "desktop analysis" that relied on existing organisational data. *Intra-operative* data reported in the *OTS Surgical Register* represented the only category of quantitative data pertaining to the HLI to surgical procedures. Hence, intra-operative times were used as the basis for estimating perioperative HLI by the *pro rata* apportioning of all OTS staff time not accounted for by the time spent actually doing the procedures. This means, for example, that a procedure having a mean operating time of ten hours is assumed to require ten times the perioperative HLI of a procedure with a mean operating time of one hour.

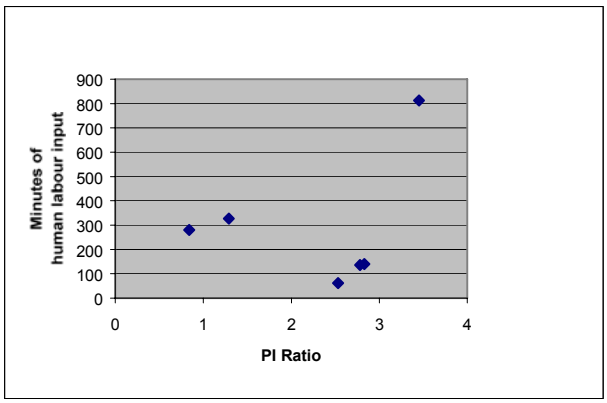
Table 5(n) reports the total HLI into each procedure along with an innovative measure, that I have called the *PI Ratio* (ie. the *Periop-Intraoperative Ratio*), which expresses grand mean perioperative HLI as a proportion of the grand mean intra-operative time for each procedure using data reported originally in **Table 5(g)**. A *PI Ratio* equal to 1 means that total perioperative HLI equals the intra-operative time.

Table 5(n): The *PI Ratio*: Perioperative HLI as a proportion of intra-operative time for each procedure

Procedure	Grand mean perioperative HLI (mins)	Grand mean intra-operative time (mins)	PI ratio
Open Cholecystectomy	83.11	130.73	**0.64**
Laparoscopic Cholecystectomy	128.38	93.96	**1.37**
All colonoscopies	82.05	28.96	**2.83**
D&C only	34.18	13.49	**2.53**
D&C Hysteroscopy	79.32	28.56	**2.78**
All knee replacements	514.68	149.08	**3.45**

With results ranging from 0.64 to 3.45 for the six procedures, these *PI Ratios* serve to reinforce that this research does not support the notion that perioperative HLI to a procedure is directly proportional to intra-operative time. The scatterplot in **Figure 5(y)** graphically displays the disparities between the *PI Ratios* and the total minutes of HLI to each of the six procedures.

Figure 5(y): Scatterplot of the PI Ratio and total human labour input for the six procedures



5.9 Conclusion

This chapter commenced with an overview of the characteristics and relative activity of the five study hospitals. It then introduced and described, in detail, the various surgical procedures and their associated technologies, thereby providing the contextual background for the analysis of the volume of human labour input to their production and the changes that have occurred within OTSs, between 1988 and 1998, as a result of new intra-operative artefact adoption. Overall, it was concluded that the net effect of new intra-operative artefact adoption has been a substantial increase in the human labour input required to produce surgical procedures within OTSs.

The chapter then analysed the current Australian Government estimates of the human labour costs associated with producing these procedures within OTSs, and, in so doing, introduced an innovative measure, the *PI Ratio*, as a means of reinforcing other evidence that has contributed to the conclusion that: *the estimated costs of the human resource component of the Australian Government's National Operating Room Service Weights for specific surgical procedures by designated Diagnostic Related Group (DRG) do not accurately reflect the volume of human labour input to their production*. This conclusion represents the secondary *(positivist)* paradigm outcome of this thesis.

The following chapter presents the *naturalistic* paradigm results and conclusions of the present research and culminates with a discussion that brings together the evidence in support of the dominant paradigm proposition of the present thesis.

Chapter 6

New intra-operative artefacts: Goals, choices and consequences

6.1 Introduction

This chapter presents the *naturalistic* paradigm results and conclusions of the present research concerning the goals, the choice-making process, the characteristics of technological change, and the organisational consequences of the adoption of new artefact technologies in the operative phase of surgical production within operating theatre services in NSW hospitals between 1988 and 1998. It culminates with a discussion that brings together the evidence in support of the dominant paradigm proposition of the present thesis: that the process and organisational consequences of new intra-operative artefact adoption cannot be explained using the set of theories and management perspectives to which I have collectively referred throughout the thesis as the techno-economic theories of production.

Consistent with the mixed methods, mixed methodology design outlined in Chapters 1 and 4, this chapter presents data derived from the many interviews, informal conversations and participant observations in the field, and interprets them, often in conjunction with quantitative data presented in Chapter 5. The qualitative data were collected until a point of saturation was reached and, following a thematic analysis of the textual data, conclusions have been drawn, primarily using the technique of data triangulation.

Most of the present chapter is dedicated to answering the five research questions that arose from the dominant paradigm research proposition, and it is structured, consistent with the sequence in which the associated topics in the literature were reviewed in Chapter 3, to address each of them in the order in which they were originally posed:

1. What are the dominant technical characteristics and functional goals of new intra-operative artefacts adopted between 1988 and 1998?
2. What are the benefits expected by key internal stakeholders of adopting new intra-operative artefacts?
3. What are the actual consequences for surgical production within operating theatre services of new intra-operative artefact adoption?
4. Are the consequences for surgical production within operating theatre services of new intra-operative artefact adoption congruent with expectations and, if not, why not?
5. By what processes are decisions made to adopt new intra-operative artefacts, and how are the benefits expected by key internal stakeholders of adopting them influential in these decision processes?

The first of these questions has already been partly addressed in Chapters 2 and 5. For example, Chapter 2 included a brief history from the literature of the evolution of surgical technologies and a review of a range of clinical and health economics literature dealing with the benefits of adopting particular technologies in the types of procedures that were selected for study in the present thesis. It provided evidence that the main functional goal of new intra-operative artefacts is to improve the process and/or outcome of the treatment of disease in individuals (ie. patients) by means of *process innovations* or *product innovations*. It also introduced some of the general technical characteristics of new intra-operative artefacts, a topic that was taken up in Section 5.3 when the technologies associated with the six selected procedures were described in detail.

Chapter 2 also presented an important outcome of the present research in the form of my classification and definition of surgical technologies and a conceptual model of their process relationships in surgical production (see **Figure 2(a)**). This was incorporated early in the thesis to establish the set of terms pertaining to *surgical technologies* that would be used throughout. Section 6.3 will further explain the model.

The present chapter expands on previous discussions about the *technical characteristics* and *functional goals* of intra-operative artefacts using the theoretical framework provided in Chapter 3. For example, Section 3.3 showed how increasingly sophisticated machines have been developed to achieve a variety of strategic outcomes for organisations, such as improved product quality and increased cost-efficiency, and how *automation* leading to labour displacement is implicit in most of these strategies. The present chapter provides persuasive evidence that new intra-operative artefacts do *not* automate the human activities contributing to the intra-operative phase of surgical production, and builds on evidence presented in Chapter 5 to conclude that they do *not* provide the potential to displace labour.

The chapter then explores the expected and actual organisational outcomes of new intra-operative artefact adoption, issues that are central to research questions 2, 3 and 4. The themes covered in the literature review in Chapter 3, in Sections 3.3.2 and 3.3.3, provide the empirical framework for analysing the evidence derived from the research process on these questions. The present research reveals that clinicians are primarily motivated to adopt new surgical technologies for *altruistic* reasons that reflect their belief that patients' best interests will be served if they do so. The procedural specialists see themselves as the drivers of most technological change in surgery, and will not continue to use a technology (ie. artefact or technique) that does not fulfil their clinical expectations. Consequently, new intra-operative artefact adoption is rarely a simple case of "choosing and using", and a largely hidden aspect

of this process is trialing many new intra-operative artefacts that never end up being adopted. And even when a choice has been made, incorporating the new artefact into practice typically involves incremental adjustments in technique, and possibly the adoption of other artefacts, until the procedural specialist is satisfied with the overall process and its outcome – a process that is repeated when other innovations emerge in one or other procedure.

The present research reveals that managers' expectations, and the strategies they put in place within their organisations, concerning the acquisition of new intra-operative artefacts, are strongly influenced by the strategic return-on-investment, techno-economic logic associated with new technology adoption in manufacturing firms. Moreover, this orientation leads them to erroneous expectations that the adoption of new intra-operative artefacts should create opportunities either to displace labour or to increase employee productivity and/or OTS throughput to accommodate increased hospital capacity arising from reduced lengths of stay.

In this connection, Chapter 5 reported the increases that have occurred during the ten years from mid-1988 to mid-1998 in the human labour input to surgical production. It provided evidence of both a 15.85 per cent increase in the average operating time of all procedures and significant increases in the volume of human labour input to the perioperative phase of production of some high volume procedures that had undergone technological change during the ten years. These latter increases ranged from around 37 per cent in the case of total knee replacement to 130 per cent in the case of hysteroscopy employed as a complementary technology with diagnostic curettage of the uterus. The present chapter now draws on the qualitative data to explore the causes of these increases, which derive principally from:

- increases in the complexity and specialist nature of new intra-operative artefacts
- frequent new intra-operative artefact adoption and the high volume of artefacts trialed but not adopted, and
- increases in the manual labour involved in the perioperative phase of surgical production.

The present chapter discusses how these outcomes are inconsistent with the pervasive theme of the techno-economic literature that generally equates "new technology" with automation, work simplification, labour displacement, and the economic benefits accruing to an organisation when it adopts new artefact technologies.

The final research question concerns the nature of, and influences on, the new intra-operative artefact decision processes within hospitals. The very asking of a question about decision processes assumes that human agency is active in the new intra-operative artefact adoption activities that are the focus of the present research. In this connection, in Section 3.2, I presented my *mediated attribution perspective* on the technological determinism/voluntarism

debate. This perspective posits that, within organisations, "all new technology can be *attributed* with the power to transform organisational structure somehow (ie. effect change in some entity and/or process), …but its capacity to do so is *mediated* by individual and/or collective human agency"; hence, the organisational structural consequences of adopting a new technology are the products of both the characteristics of the technology *and* human agency. This perspective provides the theoretical foundation for an innovative 7x2 matrix that I have entitled *a situational stakeholder participation and adjustment matrix of technological change*. It provides an analytical framework by which to explain the specific *decision roles* and new technology *receiver status* of individual stakeholders in specific new intra-operative artefact adoption scenarios, along with the consequences for *receivers* of new intra-operative artefacts.

6.2 New intra-operative artefacts: Functional goal, main technical characteristic and main reasons for adoption

This and the following section continues my response to the first and second research questions. On the issue of the main *functional goal* of intra-operative artefacts, it provides support for the prevailing view in the medical literature that the main functional goal of technological change in therapies and diagnostic procedures is to improve the process and/or outcome of the treatment of disease by means of *process innovations* or *product innovations* (cf. Hirsch 1994; Doessel 1992; Brewer 1983). It shows that achieving this goal is exactly what procedural specialists want for their patients – that their main reason for adoption is *altruistic*, insofar as they expect their patients to benefit more from them doing so than if they continued to use established technologies.

How new intra-operative artefacts contribute to the achievement of this goal is comprehensively discussed later in this chapter but, at this juncture, it is important to bring attention to the fact that they do not automate the surgical process. In other words, the *dominant technical characteristic* of new intra-operative artefacts is not automation. Of particular interest to me, as researcher, was that no clinician volunteered a perspective on the issue of automation without an opportunistic question such as the one I posed to a general surgeon: *"would it be correct, then, to say that these technologies are facilitating a new approach to surgery?"* He replied: *"Yes that's all they do. They don't replace people. I mean there's still the same number of people, if not more people needed with these technologies. They just facilitate. They don't replace or take over"* (Informant VZ002).

An extract from my interview with an OS nurse explains this phenomenon in relation to an innovative MAS approach to removing a calculus (ie. a stone) from a ureter:

"They go in now to get a stone out of the ureter using an instrument called a ureteroscope... It's more intricate precision-type surgery… I mean how amazing to think that they can put a little catheter up there, go past the stone, open the basket and then pull all that out to save the patient having to have open surgery" (Informant DX010).

The following description given by a Gastroenterologist-Endoscopist of the various technologies that have been progressively adopted into his clinical practice since about 1988 explains some of the functional goals of a number of intra-operative artefacts. His frequent reference to himself as being the operator and controller of the various sophisticated surgical instruments serves to reinforce that these are non-automating technologies. He said:

"Take, for example, the development and use of thermal devices for various things. When I say thermal devices, these are bits of equipment which have [something] like a heater probe which goes down the endoscope [and] when you use the diathermy device it heats up the end of the probe. You can use that for stopping bleeding vessels in ulcers… The use of lasers …we can use those for stopping bleeding lesions which lead to chronic slow bleeding – things like arterio-venous malformations in the stomach or the colon which can lead to chronic blood loss and transfusions repetitively. Usually we can adequately treat them either with the laser… or there's even a newer device that's come out which is called an argon plasma coagulator and that's a bit of equipment where basically you put an electrical current through an ionised gas, which is argon, and if you're at an appropriate distance from the wall of whichever part of the bowel you're treating, the current goes through this ionised gas and coagulates that blood vessel. You can use it for treating tumours as well. That's only really been available, I guess realistically the last three or four years" (Informant DZ002).

When I posed the question, *"what are the factors that influence you to adopt new technologies?"* to an orthopaedic surgeon, his reply indicated a similar primarily *altruistic* motive for adopting new technologies (cf. Smith 1776, reproduced in Skinner 1970:44), although some *self-interest* goals (cf. Babbage 1832; Richardson et al. 1991) were also evident:

"The single most important factor is the patient. There's no question about that. They are the person that drives me… When you're a specialist you know a lot about a little so, you need to be a personality that will get satisfaction from doing something repeatedly, but better than the next person. So there's a bit of self-competition. Like

playing golf. What drives a person to go back onto a golf course? …They want to get a score better than last time. And so you go back, and you want to get better than you were last time with this problem for the patient's sake" (Informant DZ001).

Like the previous informant, a Gastroenterologist/Endoscopist indicated that the benefits to patients were paramount, and that other benefits might also accrue to him – in this case, greater ease of use of the equipment (cf. Berguer 1997). He remarked:

"If the new technology is clearly going to be of benefit to the patient in terms of less morbidity or less mortality, averting more invasive surgery, less hospital stay, then that's clearly a major factor in whatever technology we use. And then, if the technology is also easier to use for the operator, in terms of ergonomically easier to use, then that would be the second factor that would really influence what we do" (Informant DZ002).

The *self-interest motive*, although secondary, is evident in other ways. For example, based on their professional interests and the types of technologies that are sources of work satisfaction, procedural specialists are prepared to devote the time, energy and money to learning and gaining proficiency in using selected new technologies – something that has ramifications for the business side of their practices (cf. Escarce 1996; Commonwealth of Australia 1996). For example, a general surgeon practising in regional NSW remarked:

"When [laparoscopic cholecystectomies] first started to take off one of my colleagues was very keen. He was the first doing them west of the mountains [but] I kept going with the opens for a while and then I realised that laparoscopic was the way to go, so I used to refer all my gall bladders to him. Then it started to look like laparoscopic was going to be… you know, people started doing hernias, they were talking about bowels and I thought, geez, I'd better learn myself [because] I wasn't prepared to let all that go. So the amount of work I was doing was driving me a little bit because of the financial side" (Informant VZ002).

When an OS nurse manager raised the matter of the extra work associated with the adoption of new intra-operative artefacts (discussed later), I asked, *"well then, who is the winner with all of these new [minimum access] technologies?"* She replied: *"Well I believe the winner is the patient. I say that because they've had less traumatic surgery, they're in hospital for less time"* (Informant DX010).

Top managers, despite their non-clinical roles and responsibilities, are also acutely aware that benefit to patients is the primary goal of adopting new clinical technologies in any area of the hospital. For example, one reflected:

"I can remember one particular person who would say, 'whenever you're thinking about these things you've just got to think about the patient', and that is something that's stuck with me. It is important when you're in the business side of the organisation to try and inject that as a balance to being hard nosed… There's a constant tension between business decisions and decisions that really impact on patient care and people as human beings" (Informant BY003).

6.3 Surgical technologies and their process relationships in surgical production

Any occasion of adopting a new intra-operative artefact can set off a chain of events that has consequences for both intra-operative techniques and organisation, and perioperative technologies (ie. perioperative artefacts, techniques and organisation) throughout an OTS. The third research question asks, "what are these consequences?"

However, before seeking to answer that question, the various surgical technologies that contribute to surgical production are described using the framework provided by my conceptual model (introduced in Section 2.5.1) of *the classification of surgical technologies and their process relationships in surgical production*. In so doing, more technical characteristics of intra-operative artefacts emerge and the core characteristics of the model, supported by examples of the qualitative evidence that guided the development of its content and structure, are reiterated. This model (see **Figure 2(a)**), with its classification system and associated definitions of the various surgical technologies, is one of the outcomes of the present research.

The classification system's "base" of *intra-operative artefacts* reflects the focus of the research on the process and consequences of adopting new intra-operative artefacts in surgical production. Three categories have been defined: *surgical instruments*, *surgical materials*, and *enabling equipment*.

6.3.1 Intra-operative artefacts

Surgical instruments

As explained in Section 2.5.1, s*urgical instruments* are tools/implements/devices used directly on the patient and manipulated by a member of the *operative team* during the operative phase of surgical production. A hospital General Manager, who was formerly a nurse, drew attention to the changes that have occurred in surgical instruments when she reflected: *"Not that long ago, the instruments that you used were nice stainless steel things… They didn't wear out and they were always there, and you got them resharpened and away you went. It's very different now"* (Informant BY001).

These “nice stainless steel” instruments still represent the majority of surgical instruments and, being reusable, they require reprocessing using *instrument (re)processing technologies* that usually involve a combination of manual and mechanically-assisted processes, and machine sterilisation. These instrument reprocessing technologies were comprehensively described in Section 5.4.1, and the labour process ramifications for instrument reprocessing of adopting new *surgical instruments* are discussed later in this chapter.

All of the OS nurses and SD technical aides said something in their interviews about how the technical characteristics of multiple use (ie. *reusable*) surgical instruments used in MAS made them difficult and time consuming to clean. Some informants explained how the national sterilising standards (Standards Australia 1998) mandated that reusable MAS instruments must be fully dismantled for cleaning. This presents problems for the hospitals because the instruments are *“expensive, break easily, and are difficult to take apart”* (Informant EY001). Some hospitals have resolved this problem by averting the reprocessing and potential repair costs with the adoption, in many instances, of *single use* instruments. A top manager elaborated by saying: *“While we try to reduce costs, there are areas that you can’t, and infection control is one of the biggest. It has probably been the area where we have spent more money recently, in the operating theatres in particular, because of the increase of single use items”* (Informant CY002).

Many OTS staff use the term, “disposable” when they refer to single use instruments. However, until the early 1990s, the term, “disposable” had been used primarily to distinguish *surgical materials*, such as bandages or surgical sponges that were (but are no longer) reprocessed, from other materials such as surgical swabs and catheters that were discarded after one application. The term, “disposable” now differentiates *reusable surgical instruments* from the ever-increasing number of sophisticated *single use instruments* or *single use instrument components* used largely in procedures employing MAS technologies. For example, it was in the context of a discussion about MAS that an OS nurse remarked, *“we use a lot more disposable stuff now than we used to”* (Informant DX003).

Single use and reusable instruments are employed in a wide range of endoscopic procedures, but the reasons for choosing certain combinations varies from hospital to hospital. Many OS nurses spoke of reasons, such as the constraints imposed by the sizes and designs of their OTSs, the high cost of disposable instruments, and the difficulties associated with trying to minimise costs whilst ensuring quality and safety for patients. For example, all of the study hospitals, like the majority within NSW, were designed and built before the MAS “explosion” that occurred from 1990 onwards. Consequently, their sterilising departments,

and the reprocessing technologies in them, were not designed to handle substantial quantities of reusable MAS instruments. An OS nurse explained: *"We're using a lot of disposable lapro-gynae instruments at the moment… I think it is safer for the patient to use disposables because our CSSD doesn't really have the technology for cleaning those fine cannulated instruments"* (Informant AX004).

However, the cost of single use instruments is high. For example, the *single use* versions of the reusable trochar and cannula sets employed in laparoscopic surgery (shown in **Figure 5(a)**) cost in excess of AU$500 for four per patient. Consequently, some hospitals, such as Hospital B, have elected to continue to use their reusable instruments, but with *single use* components to overcome the problems associated with gas leakage from the abdomen resulting from the rubber washers in the cannulae perishing from age and multiple usage.

Another important example of a single use surgical instrument is the surgical stapler. It brought with it an entirely new technology for clamping blood vessels during surgery and, as the following example highlights, the anastomosis (ie. re-joining) of the bowel after a diseased section has been removed. A general surgeon explains:

> *"The other technology and techniques in the last ten years has been with staplers for bowels. I think staplers are certainly better than hand sewn anastomoses for anterior resection and we're tending to use them for all anastomoses now virtually because they are as good as, if not better than, hand sewn"* (Informant VZ002).

Although the stapling devices are discarded after use in a procedure, many are designed to be reloaded with a cartridge of additional staples for multiple "firing" within a single procedure.

Figure 2(a) showed the process relationships of both *single use* and *reusable surgical instruments* with *perioperative technologies* which, in the case of the former, involves resupply via *inventory management technologies*. This, like *surgical materials* discussed following, may be facilitated via automated on-line ordering from suppliers (Dowling 2001), although none of the study hospitals had such sophisticated ordering systems. *Inventory management technologies* include not only *hardware/artefacts* such as computer systems, card-based filing systems, but also the *techniques* and *organisation* aspects of technology that include the human functions of receipting, storage, and distribution of inventory items to points of use within the operating suite.

Surgical materials

Surgical materials are articles of any kind (exclusive of *surgical instruments*) that are manipulated by any member of the operative team during the operative phase of surgical

production. I have categorised them as *prostheses*, *patient in situ items* and *ancillaries*. During the late 1980s, some *surgical materials* were reprocessed, but now all are intended for *single use* only.

Prostheses are permanent and semi-permanent implanted items, such a cardiac pacemakers, artificial knee joints, vascular grafts, and intra-ocular lenses. *Patient in situ items* are items that are left post-operatively, usually temporarily, in a patient, but for therapeutic, non-prosthetic purposes. Examples are urinary catheters, wound drains, surgical staples, and sutures. The surgical staples described previously are categorically *surgical materials*, but when they are used within the body, for example, instead of sutures in bowel resection, they are categorically *patient in situ items* that are not removed.

Ancillaries are customarily single use items used during the course of the procedure that are categorically not any other type of surgical instrument or material. They include surgical swabs and sponges, syringes, suction devices, arterial balloon catheters, and irrigation catheters. As mentioned previously, all types of *surgical materials* are used during only one procedure and either discarded immediately after the procedure, or, as is the case for *patient in situ items*, discarded when they are removed from the patient. They are re-supplied via *inventory management technologies*.

Enabling equipment

The term, *enabling equipment*, refers to the diverse machines employed during the operative phase of surgical production. Items are typically electronic, and may possess some algorithm-based "machine intelligence" that is usually supplied by the types of computing technologies that are associated with "programmable automation" in production industries (cf. Matthews 1989). Many examples of enabling equipment were pictured and described in Section 5.3 in connection with laparoscopic cholecystectomy, colonoscopy, and hysteroscopy.

My decision to use the term, *enabling*, serves to highlight that such equipment *does not automate* any part of the surgical process (as previously discussed). Overall, their built-in intelligence does not perform functions that would otherwise be performed by humans. In other words, with rare exceptions, such as the surgical robot (discussed later), they are not designed to displace human labour (cf. Zuboff 1988; Probert 1989; Thomas 1994). Rather, the main *technical goal* of the diverse enabling equipment observed during the course of the present research is only to *facilitate* the operation of the sophisticated surgical instruments used and controlled by one or more members of the surgical team during the operative phase of surgical production.

The function of the built-in machine intelligence of *enabling equipment* is most frequently to provide digital or other functional displays and operator alerts in the events of machine malfunction and/or pre-programmed or operator-programmed safe operating parameters being exceeded. Even the fairly recent phenomenon of the surgical robot functions under the voice-control of an operator-surgeon. Its function is actually very basic, insofar as it is typically employed in MAS procedures to hold the operating telescope steady and change direction in pre-programmed increments on command. None of the study hospitals were in possession of one during the study period. The surgical robot serves to replace a human operator – the surgical assistant, and is the only example of human labour displacement, or more accurately, role-displacement, resulting from new intra-operative artefact adoption, that has come to light in the course of the present research. I have said "role displacement" because I suspect, based on my observation of a demonstration at a trade display in 1998 by a biomedical company representative and my observations of other instrument reprocessing whilst in the field, that the perioperative work involved in setting it up, dismantling it and maintaining it, although unquantified, would be time consuming. Consequently, the net effect is more likely that of replacing one human factor of surgical production with another at a different phase of production, albeit at a lower human labour rate of employing nurses and technical aides rather than a surgical assistant. However, the capital cost of a surgical robot is very high, its diffusion is low (although this could change as its potential for use increases), and its voice-recognition facility must be programmed for every potential operator-surgeon who must be up-skilled to use it.

The topic of surgical robotics emerged during the course of my interview with a general surgeon (Informant VZ002):

> Informant: *The concept of robots and things… you might get a robot to hold a retractor or something.*
>
> Researcher: *Can you envisage a day where any of those technologies take away some of those roles from the surgeon?*
>
> Informant: *Not really. What's blocking people is they think of robots doing laparoscopic gall bladders like we do them now, only with a robot. That's childish. I think there will be new technology…*
>
> Researcher: *But will it still be under the control of the surgeon?*
>
> Informant: *Well it may not be a surgeon… but, yes, it will be done by someone, a specialist, perhaps a radiologist.*

This surgeon's comments are in stark contrast to the media portrayal of "high tech" surgical innovations such as the surgical robot (eg. *Under the Knife,* 12 April 2001). Their reporting tends, by omission, to convey the "simplification-automation and labour displacement message" of much of the socio-technical literature (eg. Braverman 1974; Littler 1988; Adler 1992; Hirschhorn 1984) that goes back to the likes of Adam Smith (1776, in Skinner 1970:46) who observed that 'machines facilitate and abridge labour and enable one man to do the work of many'.

Towards the end of my interview with an endoscopy nurse, the topic turned to the goals of new technologies and I had the opportunity to explore her thoughts on whether the new artefacts could displace staff. She replied:

> *"No. It just adds to our workload. No. We haven't lost staff. I think we've actually gained a staff member since I've been here. Things have become more difficult and complicated …we needed more staff because most of the stuff we've got needs to be cleaned and looked after. No. It doesn't replace nurses"* (Informant DX011).

OS nurses were always emphatic when expressing their views on this topic. For example, in one conversation I sought to clarify something the nurse was saying, and asked, *"so, adopting the new technologies hasn't been driven by trying to replace somebody's job with a machine?"* She replied, *"Oh no! I don't see it that way at all!"* (Informant DX009).

Comments such as the preceding three are typical of many that were made about *enabling equipment* and their associated *surgical instruments*. The extracts serve to highlight that reports in the post-1980 literature of reducing the physical component of human labour via operators watching through an interface and pushing the buttons that operate the machines, as well as operator-less machines (eg. Adler 1992; Williams 1992; Hirschhorn 1984; Zuboff 1988; Cockburn 1983) could not be further from the reality where new intra-operative artefacts are concerned.

Medical imaging-assisted surgery is another case in point. Several informants at the largest of the study hospitals (Site D) talked at length about stereotactic neurosurgery (Wadley et al. 1999) – also known as computer aided neurosurgery (cf. Visarius 1997) – that had been adopted early in the study period. This involves the use of medical imaging technologies to pinpoint brain lesions to facilitate their treatment via MAS or to act as a guide to a neurosurgeon to locate the lesion during open surgery. However, *"there's a lot more instrumentation… [and it's] far more technical than it used to be"* (Informant DX003) for the OS nurses, but the patient benefits greatly from having a less invasive procedure on his/her brain in which the risk of post-operative complications is significantly reduced and recovery

time shortened (cf. Apuzzo 1996; Rosenfeld 1996; De Salles & Lufkin 1997). Nurses reported that it is more time consuming to set up than predecessor technologies and much of the equipment is cumbersome.

Finally, the *enabling equipment* in the procedure of colonoscopy, for example, comprises all of those peripherals to the colonoscope that make it possible to inflate the colon with air, pump water into it and aspirate fluid from it, supply the "cold light" that is transmitted via the fibre optics built into the colonoscope to illuminate the colon, and continuously transmit the images onto the television screen. They constitute the colonoscopy "stack" of electronic equipment, shown in **Figure 5(j)** and described in Section 5.3.2. Without this enabling equipment it would be impossible for the procedural specialist to perform the colonoscopy or any associated procedures such as tissue biopsies, removal of polyps, cauterisation of bleeding vessels, or laser treatment to tumours. In most cases, other types of enabling equipment and surgical instruments are required when these procedures are performed. For example, when removing polyps, the polypectomy snare is connected to an electrical lead that plugs into a diathermy machine, shown in **Figure 5(h)**, that supplies the electrical current necessary to cauterise the blood vessels to the polyp. The electrical circuit is completed with an electrode being affixed to the patient and its connecting cable is plugged into the diathermy machine. The proceduralist selects the level of electrical current that will be used, and the entire procedure is controlled and completed by him/her.

6.3.2 Perioperative technologies

The concept of *perioperative technologies* was introduced in Chapter 2. In the present thesis it refers to the *artefact*, *techniques*, and *organisation* aspects of technologies associated with the (re)processing, maintenance, and management of intra-operative artefacts during the *perioperative* phase of *surgical production*. I have categorised them as *instrument (re)processing technologies*, *equipment maintenance technologies* and *inventory management technologies*. The present thesis limits its study of perioperative technologies to those within the OTS that change as a consequence of the adoption of new intra-operative artefacts.

Perioperative technologies associated with instrument (re)processing and inventory management have already been discussed, and are further discussed in the context of discussing other issues in the present chapter. So my attention turns briefly to *equipment maintenance technologies*.

OS nurses customarily undertake the day-to-day, point-of-use trouble shooting and between-use care and maintenance of certain *instruments* (such as endoscopes) and *enabling equipment* during the course of their perioperative work. However, the ongoing maintenance

and repair of *surgical instruments* customarily occurs as part of the *instrument reprocessing* activity, and generally occurs in the sterilising department. Activities include checking the alignment of the teeth on dissecting forceps, sharpening scissors, testing the integrity of the electrostatic coating on diathermy leads and forceps, and checking and tightening screws in the joints of instruments. As a SD technical aide explained: *"We just keep checking everything works, and keep checking all the screws are done up properly… and keep reminding people to keep checking them"* (Informant DX007).

The periodic servicing/maintenance of instruments, such as colonoscopes, and enabling equipment, such as diathermy machines and diverse electronic equipment employed in MAS, is undertaken by biomedical engineers as part of the quality control programs within hospitals. An endoscopy nurse explained:

> *"We do microbiological testing on them on a monthly or three monthly basis, depending on the 'scope. We leak test them. We have a very good biomedical engineering department and they come and look at them periodically because they've got angulations and all these fiddly little things on them… and they come and check them and take them off to tighten them or do other maintenance"* (Informant DX011).

However, because these latter activities are undertaken outside the OTS by non-OTS personnel, they are not included in the analysis of perioperative work in the present thesis.

6.4 Changes in surgical production: 1988-1998

This section provides answers to the third research question concerning the consequences for surgical production within OTSs of new intra-operative artefact adoption. It discusses how increases in the volume, diversity and technical complexity of new intra-operative artefacts, since the late 1980s, have resulted in substantial changes in the nature and volume of work of the *receivers* (defined in Section 2.9) of those new intra-operative artefacts. The main changes and their consequences are discussed under four sub-headings:

6.4.1 Increased volume of specialist, sophisticated intra-operative artefacts

6.4.2 Increased technical complexity of intra-operative artefacts

6.4.3 Ad hoc, short-lived changes in intra-operative technologies

6.4.4 Structural characteristics of surgical production

The evidence presented on each of these topics combines to show how different the consequences of new intra-operative artefact adoption are to those described in techno-economic, return-on-investment interpretations of technological change.

6.4.1 Increased volume of specialist sophisticated intra-operative artefacts

This section discusses the rapid increase, since the late 1980s, in the volume of sophisticated intra-operative artefacts that are designed for dedicated specialist applications. Along with the high cost of new intra-operative artefacts, this has led to a growth in the practice of biomedical companies hiring out sets of instruments for specialist applications (as explained in Sections 5.3.4 and 5.4.2), and to the parallel use of several generations of technologies for particular procedures (discussed following). As previously discussed, the loan set phenomenon has resulted in significant increases in perioperative processing work. This, along with the parallel application of alternative technologies, has contributed to the need for *receivers* to have a wider knowledge and skills set than they used to require.

According to OTS personnel who had worked in the field for up to thirty-five years, the speed of change, particularly between 1988 and 1994 was greater than anything they had previously experienced. A Critical Care Services Manager with OTS nursing experience since the mid-1960s, covered some of these issues when she explained:

> *"I would think it must have been around the late 80s. I can remember thinking that you needed a degree in technology or electronics as well as the nursing background that you have, because things changed, and they changed very rapidly. Not only was it changing for the nurses, it was changing for the doctors. They were going through a learning curve the same time as we were… Advances in minimum access surgery in the early 90s had a really big impact. It was reasonably manageable when you had just the Gynaecologist and the Orthopod wanting the TV monitors and so on, but then the Urologists and the general surgeons... They all wanted to do it... I have a long background in theatres, and I know that nothing much had changed for a long time. And then we had this sudden five years of fairly steep curve of changes from the late 80s… When you had to actually go from taking a gall bladder out using a 10 inch incision, to a couple of little stab wounds and a whole lot of equipment, making sure it was all plugged into the right place. Even for the surgeon it was all new. Nobody in the theatre was an expert... I think there have been changes and improvements since 1994, but it hasn't been as huge a change as previously"* (Informant EY001).

An experienced OS nurse manager at another hospital put it this way:

> *"When I first came to theatres [twenty-one years ago] everything was fairly simple and the amount of equipment that we used was relatively small whereas now it's just huge… the amount of stuff that's used… Each type of surgery, whether we're talking*

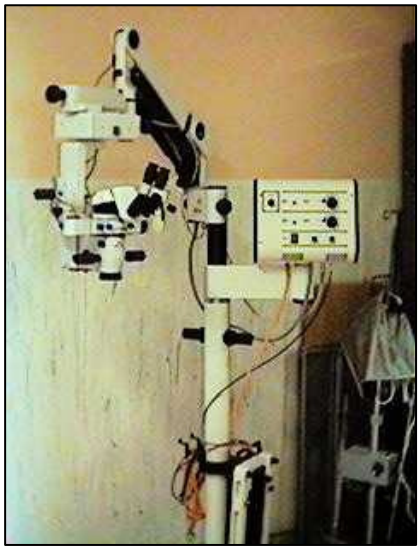
about laparoscopic gynae work or urology work, it's all changed immensely in ten years and the technology behind it has changed as well" (Informant DX005).

Operating rooms were ill-prepared for this dramatic change. The volume of *enabling equipment* now required in an operating room for even relatively short diagnostic procedures, such as hysteroscopy and cystoscopy, increased dramatically. Equipment "stacks", such as the those described in Chapter 5 (see **Figure 5(c)**) for laparoscopic cholecystectomy, are large, so operating rooms that had previously been adequate in size, became "too small", as an OS nurse explained:

"When we started doing lap choles, I felt the rooms were too small because there were so many monitors and other equipment… We used to just have two trolleys and the anaesthetic machine and of course the operating table… Now, with all this equipment coming into the rooms. We all felt very claustrophobic" (Informant AX004).

No speciality area of surgery seemed to be untouched by technological changes during this period. Eye surgery for the treatment of cataracts is a case in point. Until the late 1980s, the main requirements were an operating microscope, shown in **Figure 6(a)**, and a set of micro-fine surgical instruments. The surgeon was usually assisted by an instrument nurse and a circulating nurse and, depending on the circumstances, there might have been a third nurse to assist the anaesthetist.

Figure 6(a): An operating microscope



The development of the phaco-emulsifier technology (see **Figure 6(b)**), accompanied by changes in intra-ocular lens technology, transformed cataract surgery in the late 1980s. No longer did a relatively long incision need to be made in the eye to remove the cataract-

damaged lens. Rather, through a very small incision, an instrument connected to the phaco-emulsifier machine is employed to transmit the shock waves that shatter the damaged lens. The surgeon then aspirates the lens from the eye and inserts a new flexible lens.

Extracts from interviews with nurses at Hospitals D and A, such as the following two, provide some insights into the impact of this transformation on their work:

> *"With the technical side of [the Phaco emulstifer approach] there was all this equipment to hook up, there was a change of machines and they were continually, it seemed, trialing and updating the machines. So you'd sort of just learn one technique and one machine and then another one would come and you're adjusting all the time to changes there"* (Informant DX009).

Figure 6(b): Phaco-emulsifier equipment used during cataract extraction

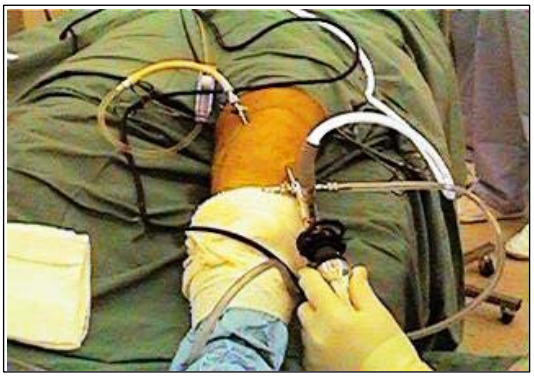
Whilst the new technology, supported by new anaesthetic techniques, resulted in very significant benefits to cataract-suffering patients, it also resulted in increased technical complexity and increased labour intensity of OS nurses' work. At Hospital A, where an ophthalmic surgeon performs this procedure on up to fourteen patients in a single day's operating session, the OS nurses developed a new system of work organisation to overcome the logistical problems that developed from the greatly reduced intra-operative time and the complexity of the new intra-operative artefacts. It involved four nurses "working the list" instead of the two or three that were required prior to the adoption of the phaco-emulsification technology. An experienced ophthalmic OS nurse explained:

> *"There are two Registered Nurses who scrub. While one person is Scrub Nurse for the particular operation that is going on, the other one is preparing for the next*

operation [and] will take over for the next operation when the first person is out washing and resterilising their instruments and getting ready for the next case… There is another Nurse who is the Phaco Nurse and another nurse is the Anaesthetic Nurse, so there are four Nurses in theatre… There's a lot of work involved. Preparation-wise we start ourselves about an hour before the doctors arrive, setting the operating theatre up because it is set up in a particular way, opening things up, getting the microscopes, the phaco machine and everything ready… and we're running the whole day" (Informant AX001).

Another example is orthopaedic surgery, which has undergone very significant advances in MAS to most joints of the body – particularly shoulders, hips, ankles, wrists, and knees (see **Figure 6(c)**). Many types of specialised *surgical instruments* have been developed to facilitate a wide range of surgery that has either averted the need for open surgery or provided the opportunity for a therapy or diagnostic procedure where one had not been previously considered possible or justifiable using open surgery.

Figure 6(c): Minimum access instruments inserted into a knee joint



However, technological changes in orthopaedic surgery have not been limited to MAS technologies. Open joint replacement surgery has also undergone substantial, although largely incremental, continuous change – issues that were discussed in Sections 5.3.4 and 5.4.2 in connection with TKR and the loan set phenomenon. The use of loan sets is associated, most frequently, with hip and knee replacement surgery, as an OS nurse at a hospital in regional NSW explained:

"In hip and knee replacements, the surgeons here like to use special equipment. People order them in because the equipment is so dear to purchase. They make loan equipment available so you can hire the equipment, and get it sent up from Sydney – all the instrumentation and implants with the set up… But it's very time consuming checking it all in… and we always have two people check them in. The instruments

come up unsterile and they all have to be washed and put through the process and sterilised" (Informant AX007).

In Chapter 5, I presented the results of my analysis of the consequences for *perioperative* workload of using a loan set of instruments for a TKR rather than a hospital-owned set – an average increase of at least 200 minutes of human labour. All of the interviews conducted with OS nurses and SD technical aides in which the topic of joint replacement surgery arose, concurred that the loan set phenomenon had been the source of substantial increases in perioperative processing times. The same was true for other types of surgery for which the necessary intra-operative artefacts were hired from the biomedical companies.

An orthopaedic surgeon in regional NSW gave some insights into the magnitude of the practice when he remarked:

"They estimate that there are six hundred loan sets buzzing around Australia every night. You wouldn't believe it but it happens… from Melbourne to Mildura and back to Melbourne and over to Albury and from Sydney to so and so… and they're just buzzing around all over the place by courier, at quite an expense" (Informant AZ001).

This creates other problems which are sources of stress for OS nurses, as a former OTS nurse manager explained:

You don't have much time in the morning to get a theatre ready for a joint replacement. Just time to do your sterile set-up, so you had to have some trust in the person who had got it ready for you the night before. And you also had the added problem that if you hadn't got some component in the consigned instrument set, it might be interstate or something, so the variables were awful. You might have a patient on the table with a hip open and you didn't have everything you needed" (Informant EY001).

Finally, the very high cost of certain new intra-operative artefacts, combined with the frequency of innovations, often results in the incremental introduction of new intra-operative artefacts such that there may be parallel application of various technologies for as long as the older instruments and equipment are fully functioning. This adds to the complexity of work for *receivers*, particularly OS nurses and SD technical aides, because of their need to retain their knowledge and skills pertaining to the old technologies whilst expanding them to accommodate the new.

6.4.2 Increased technical complexity of intra-operative artefacts

Another important consequence of new intra-operative artefact adoption arises from the increased technical complexity of those artefacts. The concept of *technical complexity* is used in the present thesis to refer to how easy or difficult it is for *receivers* to learn how to use and/or do their work connected with new intra-operative artefacts. I propose that it is an element of the *knowledge* aspect of technology (MacDonald 1983) that is implicit in Winner's (1977) concept of *techniques*. Much has already been described about the increased technical complexity of intra-operative artefacts adopted between 1988 and 1998, so my primary purpose at this juncture is to explore how this increased complexity has impacted, in some different yet significant ways, on both intra-operative and perioperative work.

Intra-operative impact

The main impact on *intra-operative* work of the increased technical complexity of intra-operative artefacts is the ever-heightening technical nature of the knowledge and skills required by OS nurses to be competent at what they do. Not only are new intra-operative artefacts more technically complex, but, as previously discussed, the number of specialised intra-operative artefacts is growing at a rate that makes it increasingly difficult for nurses to keep abreast of those changes.

Two previously little experienced change phenomena have occurred since 1988. The first is the growing dependence on a wide variety of *surgical instruments* used in conjunction with diverse *enabling equipment*, both of which have a propensity to failure or sub-optimal performance intra-operatively. As one nurse remarked:

> *"Laparoscopically is much more technical instrument-wise than an open cholecystectomy. I think the people outside don't understand the trouble you can get into. If we have a problem with any of the monitors or any of the machinery or instruments, that can actually change that whole operation into an open cholecystectomy. So if you don't have the knowledge to trouble shoot and fix the problem, it could turn into a major operation, a longer operation, which is worse for the patient"* (Informant BX005).

OS nurses have found that much of the responsibility to "trouble shoot" and resolve such technical problems falls on them. This is a source of distress for many of them (cf. Johnstone 1997; 1999; 2000). Several inter-dependent factors are contributors to that distress. The first is the need for them to be constantly alert to the possibility of intra-operative equipment malfunctions. The second is the nagging concern about whether or not they, or others within their operating suite, will be able to resolve any technical problems when they occur. This is

compounded by their concerns about the delays that will occur in the operating list if technical problems are time-consuming to resolve, and the possibility that some elective procedures might have to be postponed due to insufficient time being subsequently available. This links to the third factor, which is their concern for patients' welfare. Nurses are concerned when patients' operations have to be postponed to a later date and, as the previous informant explained, about the consequences for patients when MAS procedures convert to open procedures, resulting in longer times on the operating table and protracted convalescences.

When an OS nurse at Hospital C raised the matter of equipment/instrument failure, I asked, *"so who sorts matters out when the instruments aren't operating properly?"* She replied:

> *"We do. The doctors would say, 'I haven't got a picture nurse'. So we had to become technicians didn't we?" It's a lot of pressure when things break down. Surgeons, for some reason, are rather unforgiving people, and everything has to work… so, 'why doesn't it?' The magic wand doesn't always work either (laugh)"* (Informant CX002).

A former OTS manager elaborated:

> *"I would be on the phone to the company reps saying, 'I have three lines and some dots on the screen' and they would say, 'well try this, this and this'. And you would try this, this and this, and the surgeon would call you in again, and you would be on the phone again and try something else. And sometimes you just couldn't fix the problem"* (Informant EY001).

OS nurses also need to have up-to-date knowledge on the safe operation of the enabling equipment. One explained:

> *"When we're using the light source we regulate the colour depending on the colour inside the patient. When there is bleeding, you get a very dark screen so we have a grey button which we can push to give us some more light. When the telescope is taken out of the cannulas and sat on any drape, we indicate to the scout nurse to push the half-light button. If the light is left on full strength, it's that hot it can actually burn the drapes and will smoke and it can burn the patient. So we have someone there at all times to regulate the heat intensity of the telescope"* (Informant BX005).

Perioperative impact

The increased technical complexity of intra-operative artefacts also has consequences for *perioperative* work. They are explored separately in the following discussion according to the location of that work – the operating suite or the sterilising department. In so doing, the

perioperative work consequences of the increased technical complexity of intra-operative artefacts for OS nurses and SD technical aides are distinguished.

In the operating suite

Within the operating suite there are many time-consuming *perioperative* activities associated with ensuring that intra-operative artefacts are available and operational whenever they are required. Activities include a range of functional checks and quality assurance activities connected with the *enabling equipment* and many of the MAS *surgical instruments*, as well as the *Steris*^{TM} and *Medivator*^{TM} sterilising machines. Several OS nurses commented specifically about the erroneous perception of top managers that the new sterilising machines eliminated all of the *manual handling* aspects of instrument cleaning and sterilisation. For example, concerning reprocessing the colonoscope, one nurse remarked:

> *"It is all manual handling. The 'scope needs to be cleaned. It needs to be rinsed, soaked, the channels cleaned again. The only change here is that it is actually put through the Steris… It's just that we don't soak them in gluteraldahyde any more… It's actually created an extra headache because it's an extra bit of equipment that needs to be checked [and] extra equipment that needs to be ordered to run the Steris. And there's problems that occur with the Steris, with filters failing [and so on]…"* (Informant BX004).

Many detailed examples of perioperative activities were given by OS nurses but space does not permit descriptions of activities like changing filters on sterilising systems or taking regular swabbings from all endoscopes for pathological examination, or the volume of documentation required to provide audit trails of such activities for quality assurance purposes.

OS nurses are also responsible for ensuring that there are adequate supplies of items, such as the chemicals used in the sterilising machines and the *single use surgical instruments* and *materials*. The dramatic growth in MAS since 1988 has resulted in a significant increase in the volume of *inventory management activities* needing to be undertaken by OS nurses. Usually, the responsibility for identifying the stock requirements of each surgical speciality lies with clinical nurse specialists practising within each speciality area. For example, one OS nurse said: *"We have people responsible for each specialty and doing stocktaking in that particular area once a month… It might take a couple of hours to do it all up. You just have to try and fit it in your day somewhere"* (Informant DX009).

The responsibility for actually placing the orders and receipting purchased items usually resides with the OTS manager or the nurse managers of specialist units. However, at Hospital

E, an enrolled nurse was employed specifically to be an inventory manager. Her role also involved dealing with most visits made by the representatives of biomedical companies, whilst at the other four hospitals, the nurse managers of specialist units or the OTS manager handled most of these visits. An OS unit manager for cardiac surgery explained the frequency of this for a single speciality: *"I think as a manager, I must get calls from some reps on a weekly basis about something new they want to show me. And a lot of the surgeons organise for reps to ring me up to arrange to come and show me something new"* (Informant DX005).

For managers of multidisciplinary OTSs, these dealings with representatives of biomedical companies can consume a substantial portion of each week. The reason for this is quite simple. The constancy of innovations in intra-operative artefacts drives the need for biomedical companies to promote their products to those whom they regard as most influential in the decisions to trial and/or adopt them, the procedural specialists and the OS nurses – issues that are explored later in Sections 6.4.3 and 6.6.2.

In the sterilising department

Within the sterilising department, the increased technical complexity of intra-operative artefacts has led to an increase in the proportion of *surgical instrument reprocessing* activities that are undertaken *manually* as opposed to being undertaken by machines. This is compounded by the increase in the number of instruments requiring detailed inspection before they are packaged for sterilisation. (These issues were discussed at length in Section 5.4.1.) The cumulative effect of these developments for SD technical aides has been the need to *upskill* them to deal with the increased technical complexity of the intra-operative artefacts that they are reprocessing. All interviews with SD technical aides mentioned these things. The SD manager at Hospital D explained:

> *"When the increase [in MAS] started we had great problems with the staff because of training issues and the staff adjustment to that. It's hard. One day you're doing the instruments like… you just open them up, put them in a basket with lots of other instruments, and then send them through the ultrasonic [machine], and the next day somebody says, "do this laser equipment" or "here, be a mechanic and pull that apart and put it back together again". With the minimum access instruments, you wash one at a time and you have to do it by manual handling. You hold the instrument in your hands and count the screws and everything else. There is no putting it through a machine"* (Informant DX008).

The net result of the various changes is that sterilising departments *"are no longer a step up from the laundry"* (Informant EX001). Rather, they demand skilled and flexible staff who are

able to deal with technical complexity, diversity, and task variability, and to perform their tasks to a high standard whilst mostly unsupervised. One technical aide reflected on these changes in the following way:

> *"When I stop and think about it, we certainly have a lot more responsibility now than when I started working in the CSD. I mean I think the legal side of it now as to whether things are sterilised properly, documenting all the equipment that you use, the documenting of steriliser loads and things like that. When I look back…what we were allowed to do then and what we're expected to do now are certainly a lot different"* (Informant BX002).

6.4.3 Ad hoc, short-lived changes in intra-operative technologies

This subsection continues the response to the third research question concerning the consequences for *receivers* of new intra-operative artefact adoption between 1988 and 1998. Various consequences of the increased volume of specialist, sophisticated intra-operative artefacts, and their increased technical complexity, have already been discussed, and now a third factor is identified – the increase in the volume of new intra-operative artefacts that are trialed prior to a decision being made to acquire or not to acquire them. This practice has the effect of adding to the technical complexity of surgical production for the simple reason that all changes in surgical technologies add complexity to the process, at least until the new technology is mastered or discarded.

Receivers of the intra-operative artefacts being trialed must be instructed in how to use, care for, and, if relevant, reprocess them. This can be a time-consuming, challenging process for those concerned, especially when the process might be repeated for any number of artefacts during any given period of time. OS nurses required to be skilled across a wide range of surgical specialities appear to be most affected by this practice because, for example, they could be involved in trialing artefacts in several surgical specialities at any given time. Most significantly, there is no predictable pattern to trialing new intra-operative artefacts. Rather, it occurs in an ad hoc manner, and the short time frames associated with most trials means that, unless the artefacts concerned are adopted after the trial period, the sequel to the trial is further technological change (cf. Geisler & Heller 1996; Gelijns & Rosenberg 1994). This change might be a return to the former technology or it could involve another trial and, hence, another technological change.

An orthopaedic surgeon explained this process in relation to knee joint replacement surgery:

> *"Things work in fashions and trends… You'd dabble with the occasional new prosthesis but you'd generally have maybe one prosthesis you'd use for two years or*

three years and then something else comes along that's a major change which usually you need to move towards. Along the way you might do two or three new brands... It's sort of like comparing a Holden [car] and a Falcon, sometimes you just sort of go for a test drive with the other one to see whether or not you feel comfortable with the way the instrumentation works and the predictability for you to do that procedure" (Informant DZ001).

Suggestions to trial some types of new surgical instruments and materials are often made by nurse managers or experienced OS nurses within the OTS. This is primarily because they are important internal stakeholders targeted by the biomedical companies in marketing their products. However, trials of products are not always recommended, as this comment by an OS nurse manager indicates:

"If we can see the benefit for the patient from using this particular piece of equipment, we're pretty happy to go with it… We tend not to just trial things willy nilly. We want a really good reason for trialing something and to make sure that… there's some evidence to support the need of it" (Informant DX005).

The process whereby the decisions are made to adopt or, in the interim, trial new intra-operative artefacts, is explored in the final section of the present chapter. Suffice it to say at this juncture that it is the procedural specialist who decides whether (s)he will trial or adopt any new intra-operative artefact, regardless of who participated in the process that culminated in bringing the new artefact to the procedural specialist's attention. However, the important points of the foregoing discussion are that any process of trialing new intra-operative artefacts represents *technological change*, and that the frequent, ad hoc occasions of trialing new artefacts means that *receivers* are constantly exposed to technological change that is often impossible to plan ahead. The time-frame for deciding to embark on a trial is typically days or a couple of weeks, and so the advanced training of intending *receivers* is often rushed and, at times, neglected due to lack of available time. This results in much of the training occurring "on the run" as it were, during procedures in which new intra-operative artefacts are being trialed or adopted, possibly overseen by a biomedical company representative.

6.4.4 Structural characteristics of surgical production

The fourth, and final, factor identified as having significant consequences for *receivers* of new intra-operative artefact adoption between 1988 and 1998 concerns changes in *structural characteristics* of surgical production arising from changes in the *knowledge* and *organisation* aspects of new intra-operative artefacts. In the *knowledge technology* domain, high task variability and increasingly difficult to analyse problems in work that is

characterised by a high propensity to technological innovation appear to be factors contributing to the trend to greater specialisation amongst procedural specialists and OS nurses. Furthermore, the higher the task variability, the greater the frequency of the need for *receivers* to update their knowledge and skills. In the *organisation technology* domain, the dominant themes relate to the division of labour in surgical production, the nature of teamwork during the operative phase of surgical production, and the practical ramifications of the increases that have occurred in the volume of direct and indirect labour input to surgical production. These factors of *task variability* and *problem analysability*, *specialisation*, *division of labour*, and *teamwork*, are explored in the ensuing four subsections. Their analysis concludes my response to the thesis' third research question.

Task variability and problem analysability

Chapter 3 outlined a number of studies that investigated the technology-structure relationship. Most were conducted in manufacturing organisations, but Perrow (1967; 1979) was one to have studied service organisations, such as hospitals. In so doing, he analysed the types of activities that are performed in organisations at the level of the people actually carrying out the tasks. Perrow's (1967; 1979) *raw materials* and *tasks* typology for defining organisational characteristics is applicable to the transformation of inputs to outputs, with or without the aid of tools or mechanical devices. Section 3.3.3 described Perrow's two dimensions of knowledge technology, *task variability* and *problem analysability*, which he articulated into four alternative types of technologies by which an organisation's structure (ie. its system of getting work done) might be described.

I propose that it is possible to distinguish the *knowledge technologies* of each of the three OTS professional/occupational groups in the present study using Perrow's categorisation system, and contend that, despite his focus on "the organisation", his approach does not preclude either the analysis of organisational sub-units or the proposition that heterogenous occupational groups within a sub-unit might employ categorically different technologies. In the following subsections, I argue that there are differences between the *task variability* and *problem analysability* of work undertaken by procedural specialists, OS nurses and SD technical aides. More importantly, I argue that new intra-operative artefacts have increased task variability and resulted in *receivers*' tasks/problems being at least no less difficult to analyse than they were with predecessor technologies. However, before doing so, I need to explain what single factor prompted me to explore these theoretical concepts of *task variability* and *problem analysability*.

During the course of some of the interviews conducted early in the research process, some OS nurses were using the terms, *craftsman* (see Chapter 3 endnote) or the *surgical craft* in reference to the work of the procedural specialists. Consistent with the principal of seeking evidence until a point of saturation has been reached, I picked up on the lead and, as I had opportunity in subsequent interviews with both procedural specialists and OS nurses, I explored this concept. During the same period that I was conducting the interviews, I explored the literature on *crafts*, *craft technology,* and *craft modes of production,* with the result that I identified Perrow's (1967) four types of technology as providing a useful framework by which to analyse the technologies I was observing in the work of the three categories of participants in surgical production who are informants in the present study.

The *craft mode of production* is characteristically the opposite of *division of labour by task fragmentation* where individuals complete a sequence of tasks, usually with some identifiable outcome (ie. a completed product such as a chair, a newspaper article, or a surgical procedure). Some refer to the craft mode of production in terms of 'from conception to execution' (Heilbroner & Galbraith 1990:23), a concept which is explored in a later subsection dedicated to the topic of the division of labour within OTSs.

The craft mode of production constitutes one aspect of the work of *craftsmen* that is present in the notion of *craft technologies*. For example, Piore and Sabel (1984) described the work of craftsmen as depending on two factors: a sequence of specialised procedures (something akin to Perrow's difficult to analyse problems), and the ability to take on a novel job and respond with an appropriate set of tools and techniques. I propose that this latter characteristic equates with Perrow's task variability, although Piore and Sabel's (1984) definition is not explicit about the degree of variability in a craftsman's tasks. To be consistent with Perrow's definition of a *craft technology*, the novelty or originality of a *craft* would need to be located in the object of the craftsman's attention (ie. the product) and the variability of the tasks employed in the transformation process would need to be low (ie. few exceptions) (cf. Hirschhorn 1984).

Interestingly, it was the specialised nature of the tasks, combined with the practical skills to carry them out at a high standard, that informants in the present study used as the basis for supporting the notion that procedural specialists and possibly OS instrument nurses have the characteristics of craftsmen. For example, when I asked a general surgeon if he saw himself as a craftsman, he replied: *"Yes that's quite true. That's why the more time you do a procedure the better you get at it. You're learning the craft if you like"* (Informant VZ002).

An orthopaedic surgeon responded to the same question with: *"I think there's a combination of two things. We are tradesmen, and there are good tradesmen and there are bad tradesmen. All the variables you'd put onto a tradesman exist in surgical specialties, and a good surgeon is a craftsman in his area"* (Informant DZ001).

I suggest that these remarks reflect the every-day meaning of a *craftsman* as a person who practices 'an art, trade, or occupation requiring special skill, especially manual skill' (*The Macquarie Dictionary* 1997) and that informants' identification with certain characteristics of a *craft* should not lead us to conclude that their work/tasks are categorically a *craft technology* (after Perrow 1979). Instead, I have concluded that, so far as their contributions to surgical production within OTSs are concerned, the work of procedural specialists is best categorised as an *engineering technology* and the work of sterilising department technical aides is categorically a *routine technology*. The work of OS nurses, on the other hand, does not fall neatly into one category, primarily because of the very different nature of their perioperative and intra-operative tasks. I have concluded that OS nurses' perioperative work is categorically a *routine technology* whilst their intra-operative work, like that of the procedural specialist, is an *engineering technology*.

The decision to categorise the *intra-operative* work of OS nurses and procedural specialists as *engineering* rather than *craft technologies* turns on the characteristic that, despite their diversity and high degree of problem difficulty, exceptions can be handled in a rational and systematic manner (Perrow 1967; cf. Robbins & Barnwell 1998). That their skills are manual, and can be honed in a manner similar to a craftsman refining his/her craft, does not alter my conclusion.

In this connection, I reflect on the comment of a surgeon, with whom I had worked in the late 1980s, after we had completed emergency surgery on a young man who had had an arm torn off at the shoulder in an industrial accident. He said, "it's all in the planning", a possibly surprising remark in the light of the fact that he adjudged, in less than two minutes, that the man's arm was unable to be reattached, and that the paramount concern was to save his life by arresting the haemorrhage from his mutilated shoulder. This involved opening his chest to achieve the most rapid access to the main artery supplying blood to the now absent arm so it could be clamped. Afterwards, the patient's condition stabilised and we directed our attention to repairing his shoulder.

This example shows how, despite the difficulty of the problem and the infrequency with which it might be faced by any surgeon, this surgeon drew on his expert knowledge of anatomy and surgery to deal with the problem in an individualised, but rational and

systematic way. The nature of the problem demanded a unique, immediate, customised response by the surgeon, characteristics that are present to a greater or lesser extent in all surgery, regardless of their types and circumstances (ie. elective or emergency), as the following orthopaedic surgeon's comment highlights:

> *"I always do something differently. I'm always looking for a better way of doing something if I'm not happy with the previous procedure… you are always changing. There is never a stagnant period. If there is, you've had it… You might look at a new technology and not adopt that technology, but adopt something in the manual that shows how they do some sort of skin cut a little differently. In other words you change every minute, every time"* (Informant DZ001).

An important point here is that during any procedure, the nurse is a "fellow traveller" with the surgeon, involved with the same intra-operative artefacts, whilst fulfilling a role that complements the surgeon's role by being able to pre-empt, prepare for, and/or adapt immediately to technological changes made at any time during a procedure.

Moreover, the principles concerning the relationship between the surgeon and the OS instrument nurse are the same whether procedures are categorically emergencies or "routine", for even the notion of "routine" does not mean "exactly the same". Hence, I propose that the intra-operative work/tasks of both the instrument and circulating OS nurses are categorically *engineering technologies* (after Perrow 1967) because they involve relatively difficult problems with a large number of exceptions (ie. high task variability necessitating flexible responses) that can be handled in a rational and systematic manner.

The foregoing discussion draws attention to the different relationships of the procedural specialists and OS nurses with intra-operative artefacts. It is clear that the intra-operative artefacts are the "tools of trade" of the procedural specialist who elects what artefacts to use, and when and how (s)he will use them during a procedure. However, the OS nurse's role is different, working *with* the artefacts, ensuring that they are available for, and ready to use by the procedural specialist when required. The nurse rarely employs the artefacts directly on a patient, and if (s)he did, it would be under the procedural specialist's direct supervision. Hence, the intra-operative artefacts are categorically *not* the "tools of trade" of OS nurses – quite a different human-technology scenario to a nurse in a hospital ward independently using an electronic thermometer to record a patient's body temperature or managing a patient's intravenous infusion via an infusion pump in the course of nursing care (Brewer 1983; 1986).

Consequently, OS nurses are not independent practitioners in the care of a patient during the operative phase of surgical production. Rather, they are members of a team of people, headed

by the procedural specialist, who are working cooperatively to bring the procedure to successful completion. This does not imply that the OS nurse never gives independent care to a patient within the operating suite. Rather, so far as the present thesis is concerned, it means that an operating suite nurse's *independent* practice is limited to the *peri*operative phase of surgical production. However, the lack of independence does not alter the *engineering technology* characteristic of the intra-operative work of OS nurses.

The *perioperative* role of the OS nurse is quite different. I propose that it is categorically a *routine technology* because most tasks are repetitive in nature. They include activities such as routinely writing up the case details of all the procedures they have participated in each day in the *OTS Surgical Register*, preparing an operating room for a specific procedure, organising patients to be transported to the OTS, clearing and cleaning the operating room after each procedure, and any number of *inventory management* or *equipment maintenance* activities described earlier in this chapter. Most of these activities, although increasingly numerous, diverse, and often time-pressured, have low task variability and involve easy to analyse problems (after Perrow 1967).

The reprocessing work occurring in sterilising departments, and the changes that have occurred in the diversity and complexity of the work, were comprehensively described in Chapter 5. It is readily apparent from those descriptions, and the following comments by SD technical aides, that their work is characterised by *easy-to-analyse problems*, because their reprocessing tasks follow established standards, and *low task variability*. Although their work contains tasks of varying complexity, and the content of their work varies throughout any given day, it is, nonetheless, fairly predictable (cf. Robbins & Barnwell 1998). So, based on Perrow's (1967) typology, sterilising department work is categorically a *routine technology*.

Interestingly, some SD technical aides referred to their work as "repetitious". However, as the following interview extracts highlight, they were not saying that their work lacks diversity or that their work regimes are absolutely predictable. Evidence derived from my interviews and my observation of SD technical aides at work causes me to conclude that they are definitely not automatons undertaking repetitive work that requires scant intellectual input. On the contrary, they need to be mentally alert, knowledgeable about standards of reprocessing, capable of applying those standards to their practice, and adaptable to contingencies occurring "up the line" in the theatre in the time-management of their work. One SD technical aide explained:

> *"It's pretty repetitious work. You do get new sets you've got to learn. You can't remember everything. You can't become too blasé about it and think you know*

everything, because you can't. Some days are extremely busy. But, as I say, it's repetitious. You get used to what you are doing, but no two days are the same. You are on a different job every day, so there's no boredom… Sometimes a few cases finish at the same time and all of a sudden you have six, seven trolleys full of instruments… In the beginning it was "shock, horror! Where do I start?" But, gradually, after two to two and a half years… it started to sink in what was what. You knew by looking at a theatre list roughly what you were going to get. You could be prepared for it" (Informant EX001).

And at another hospital: *"There's a little bit of repetition, so I roughly know how long this is going to take me, and I look at the [operating] list and I guess we're going to be finished by that time"* (Informant CX001).

However, I have found that, amongst top managers, there is a propensity to associate the application of technical artefacts, even in their most sophisticated form, with a form of production that is akin to the *routine technology* type. I say this because their expectations are evidently influenced by the techno-economic perspective that the dominant technical goal of new technology adoption is the automation of production tasks, to the end that subsequent work reorganisation results in job simplification and task repetition. The present chapter has already shown that the technical goal of new intra-operative artefacts is not automation, and it will shortly be discussed how, since 1988, only minimal changes in the division of labour by tasks have occurred, changes that have not resulted in job simplification or increased task repetition. However, it has resulted in greater specialisation amongst procedural specialists and OS nurses, as the following subsection will show.

Specialisation

Procedural specialists

The increased volume, diversity and technical complexity of intra-operative artefacts have contributed to an increase in the task complexity of the operative phase of surgical production. This, combined with the *engineering technology* characteristics just discussed, and heightening consumer expectations, has led to a growing recognition of the need for greater *specialisation* amongst procedural specialists and OS nurses. Amongst procedural specialists, specialisation is undergoing transformation to "super-specialisation", such as a gynaecologist specialising in gynaecological cancers (Informant VZ001). An orthopaedic surgeon in regional NSW explained:

"There's been an enormous change in the last ten to fifteen years in super specialisation… doctors specialising on the shoulder joint, the spine, or knee and hip

work… There's been such an enormous explosion of technical knowledge and technologies in all joints and all specialties that it's virtually impossible to keep up with everything and to be able to do everything, whereas thirty years ago a general orthopaedic surgeon could turn his hand to most things" (Informant AZ001).

Operating Suite nurses

It is becoming increasingly necessary for OTS managers to introduce a form of *social division of labour* (Smith 1776, reproduced in Skinner 1970:46) amongst OS nurses, particularly in the larger operating suites. By this I mean that the practice of certain OS nurses is limited to several specialist surgical areas in which they become experts (ie. they *specialise*), but at the same time they maintain their competence to deal with a range of emergency procedures. For example, at Hospital D, where work was managed in four discrete "modules", nurses in one module specialised in cardiac and gynaecology surgery. A nurse manager explained: *"What's happened is there's a great amount of increased knowledge required. It's become bigger and bigger… There's just so much more to it. How can you retain all those skills? You have your basic skills, but you can't retain all the specialised skills for everything"* (Informant DX010).

A nurse manager of another module in Hospital D reflected on the same issues, and said:

I think specialty surgery progresses at such a rate that if you haven't done it for a year then you're out of touch… A lot of the staff here can scout quite well for any of the specialties that we have up here, but to turn their hand at doing [instruments for the] super specialties of neurosurgery and orthopaedics for example, it would be quite difficult… And even things like cystoscopies, they're not the cystoscopies that we were doing ten or fifteen years ago. They've also got a huge range of equipment and technology with them as well. So I don't think we do simple procedures here any more" (Informant DX005).

Finally, on the topic of specialisation, are the observations of the CEO of the private hospital in the present study, whose insights are obviously informed by the fact that she is also a registered nurse. Her understanding of the practical aspects of surgical production within OTSs is much greater than that of top managers without her clinical background, albeit a background that was not in an OTS. However, the following extract highlights how the work of both the instrument nurse and circulating (ie. scout) nurse has become more specialised, and how hospitals are finding it difficult to provide the infrastructure whereby OS nurses can keep up-to-date in their knowledge and skills. It also provides further evidence of the work of

the OS circulating nurse being categorically an *engineering technology* (as previously discussed):

> *"Whereas a scout in the past could be a pair of hands that could help out just opening sterile packages, the scout now has to have a comprehensive knowledge of the technology, because while the scrub sister [ie. instrument nurse] would put together the equipment and check it prior to the procedure… the insufflators, the light sources, the cameras, the whole lot has to be connected by the scout. The scout has to trouble shoot, and so it has got to the stage where a scout has to be a specialised person… Nurses have had to increase their skills as new technology comes in and often it is difficult for them to get those skills except by learning on the job. There is not much in-service education available and there isn't a great deal of time – given staffing levels – for them to achieve the level that they should"* (Informant CY002).

Division of labour

My response to the third research question continues with an examination of changes in the *division of labour* which are consequences of new intra-operative artefact adoption since 1988. The topic has received some attention in the preceding subsections in terms of "who does what?" The following subsections continue on this theme, but with the additional question, "has this changed?" Three "divisions" are examined: the intra-operative roles of procedural specialist and OS nurses; the various intra-operative roles of OS nurses; and the perioperative roles of OS nurses and SD technical aides.

Intra-operative roles of procedural specialists and OS nurses

Overall, no changes have occurred in the intra-operative division of labour between the procedural specialists and OS nurses during the study period. They have enduring, distinct but complementary roles that have already been described – roles that an orthopaedic surgeon distinguished by saying: *"I do the surgery and the nurse's role is to make my job easy by way of handing all the equipment and pre-empting what I need"* (Informant DZ001).

This statement alludes to the fact that OS nurses (both instrument and circulating nurses) have various responsibilities that make it possible for the procedural specialist to come into the operating room, perform the operation, and then leave with the expectation that others will clean afterwards. From this perspective, the terminology borrowed from live theatre, whereby the surgeon *performs* in the operating *theatre* during the *main act* (ie. the procedure), makes sense. It is also consistent with Oakley's (1993) analogy of the father/doctor–mother/nurse–child/patient relationship. This analogy sees the procedural specialist as the man of the house, who largely fits in, not unlike a guest, with what the

mother organises. It is not unreasonable to describe the procedural specialists in terms of the "guest" in the operating suite because everything (equipment and human assistance) is prepared for him/her to walk in to do the procedure and walk out as soon as it is done. The instrument and circulating nurses and the technical aides in the present study have roles similar to the mother/wife/host(ess), who is responsible for managing the home environment for both the father and the child(ren)/patients – "picking up the dirty socks" as it were, washing them and returning them to their storage places ready for the father or child to wear again. This analogy should not be interpreted as demeaning the roles of OS nurses or SD technical aides but, rather, it is one way of describing the nature of their roles and responsibilities in relation to those of procedural specialists. In my personal anecdote about the man with the traumatic amputation of his arm, for example, the surgeon left the OR when the patient did, and the nurses stayed to clean up what was literally a "bloody mess".

Intra-operative work of OS nurses

Within the operating suite, the adoption of new intra-operative artefacts, between 1988 and 1998, has had a dramatic impact on structural characteristics of OS nurses' intra-operative work that are largely limited to changes in the *content* of their work. Overall, it has not resulted in any changes in the intra-operative *division of their labour by task fragmentation*. As previously mentioned, their work in the larger hospitals, in particular, has undergone a form of *social division of labour* that is resulting in *specialisation*. However, their work remains typical of craft production in the sense that their roles and responsibilities span all of the functions that contribute to the intra-operative phase of surgical production – from start to finish (cf. Heilbroner & Galbraith 1990).

Perioperative work within the OTS

Concerning the OS nurses and the SD technical aides, some changes have occurred in the *social division* of their labour (Smith 1776, reproduced in Skinner 1970:46). These changes have resulted from several interdependent factors, the first two of which are consequences of new intra-operative artefact adoption:

- the constantly increasing volume of special surgical instruments requiring careful manual reprocessing
- the inordinate and ever-increasing amount of time that OS nurses were previously devoting to instrument reprocessing activities, and the growing recognition that this was an inappropriate use of their knowledge, skills and qualifications, and

- the elimination of a number of functions from the sterilising department that has gradually transformed its role to be predominantly one of reprocessing surgical instruments.

Within sterilising departments, the division of labour has traditionally been characterised by *task fragmentation*, and remains so. Section 5.4.1 described how sterilising departments are divided functionally according to whether instruments are soiled, clean or sterile, and how specific stages of instrument reprocessing are clearly delineated. In the larger sterilising departments, tasks are divided amongst the technical aides according to these stages because of the high volume of reprocessing work, which has the organisational benefit of achieving some economies of scale (cf. Folland et al. 1993; Terry & Forde 1988).

However, in the smaller hospitals, B and C, it is not uncommon for only one technical aide to be on duty at one time. This necessitates a different form of task fragmentation where the various tasks associated with reprocessing the instruments used in one or more procedures would be undertaken sequentially, first in the "soiled" area, then in the "clean" area, and finally in the "sterile" area. These basic work organisation principles did not change during the study period.

However, one significant change did occur in the division of labour within OTSs during the 1990s. It arose from the need to reprocess instruments used in MAS individually and by hand, rather than in batches with the aid of mechanical washers and dryers. The vulnerability to accidental damage of these instruments, combined with the increased task complexity of reprocessing them (due to their need to be dismantled for cleaning and reassembled), has necessitated that selected staff be *upskilled*. In the larger sterilising departments, where the volume of reprocessing these "specials" was deemed sufficient, internal restructuring resulted in the creation of an area dedicated to reprocessing them in a less task fragmented way than occurs for most of the other instruments processed through the sterilising department.

Early in the study period, which was just before the dramatic increase in the volume of MAS, most of the reprocessing work associated with these "specials" was done by OS nurses. I asked one nurse, *"Can you recall how the processing of those special bits of equipment was done when you started doing some of the minimally invasive procedures?"* She replied: *"We had a cleaning room down near materials handling [within the operating suite]…[We] would clean all of the delicate instruments by hand, then send them through for sterilisation in the CSSU"* (Informant DX004).

Occurring independently of the changes in intra-operative artefacts, the move to out-sourcing surgical materials, such as surgical swabs and sponges, worked in reverse. It shifted the associated *inventory management* responsibilities away from SD personnel to OS nurse managers. Informants at Hospitals A, D and E explained how the move to out-sourcing occurred at about the same time that it had become apparent to OS nurses that they could not continue to take personal responsibility for reprocessing the ever increasing numbers of instruments used in MAS. The end result was that by the end of 1994, the work of SD technical aides at all of the study hospitals had been restructured for them to take on the additional role of reprocessing virtually all of the MAS instruments (cf. Commonwealth of Australia 1996). This role change is reflected in the renaming of Central Sterilising Departments (CSDs) and Central Sterilising Services Units (CSSUs), that were previously administratively independent of the operating suite, to Sterilising Departments/Units that are now located administratively within Operating Theatre Services.

A Critical Care Services Manager summarised the changes in the *social division of labour* between OS nurses and SD technical aides in the following way:

> *"The infection control guidelines came out and said that you really have to take all these instruments apart...[even though] they were expensive [and] difficult to take apart. We decided that the nurses couldn't do this job any more… We utilised what we already had, which was a CSD [which] had to change, as probably every CSD in the world had to… It was a challenge for them and a challenge for us to look at how we could stop using a very expensive resource, which is a registered nurse, to be cleaning instruments. It was a real culture change for people who had worked for years in the sterilising department and were used to scissors and forceps and the like, to start looking at these minimum access instruments which broke easily. It was a very big transition"* (Informant EY001).

Teamwork

Teamwork is a little reported structural characteristic of surgical production in OTSs. Whilst only small changes have occurred in the nature of that teamwork as a consequence of new intra-operative artefact adoption, I regard an examination of the topic as an important sequel to issues raised in the context of the *division of labour*. The concept of *teamwork* was discussed then in connection with the operative team. The focus now widens to any type of teamwork amongst contributors to surgical production, and how teamwork might have changed as a consequence of new intra-operative artefact adoption.

Teamwork is manifest in two distinctive ways within OTSs. The *division of labour by process* (cf. Smith 1776, reproduced in Skinner 1970:46) describes a type of teamwork in which individuals' fragmented tasks are linked sequentially (ie. task B undertaken by one individual cannot be undertaken before task A is completed by another). This is the type of teamwork that occurs within the larger sterilising departments that have sufficient work volume in each task category to divide the labour efficiently between individual employees. A technical aide at the largest study hospital remarked, *"there's always been teamwork here"* (Informant DX007). Also, job rotation (cf. Mathews 1989) is practised both *between* teams and *within* the teams, usually for practical operational and quality of work life reasons. For example, technical aides might work in stage 1 (instrument sorting and washing) for an entire day or week, and then in other stages such as instrument checking and assembly, or wrapping and labelling, or the management of the sterilisation process. And, when working in a particular stage, *"team members rotate through all the jobs"* (Informant DX007).

It is quite different to the type of teamwork occurring within the operating suite, especially as it applies within the *surgical team*. Surgical teams are characterised by a high degree of mutual interdependence of every member of the team throughout the entire operative phase. The previous subsections described the division of labour in surgical production between procedural specialists, OS nurses and SD technical aides as a *social division of labour* (ie. by types of employment). However, this categorisation says nothing about the actual relationship between members of these three *adjacent occupational groups* (cf. Salaman 1974; Brewer 1986; Lloyd 1993).

Every procedural specialist interviewed acknowledged how the OS instrument nurse's role is vital to the whole process, and more so with the increasing technical complexity and diversity of intra-operative artefacts. The concept of *teamwork* in which individual members of the operative team, in particular, and the surgical team, generally, have different but interdependent roles and complementary skills, was strongly regarded as being increasingly critical to producing the best possible outcome for patients, largely because of the adoption of many sophisticated surgical instruments and associated enabling equipment. An OS nurse explained:

> *"I think whether you're a doctor or nurse, we both have equally important roles to play. It's just that they're different roles. Obviously there is a lot of teamwork and we wouldn't be able to achieve our goals and provide really good patient care if we didn't work in a team"* (Informant DX005).

Intra-operative nurse-to-nurse task interdependence is, and has always been high because the circulating nurse works outside the operative field principally to assist the instrument nurse by fetching any additional sterile supplies, managing much of the enabling equipment, and maintaining documentation such as the record of surgical swabs and sponges. At the conclusion of the procedure, they work cooperatively to restore the operating room to its ready-to-use state.

A nurse at Hospital B described the preliminary stage of a laparoscopic cholecystectomy. It is a clear example of the *task interdependence* of the procedural specialist, the instrument nurse and the circulating nurse. The important background information necessary to appreciate how different this is to non-MAS procedures is that, in the latter, the surgeon would not commence the procedure until all of the instrumentation and miscellaneous equipment was fully prepared:

> *"To increase the speed of the operation I, as a scrub nurse, would make up [an instrument] table up with what the surgeon requires first – the scalpel blade, Verres needle and gas lead. I put up quickly what he needs first so he can drape, make an incision, and pop a Verres needle into the abdomen. I then pass the gas lead off to the scout nurse. Then it's up to the scout nurse to be in contact with the surgeon. He relies on her to regulate the gas. While they're communicating together I'm setting up the rest of the gear for him... We work as a team, I understand that he helps himself, he understands that the instruments will be there for him to help himself. It's a buddy system…"* (Informant BX005).

In an earlier section, I discussed the notion of whether or not a procedural specialist was a *craftsman*. I wondered whether an analogy could be drawn between the instrument nurse and procedural specialist relationship and that of a tradesperson and his/her assistant/labourer. After an orthopaedic surgeon raised the idea of the surgeon-craftsman, I asked, *"well, if the surgeon is the craftsman, can you think of a term that would describe the role of the instrument nurse?"* He replied:

> *"I don't want to say what the obvious is on that one because it would sound derogatory and not be fair to them. The nurses are as individually important as I am. They're part of a team. They don't take my orders and I don't take their orders. They have a role that they've got to fulfil which is clearly defined [and] they know how to do better than I do. A tradesman can do all that the labourer can do. I can't do the nurse's job, so it's not a good analogy. It really has to be the fact that they've got a different job to mine and I need them and they need me. All the nurses in the world*

can't operate on a person and all the surgeons in the world can't operate on a person if there's no nurses. Our roles are very complementary" (Informant DZ001).

When I tested the (in)appropriateness of the analogy with an OS nurse manager, her reply, like the surgeon's, was representative of informants' views:

"They're almost a pair of craftsmen in a way, except one would be the master craftsman. Yes that's how I see it. He's the master crafter, but the nurse is more than the labourer. ...Because it's so involved, there's so much to know, and if you see a good team together, it does make a difference"(Informant DX010).

6.4.5 Summary: The organisational consequences of new intra-operative artefact adoption

The third research question asked, "what have been the actual consequences for surgical production within OTSs of new intra-operative artefact adoption between 1988 and 1998?" Section 6.4 has provided a response to that question. It has shown how there have been various direct and indirect structural consequences for OTSs of the increases that have occurred in the volume, diversity and technical complexity of new, often highly specialised, sophisticated intra-operative artefacts. Important among these consequences are: increased complexity of work content and task variability for all receivers of the new technologies; increased specialisation amongst clinicians; greater task interdependence, particularly between members of the operative team; and changes in the perioperative division of labour.

Much of Chapter 5 was devoted to another important consequence that has received little attention so far in the present chapter. This is the increased volume of human input to surgical production, a subject which is the pervasive theme of the following section's response to the fourth research question. Drawing on various quantitative and qualitative data, and applying the principles of triangulation, it describes and analyses the actual and expected organisational consequences of new intra-operative artefact adoption in surgery.

6.5 Actual vs. expected consequences for surgical production within Operating Theatre Services of new intra-operative artefact adoption

Much has already been discussed about clinicians' and top managers' expectations about the consequences of adopting new intra-operative artefacts in surgical production. All agree that the dominant functional goal of adoption is a better process and/or outcome of the treatment of disease in individuals (ie. patients) – a dominantly *altruistic* goal. From the outset of this thesis I have made it clear that my goal was not to explore whether or not the *clinical* goals of new intra-operative artefact adoption have actually been achieved. Rather, I sought only to

explore whether or not the clinical goal is the most important driver of technological change in surgery, and I believe that I have already provided enough evidence to show that this is so.

In this section I direct my attention to those expectations and organisational consequences that can be referred to as the *operational aspects* of new technology adoption. It brings together the developing body of evidence in the present chapter concerning changes in the surgical production process, and evidence reported in Chapter 5 about the increased labour intensity of both the intra-operative and perioperative phases of surgical production. This provides the foundation for exploring certain *business* aspects of new intra-operative artefact adoption, informed, to a large extent, by top managers, and the inadequacy of current OTS productivity measures to reflect the diverse perioperative human labour requirements of individual surgical procedures.

Earlier in the present chapter I discussed how *automation* is not a technical goal of new intra-operative artefacts. I also discussed how the technical goals of *process innovations* or *product innovations* (cf. Doessel 1992) in surgery are strongly linked to the *clinical* goals, and not to the traditional organisational *self-interested business* goals, such as those associated with strategies aimed at ensuring organisational survival (eg. increased profitability or productivity). I now argue that despite the primacy of the clinical goals, the majority of top managers had, nonetheless, expected the adoption of new intra-operative artefacts, between 1988 and 1998, to have improved OTS employee productivity and OTS throughput, and, possibly, to have improved OTS cost-efficiency. Some explained that these expectations had their origins in formal proposals to acquire specific technologies. Reflecting their "world view" of what technologies "do", most assumed that the new technologies would have labour-saving characteristics and/or would improve the quality of working life of OTS staff. That said, some had a growing suspicion that their expectations have not become a reality – something they actually cannot confirm because none of the five hospitals have mechanisms for post-acquisition evaluation of new intra-operative artefacts.

There is evidence that the formal proposals to acquire new intra-operative artefacts are compiled in the absence of reliable data (or no data at all) about the potential financial implications for the organisation beyond the capital costs. Consequently, they are, I propose, at best, approximations of the organisational costs and benefits of acquiring new artefacts. At worst, they can be viewed as exercises in complying with the hospital's documentary requirements (emphasising costs, anticipated clinical and organisational benefits, and value for money) for acquiring new artefacts, the outcome of which might bear little, if any, resemblance to the documented expected costs and benefits. In the absence of post-

acquisition evaluation, many assume that what has been documented in the proposal document is "truth" – a truth that is erroneously sustained by *de facto* hospital efficiency measures (such as decreased average length of stay of surgical patients) that actually say nothing about the efficiency or otherwise of surgical production within an OTS. I refer to this phenomenon as a *self-perpetuating myth.*

Managers' expectations concerning the strategic benefits to the OTS of new intra-operative artefact adoption are reinforced by their interpretation of data pertaining to relative funding and length of hospital stay for an episode of care associated with particular procedures. The logic goes something like this: "short stay equates with easy procedure, which in turn equates with quick and simple work for OTS staff". A Manager of Critical Care Services explains the conundrum and, in so doing refocusses the present discussion on the issue of the labour intensity of surgical production within OTSs:

> *"One of the things that I have trouble with now when I am putting in a submission for theatre staffing, is convincing people that an endoscopy list [of] colonoscopies… day only procedures… actually needs more nursing staff and more nursing resources than doing, say, an orthopaedic list with hip replacements and so on"* (Informant EY001).

6.5.1 Labour intensity of surgical production

Intra-operative phase

Chapter 5 presented sample quantitative data on 30,345 surgical records collected from the *OTS Surgical Registers* at the five study hospitals. It reported that mean *intra-operative* time had increased, between 1988 and 1998, by about 15.85 per cent.

Evidence has been presented in the present chapter that technological change has taken the form of either enhancements to established procedures using new intra-operative artefacts in order to improve the process and/or outcome for the patient, or the introduction of many altogether new types of procedures that employ new intra-operative artefacts. Because all of the study hospitals satisfied the "organisation stability" selection criterion (see Section 4.2.6), and because no other candidate explanations have emerged during this research, it is now proposed that, if these technological changes had not occurred, intra-operative times would not have increased.

In most production settings, increased production times would be regarded in a negative light. However, I contend that increased mean production (ie. intra-operative) time is not indicative of a decline in the technical efficiency of surgical production (cf. Duckett 2000). Rather, it is a reflection of the significant changes that have occurred in the types of surgical procedures

and the procedure mix (ie. case mix). What is problematic is that hospitals did not anticipate that it would take longer, on average, to complete the intra-operative phase of surgical production for the 1998 "basket" of surgical procedures. Nor was it anticipated that the labour intensity of the perioperative phase of surgical production would increase. A Hospital General Manager observed: *"I don't think anybody predicted the treadmill that you'd get on. That is, you're running just to stand still basically. We're devoting a lot more of our resources to theatre technology and we're just maintaining our technological base"* (Informant BY001).

Perioperative phase

Chapter 5 presented the results of my time study of the *perioperative* human labour input (HLI) to six high volume procedures. In the following discussion, I distinguish the HLI to the *pre*-operative and *post*-operative phases of surgical production, and the activities occurring within the operating suite from those occurring in the sterilising department.

Pre-operative activities

Gathering all of the intra-operative artefacts for individual procedures and "setting them up" in the operating room constitute the main *pre-operative* activities. They occur within the operating suite. How technological change has impacted on this activity cannot be fully appreciated without an understanding of certain logistical aspects of customising surgical production to individual patients.

By comparison with machines and other equipment used in manufacturing and business firms that are typically set up in permanent or semi-permanent locations and configurations in factories or offices, intra-operative artefacts are stored in various locations within an operating suite, although not in the operating rooms in which they will be used. Consequently, all enabling equipment, surgical instruments and materials required for individual procedures need to be collected, brought into the operating room, arranged and set up according to the procedural specialist's preferences. Immediately following each procedure, the OR is restored to its standard pre-operative state.

The main exception to this is the widespread practice of setting up either specialist units or procedure rooms where GI endoscopies are performed. The high volume of such procedures in most hospitals makes it possible to achieve some economies of scale (cf. Folland et al. 1993; Terry & Forde 1988) that are not normally possible in most other surgical specialities. However, occasionally for example, an orthopaedic surgeon might undertake a sequence of diagnostic arthroscopic procedures that require the same enabling equipment, or a urological

surgeon might undertake a sequence of cystoscopic procedures for which each item of enabling equipment can remain in the OR until all such procedures are concluded.

The evidence points strongly to the conclusion that the total volume of *pre*-operative work has increased due to the characteristics of new intra-operative artefacts that have already been discussed at length. More instruments, materials and equipment to prepare for each procedure usually means that setting up times will increase. This, combined with the increasingly specialist nature of those artefacts, has resulted in an overall increase in OS inventory, which has a snowball effect, increasing the volume of *inventory management* activities. Other factors, such as the size and physical layout of the OTS, also affect how long it takes to undertake numerous activities. This is because the larger the operating suite, the further people have to walk to collect (and subsequently re-shelve) all of the intra-operative artefacts required for any procedure.

The following two Tables present summary data relating to the grand mean times it took in 1998 to complete the *pre*-operative activities in the five study hospitals for two pairs of procedures. (Refer to Appendix A5 for a summary of one hospital's time study data.) **Table 6(a)** reveals that it takes 125 per cent longer to prepare for D&C with hysteroscopy than it does for D&C alone, whilst **Table 6(b)** shows that the pre-operative preparation for laparoscopic cholecystectomy is, on average, 77 per cent longer than it is for open cholecystectomy.

Table 6(a): Grand mean pre-operative work times for D&C with and without Hysteroscopy

	(a) D&C without hysteroscopy (minutes)	(b) D&C with hysteroscopy (minutes)	**Difference (minutes)**	**Percentage increase of (b) over (a)**
Average pre-operative work time (mins)	14.49	32.66	**18.17**	**125 %**

Table 6(b): Grand mean pre-operative work times for Open and Laparoscopic Cholecystectomies

	(c) Open Cholecystectomy (minutes)	(d) Laparoscopic Cholecystectomy (minutes)	**Difference (minutes)**	**Percentage increase of (d) over (c)**
Average pre-operative work time (mins)	34.15	60.56	**26.41**	**77 %**

My interviews with the OS nurses highlighted how setting up for procedures employing new intra-operative artefacts is sometimes more cumbersome work because the sets of instruments involved (eg. stereotactic neurosurgery and joint replacements) are large and heavy. Also, increased setting up time is becoming a more common characteristic of pre-operative work across all surgical specialities, but the impact is most dramatic in those employing MAS technologies. For example, an OS nurse remarked:

"Laparoscopic and arthroscopic work is a little frustrating and time consuming. It requires a lot of instruments… and it is a fiddle setting up. Setting up for a normal open operation is quite easy, but with laparoscopic surgery, particularly some of the more complicated ones that we do, it involves a lot of instruments and a lot of setting up" (Informant AX001).

Procedural specialists, such as the orthopaedic surgeon quoted following, appear to be aware of the impact on OS nurses' work of these changes: *"The technology takes a lot more setting up… the bringing in of the TV screens, the monitors, the light sources, the arthroscopes… and sterilisation of these things"* (Informant AZ001).

Post-operative activities

The *post-operative* component of perioperative work occurs in both the operating suite and the sterilising department. Within the *operating suite* the only post-operative activities for which time study data were collected were those that clearly related to a specific procedure, and which, in the event of any activity contributing to more than one procedure, the proportion applicable to a specific procedure was readily identifiable (as explained at the conclusion of Section 5.4.1). Consequently, in most cases, only the immediate post-operative work in the operating suite are represented in the data. It also means that a number of the *inventory management* and *equipment maintenance* activities referred to by OS nurses as occupying increasing amounts of their work time, are not represented. However, I propose that the absence of these latter data does not compromise the results presented here. Rather, the data are more reliable, albeit slightly underestimated by the omission, because it became quickly evident to me that it was virtually impossible to determine what proportion of these "overhead costs of production" activities related to the procedures I was studying in detail.

The following two Tables present summary data relating to the grand mean times it takes to complete the *post*-operative activities within the operating suites of the five study hospitals for the same two pairs of procedures shown in **Tables 6(a)** and **6(b)**. **Tables 6(c)** and **6(d)** respectively reveal that these activities take 218 per cent longer to complete for D&C with hysteroscopy than for D&C alone, and that the post-operative activities for laparoscopic cholecystectomy take, on average, 86 per cent longer than for open cholecystectomy.

Table 6(c): Grand mean OS post-operative work times for D&C with and without Hysteroscopy

	(a) D&C without hysteroscopy (minutes)	(b) D&C with hysteroscopy (minutes)	**Difference (minutes)**	**Percentage increase of (b) over (a)**
Average pre-operative work time (mins)	6.82	21.72	**14.9**	**218 %**

Table 6(d): Grand mean OS post-operative work times for Open and Laparoscopic Cholecystectomies

	(c) Open Cholecystectomy (minutes)	(d) Laparoscopic Cholecystectomy (minutes)	**Difference (minutes)**	**Percentage increase of (d) over (c)**
Average pre-operative work time (mins)	14.09	26.22	**12.13**	**86 %**

My discussion in Section 5.4.2 concluded that there has been an increase of about 47 per cent in the perioperative HLI to a colonoscopy. A Gastroenterologist explains some of the sources of the increase:

> *"The way we process the equipment is more complex or certainly a lot more thorough than we used to in terms of cleaning endoscopic equipment. The times we need to disinfect the equipment, all the processes that need to go on to do that properly, that's more complex. In itself that hasn't generated longer delays in our particular unit because we have enough instruments to cope with that"* (Informant DZ002).

Within the *sterilising department*, the *post*-operative activities are categorically *instrument reprocessing* activities. **Tables 6(e)** and **6(d)** show increases of 41 per cent and 48 per cent in HLI input to the sterilising department component of perioperative work for the two pairs of procedures in the preceding four tables. Compared to increases of between 77 per cent and 218 per cent for the pre- or post-operative elements of perioperative work undertaken within the operating suite, it is evident that the major portion of the increased perioperative work time has been borne by OS nurses. This is despite the changes that have occurred in the division of labour between OS nurses and SD technical aides where reprocessing MAS instruments is concerned.

Table 6(e): Grand mean SD post-operative work times for D&C with and without Hysteroscopy

	(a) D&C without hysteroscopy (minutes)	(b) D&C with hysteroscopy (minutes)	**Difference (minutes)**	**Percentage increase of (b) over (a)**
Average pre-operative work time (mins)	14.51	20.52	**6.01**	**41 %**

Table 6(f): Grand mean SD post-operative work times for Open and Laparoscopic Cholecystectomies

	(c) Open Cholecystectomy (minutes)	(d) Laparoscopic Cholecystectomy (minutes)	**Difference (minutes)**	**Percentage increase of (d) over (c)**
Average pre-operative work time (mins)	37.50	55.40	**17.9**	**48 %**

In the latter part of Section 6.4.4, I briefly discussed how the out-sourcing of surgical materials progressively eliminated a range of sterilising department tasks. The foregoing data, combined with evidence that SD staffing levels have remained much the same, support the

conclusion that these former tasks have been progressively substituted by new, more complex tasks associated with the reprocessing of intra-operative artefacts. So far as the work of OS nurses is concerned, these data, combined with the evidence that average intra-operative time between 1988 and 1998 has increased by about 15.85 per cent, give strong support for the argument that new intra-operative artefacts have contributed to a significant increase in the labour intensity of OS nurses' work (cf. Johnstone 1999; 2000). However, the net effect on individual nurses has been additive because, as previously reported in **Table 5(j)**, OTS staffing levels were essentially the same in 1998 as they were ten years earlier.

So many extracts from interviews could be included to exemplify the issues under discussion. However, many extracts quoted throughout this chapter on other topics have made reference to factors contributing to the increased labour intensity of perioperative work, so I have selected the following one to serve as a reminder of some of those factors:

> *"The changes in surgery since about '93… you know, like more laser and laparoscopy surgery, have had a big impact on our unit because with the instrumentation for minimal invasion being more complex than normal instruments and lots of parts. It has to be pulled apart and put back together again… And nowadays they do much more joint replacement than they ever did, and the instrumentation… they have ten boxes with up to twenty trays of instruments altogether. They need to be washed and packed and sterilised, just the same as any other and that's why the workload has drastically increased"* (Informant DX008).

Evidence of the increased labour intensity of reprocessing work within sterilising departments is supported by the results of the thematic analysis of the SD technical aides' interviews, undertaken with the aid of the HyperRESEARCH^{TM} computer software, on the theme, VOL WORK (ie. changes in the volume of work). (Chapter 4 and Appendices D2 and D3 comprehensively explained the methods employed, and Appendix D4 presents the results and explains their interpretation.) To summarise, the bulk of references to volume of work referred to *increased* volume of work arising from three sources, in particular: (i) increased manual handling of instruments, (ii) changes in reprocessing standards or characteristics of the reprocessing technologies, and (iii) characteristics of the new technologies such as the increased number of instruments. (Samples of detailed reports generated by the HyperRESEARCH^{TM} software are available in the Research Protocol).

Similarly, the analysis of the interviews of the thirty-one OS nurses also identified changes in the characteristics of intra-operative technologies as the major source of increases in the volume of their perioperative work.

I propose that this evidence, combined with the perioperative time study data and the samples of interview dialogue drawn from the coded chunks of text and woven into the fabric of the present thesis, *converge* on the conclusion that the adoption of new intra-operative artefacts is, indeed, a significant cause of the increases in perioperative workload that were reported in Chapter 5.

6.5.2 The business side of new technology adoption

Were the aforementioned increases in both perioperative labour and average operating time expected, and, more particularly, were they expected by the top health service managers? This section explores these and other "business" aspects of new intra-operative artefact adoption and concludes that, overall, the actual consequences are contrary to managers' expectations.

The conclusions reported in this section are principally the products of the deductive analysis of the semi-structured interviews with the thirteen top managers and, where relevant, informed by the quantitative analysis of a questionnaire containing eight Likert-scaled questions completed during the course of their interviews. These eight questions related to managers' *expectations* and *perceptions of the actual impact* of changes in surgical technologies on operating theatre throughput, employee productivity, and cost-efficiency, and the quality of work life of OTS staff. The Likert scale ranged from zero (ie. a very significant reduction) to 10 (ie. a very significant increase), where a score of 5 represented "no change" (see data in Appendix C2). After completing the questionnaire, managers were asked to explain why they had ranked each item as they had.

The following subsections present the results of the statistical analysis of these data, which are discussed in connection with a synthesis of managers' responses, on each of the four factors, to the question, "what was going through your mind when you scaled your responses to the two questions about…?" The data are summarised in Appendix C2. However, before doing so, I summarise the main themes emerging from the interviews with top managers.

Most managers highlighted that their roles and responsibilities related to the business side of the hospital, that is, to strategic choice issues (cf. Child 1972). Consequently, their primary responsibilities related to operating theatre and hospital throughput, cost minimisation and cost-efficiency and, hence, OTS employee productivity – all factors affecting the "bottom line". Although not a new phenomenon (cf. Brewer 1986), they were very conscious of the scarcity of financial resources, the opportunity costs of funding one project/purchase over other worthwhile projects, and the pressure to provide the necessary hospital services within budget. A corporate services manager stated simply, *"there is never enough money to*

purchase everything you want so it is a matter of juggling the priorities" (Informant EY003). However, most were quick to say that their business focus did not preclude them from concern about the principal mission of their hospitals to achieve high quality, appropriate patient care. A hospital general manager summarised his views by saying:

> *"Three main factors influenced my support for new technologies: (1) externally imposed Department of Health policies which mean that we have no choice but to spend the money; (2) quality concerns about patient outcomes and patient safety; and (3) budget control"* (Informant EY002).

OTS employee productivity

The concept of *employee productivity* was interpreted by all thirteen managers in quantitative terms. For example, one explained the concept by saying: *"I think of the utilisation of the individual, of their time and effort and expertise and energy. And I think of how much time they spend, as an individual, doing something as part of the process"* (Informant DY001).

The Likert-scaled responses by managers on the question of the impact of new intra-operative artefact adoption on employee productivity reveal that they had expected a moderate increase in employee productivity ($\mu_E = 7.15$, $\sigma_E = 1.58$).

Comments like the following, were typical:

> *"With new technologies there is an expectation that there is going to be some increased utilisation and some increased productivity because there is a fair financial investment. Obviously the administrators want to see some return for their investment"* (Informant AY001).

Overall, the explanations offered by the managers on this topic focus on the impact of new intra-operative artefacts on the *operative* phase of surgical production. Only one top manager considered production issues beyond the operative phase to the perioperative work, even although she, like many others, had the view that MAS technologies reduce operating time – something that the present research has shown to be incorrect. She remarked:

> *"I guess it comes back to how you perceive laparoscopic surgery when you have a superficial understanding of it. It is fairly short surgery, it's clean surgery, it's short hospital stay surgery, and all of those things initially indicate to you, easy, low risk, sausage factory type surgery. That's not what it is at all, so I guess I would have expected to see increased productivity. But that hasn't happened. There is a lot of extra time spent in cleaning, washing, sterilising instruments, checking the technology, making sure it is actually working, and working properly"* (Informant BY001).

Sections 5.6 and 5.7 discussed the changes in employee productivity that I had calculated from the sample activity and staffing data. It provided the types of evidence that could convince managers that OTS employee productivity has improved, not necessarily *because of*, but at least *in spite of* the technological changes that have occurred. For example, an increase of at least 20 per cent in the *mean operating minutes per FTE per month* across the five study hospitals between 1988 and 1998, was reported. On the surface, this conveys that there has been a significant increase in employee productivity during the period, an increase that could be interpreted as an improvement in *technical efficiency* (cf. Duckett 2000). Although a critical weakness of this measure is that it relates only to the *operative* phase of surgical production, it, nonetheless, presents a conundrum, because data already presented appear to contradict such a result. In fact, I have presented indisputable evidence that, not only has average operating time increased but, the human labour input to the perioperative phase of surgical production, which has never been included in productivity determinations, has also significantly increased. My response to this dilemma is made at the conclusion of the following subsection, which deals with an issue connected with employee productivity – that of operating suite throughput.

Operating suite throughput

The concept of *operating suite throughput* has been defined as the number of individuals on whom procedures have been undertaken in an operating suite in a given period. It is synonymous with the term, *surgical separations*. Data extracted from Appendix A3 Table 1 into **Table 6(g)** (following) for each of the sample 3-month periods in 1988 and 1998 reveal that the net increase in OS throughput at the five study hospitals is possibly around 3 per cent.

Table 6(g): OS throughput at study hospitals - one quarterly period in both 1988 and 1998

Total OTS throughput	Hospital A	Hospital B	Hospital C	Hospital D	Hospital E	TOTAL
July - September 1988	1180	794	1082	5350	1461	9867
April - June 1998	1512	1078	948	4957	1679	10174
Percentage change	+ 28 %	+ 35.7 %	- 12.4 %	- 7.3 %	+ 14.9 %	**+ 3 %**

In recognition of the possibility that the two sample quarters (being the first and last quarters of the ten year study period) might have been affected by seasonal or other variations in elective surgery, data were extracted from NSW Health data in Appendix A1 Tables 2 and 3 to estimate the net change between the *full year* periods 1992/93 and 1997/98 in surgical separations in the four public hospitals in the study. (Data for 1988/89 were unavailable). The net increase of 6.7 per cent over the five years, shown in **Table 6(h)**, confirms the trend.

Table 6(h): Surgical separations at the 4 public hospitals - 1992/93 and 1997/98

NSW Acute Public Hospitals only	Number of surgical separations 1992/93	Number of surgical separations 1997/98	Percentage change
Hospital A	3332	4155	+ 24.7 %
Hospital B	1994	2916	+ 46.2 %
Hospital D	13687	13876	+ 1.4 %
Hospital E	4537	4173	- 8 %
TOTAL	**23,550**	**25,120**	**+ 6.7 %**

Sources: NSW Health (1994b); NSW Health (1999b).

The Likert-scaled responses by managers indicate that they thought the adoption of new intra-operative artefacts had resulted in a slight increase in *OS throughput* ($\mu_O = 6.25$, $\sigma_O = 2.89$), but one that was less than they expected ($\mu_E = 7.85$, $\sigma_E = 1.94$) – differences which were statistically significant ($t = -2.9525$; Crit $t = \pm 2.179$, $p=0.05$, $df = 12$).

On the surface, managers' perceptions of the actual changes in OS throughput are consistent with the aforementioned trends in surgical separations, and one probable explanation for this congruence is that the managers are familiar with the *surgical separations* statistical data for their hospital or area health service, and/or perhaps the national data. However, none of these data can inform in any way on the *cause* of the increase in OS throughput over time. They serve only to show that managers expected new intra-operative artefacts to be among the factors contributing to the increase.

Again, there was scant consideration of perioperative workload. Overall, managers only thought about throughput capacity in terms of the operative phase, and everyone had expected that procedures would be done faster with the adoption of new intra-operative artefacts. For example, a hospital CEO remarked:

> *"I had the view expressed to me that it's a new technology, it makes life easier, anyone can do it, and because it's new, it's faster, basically that life would be a breeze using it… Maybe it was being equated to industry where technology made things faster"* (Informant CY002).

The comments of a Deputy CEO are in a similar vein:

> *"My expectation about changes in theatre throughput is that if we have an operating theatre list of the same duration, and assuming that everything else stayed equal – which is a dangerous assumption to make, I accept – that using high technology surgical equipment would have meant that there should have been a significant increase in throughput"* (Informant BY003).

The following extract from my interview with the CEO of an area health service clearly describes the techno-economic logic concerning the adoption of new technologies that was evident to varying degrees in all of the interviews with top managers.

> *"I think there was an expectation that with the new technology there is an automatic increase in throughput… I think there is a mind set in the community at large, and I'm part of that, that the new technology allows us to do more and better. When we see new factories built, car manufacturing plants, or whatever, they are designed to produce more and more…We just think that that's what they're for, and so whenever we purchase something we hope that there will be improved productivity and hopefully increased efficiency, but this doesn't necessarily happen"* (Informant BY002).

I suggest that managerial assumptions such as these have been reinforced by the fact that increases have, indeed, occurred in the numbers of patients having surgical procedures. However, returning to the earlier stated conundrum, the evidence of increased OS throughput, albeit not a substantial increase, appears to further complicate the problem for which I now propose some possible "solutions". I start by drawing attention to one of the basic principles of human resourcing the production process that was introduced in Section 3.3.2 – the absence of slack (ie. excess capacity). It was Babbage (quoted by Braverman 1974:79-80) who, in 1832, noted the value of purchasing 'exactly that precise quantity of …skill and force' necessary for any manufacturing operation, a principle that survives today in notions such as "lean production" (Guillen 1994).

The problem so far as surgical production is concerned is that it cannot be ascertained what amount of slack existed in OTSs in 1988, or whether or not any slack that existed, was avoidable. Attention was drawn in Chapter 2 to the fact that most OTSs undertake both elective and emergency surgery. This means that the nursing staff need to be either on duty or on call at all times and, if the former, some slack probably needs to be regarded as normal and unavoidable because the demand for emergency surgery cannot be predicted. Even so, an interim conclusion must be drawn from the findings of the present research that some slack existed in 1988, otherwise average operating time, employee productivity, and OTS throughput could not have subsequently increased as they have.

However, other important factors discussed in Chapter 2 are relevant here: (a) the increased throughput capacity and occupancy rates of *hospitals* that have occurred during the study period as a consequence of reduced lengths of hospital stay; (b) the enormous growth in day-only surgery often undertaken on an outpatient basis and, hence, not requiring a standard

hospital bed; and (c) other hospital efficiency-enhancing strategies (cf. Duckett 2000). However, the study hospitals had experienced no change in the numbers of operating and procedure rooms since 1988 (this being a criterion for selection). Consequently, the numbers and throughput capacity of the hospital beds providing patients to that stable number of operating rooms and procedure rooms increased significantly between 1988 and 1998.

I contend that in 1988, OTSs were most likely producing all of the surgical procedures for which their respective hospitals had patient capacity. In other words, the OTSs could probably have undertaken more procedures, but the hospital beds were not available to accommodate the patients. Hence, there was some slack. However, during the intervening period, hospital throughput capacity has increased, largely as a by-product of technological change in surgery, to the extent that OTS throughput capacity is approaching, or has reached its limit, *ceteris paribus* (ie. with no extended elective operating hours and no increases in levels of staffing).

It does not seem to have occurred to the managers I interviewed that OTS throughput capacity is *independent* of hospital throughput capacity. Rather, it appears to be assumed that as further decreases occurring in average length of stay result in greater hospital throughput capacity, the OTS will, most likely without additional resourcing, be expected to also increase its throughput. The evidence of the present thesis is that this is an ill-founded expectation.

Furthermore, the pressure on OTSs to meet such throughput expectations, which, as exemplified by the concomitant increased employee productivity and OTS throughput that they have thus far achieved (to a greater or lesser extent), is having dysfunctional consequences for many OTS staff (as discussed shortly in the topic of *quality of work life*).

OTS cost-efficiency

In the present context, the concept of *cost-efficiency* relates to *technical efficiency*, and conveys the notion that the revenue derived from production exceeds the input costs of production (cf. Terry & Forde 1988). Applying the concept to surgical production in OTSs in public hospitals is problematic because revenue, or rather, government funding, is fixed, and not matched to the services actually provided. This was the problem confronting one public hospital manager when he remarked:

> *"In terms of cost-efficiency, I would have expected a significant improvement if you were talking about cost per procedure or cost per patient. However, because the new technologies tend to mean you have higher throughput, ...you also end up with a*

greater overall cost [resulting in budget over-runs]. My concern [is] that Government funding [of public hospitals] and changes to health funding haven't caught up with the cost of that additional throughput" (Informant AY002).

Revenue in private hospitals, on the other hand, is on a fee-for-service basis, so their revenue and costs associated with surgical procedures fluctuate with variations in throughput volume and casemix.

Most managers conveyed that they had not previously thought of cost-efficiency beyond the entire episode of care involving all of the services provided within the hospital from admission to discharge of a surgical patient. However, their conclusions about the cost-efficiency of producing just the OTS component of a surgical episode of care were derived from their views about the cost-efficiency of *hospitals* in managing surgical patients. For example, one manager remarked, *"ultimately I expect that the technologies will achieve more episodes of care [in the hospital] for the same dollars"* (Informant EY002).

Duckett (2000:115) uses the previously mentioned evidence of increases in occupancy rates and reductions in length of stay, achieved principally from the 'significant increase in the proportion of day-only patients' undergoing diagnostic or therapeutic procedures (employing new technologies), as evidence of improvements in the technical efficiency of hospitals.

When managers reflected on the impact on the cost-efficiency of surgical production *within the OTS* of adopting new intra-operative artefacts, they concluded that a slight decline had actually occurred ($\mu_O = 4.47$, $\sigma_O = 2.04$) (see Appendix C2). Most of the managers drew their conclusions about reduced cost-efficiency of surgical production *within the OTS* by using the following logic. The cost of non-OTS services per surgical episode of care has decreased as a result of reduced average length of stay, and the inflation-adjusted average total cost per surgical episode of care in recent years has been fairly steady (cf. Commonwealth of Australia 1998a; CDHSH 1995a; Aisbett et al. 1998). Hence, there has been an overall cost shift to the OTS, and because this has occurred over the same period as so much technological change, high cost new intra-operative artefacts must be strongly implicated in the increased OTS costs.

Various issues were then considered by managers in the process of translating the conclusion about increased OTS costs to a conclusion about reduced OTS cost-efficiency. One top manager pondered:

"I think that the cost of the equipment and the service costs on the equipment is incredibly high. I don't think there is a significant change in the salaries and wages

cost. For example the laparoscopic work, the time in the theatres, doesn't seem to be less, so there is no cost change there. So on balance, I think that in the operating theatre itself, it is not more cost- efficient" (Informant BY003).

Quality of work life

The topic of *quality of work life* was the fourth of the domains in which the expectations and perceptions of top managers on new intra-operative artefact adoption were explored. The concept was introduced in the literature review in Chapter 3 as one of the strategic reasons why organisations might choose to adopt new technologies. It pervades many of the issues that have been discussed in the present chapter. Factors such as the increased labour intensity of surgical production, increases in manual reprocessing, increased task complexity, and many more, have consequences for *receivers* of new intra-operative artefacts that translate into changes, for better or worse, in the quality of their work lives. This section focuses on the OS nurses and SD technical aides for whom top managers have ultimate responsibility. It discusses what they reported about their work life experiences of changes resulting from new intra-operative artefact adoption and compares their experiences with managers' comments.

Interestingly, managers reported that they had not really thought specifically about how the adoption of new intra-operative artefacts might affect the quality of work life of OTS employees. As one manager observed: *"From an executive point of view… I don't think that in making the decisions [about new intra-operative artefacts] the quality of the staff's work life is ever considered. I'm not being bloody minded… I think it doesn't equate down to that level"* (Informant CY002).

Upon reflection, however, most thought that the new technologies had enhanced the quality of employees' work lives to a moderate degree ($\mu_O = 6.98$, $\sigma_O = 1.62$). They gave several reasons for their conclusions, not the least being because of expectations such as job simplification, as previously expressed, *"[we thought] it makes life easier, anyone can do it, and… life would be a breeze using it"* (Informant CY002).

The other reasons they gave for their conclusions fell into two categories. The first was opportunities for personal growth and improving job opportunities. In the course of one interview, I sought clarification on this, and asked, *"so, you consider the issue of personal growth and education as the main quality of work life issue?"* The response came:

"Yes, and the ability to adapt and therefore go from one area to another, or adapt to change. Say if this hospital became skewed towards aged care and [the nurses] want

to continue their career in theatres, they could go to another hospital and have the basic skills and confidence to adapt" (Informant EY003).

The second quality of work life category was the novelty and interest factor of using new technically sophisticated instruments and equipment but, interestingly, only the male managers presented this as an expected source of enhanced quality of work life (cf. Phillip & Taylor 1980; Cockburn 1983). Moreover, none of the thirty-one OS nurses talked in their interviews about the adoption of new intra-operative artefacts as the means of enhancing the quality of their work lives in the ways perceived by the managers. However, two factors did emerge. One related specifically to the new intra-operative artefacts, whilst the other concerned the adoption of new instrument reprocessing equipment (ie. the *Steris*™ and *Medivator*™ machines) which facilitated the elimination of the occupational health and safety risks associated with the chemical, gluteraldahyde. Only the first factor concerns intra-operative artefacts, so it is the only one discussed here.

According to the OS nurses, the advent of MAS procedures employing video technologies produced two benefits for them. In conventional procedures, for example, it is very difficult for the instrument nurse, and impossible for the circulating nurse, to have a good view of the surgical field. However, in MAS procedures everyone in the OR has the same view of the procedure as the surgeon because images of the surgical field are projected onto a television screen. OS nurses believe that this has made their work more interesting than it might otherwise have been. That said, it is notable that this "interest factor" derives from the technology's *functional benefits* and not the *technical characteristics* of new intra-operative artefacts emphasised by the managers. In this connection, numerous nurses mentioned that they were not "technically oriented", and that they have had to work hard at becoming proficient in learning and performing the technical aspects of the new intra-operative artefacts.

OS nurses also reported that seeing more of the procedure has helped them to "do a better job" as an instrument and/or circulating nurse, and that this has enhanced their capacity to achieve their primary goal, which is to provide the best possible care for the patients. This, combined with the belief that the new technologies have a greater potential clinical benefit for their patients, has resulted in nurses being generally prepared to accept the negative work-related consequences of new intra-operative artefact adoption. I have interpreted this as evidence of the *caring trait* amongst OS nurses. As discussed in Chapter 2, this trait is traditionally associated with the "bedside healing" role of nurses in other nursing contexts where the nurse is the primary provider of care (Wicks 1999), often as an independent

practitioner (as previously discussed in Section 6.4.4). However, I propose that, although the type of care OS nurses provide to patients is quite different to that provided by their peers in other patient care areas of a hospital, their *care* for their patients is, nonetheless, a pre-eminent concern. This appears to be an important source of motivation for them to become competent in their roles connected with the adoption of new intra-operative artefacts.

One significant quality of work life issue for OS nurses is the *increased pace of work*. It appears to be a consequence of the interaction between a number of factors that have already been discussed, such as increased OTS throughput, longer and more complex procedures, and the significant increases in perioperative work. It is an element of the increased labour intensity of work, which, for some, is a source of distress and dissatisfaction (cf. Johnstone 1998; 1999; 2000; Brewer 1986). For example, when I asked one OS nurse, *"overall what do you feel has been the effect [of the new technologies] on you in your working life?"* she replied: *"It can be quite stressful at times. They're push, push, pushing to get these cases done. You feel it's quite thankless at times and you're doing the best that you can. There's a lot of pressure"* (Informant DX009). Another nurse said: *"I think there's a different stress level now among the nurses than there ever was. It's more continuous, ongoing, day after day..."* (Informant DX010).

Only three top managers expressed some understanding of these workload pressures. One, for example, remarked: *"From the staff's point of view I think it became much more stressful. There's pressure on staff members to become familiar with the new equipment, to be able to use it. There's an expectation from the doctors that the staff know how to use it"* (Informant CY002).

Mention was made earlier about the propensity of new intra-operative artefacts to malfunction, particularly those employed in MAS procedures. One manager appreciated that this was a source of distress for OS nurses when she said:

> *"They can be in the middle of a procedure and for example, suddenly the lights [for the 'scopes] go out. I think, especially if you've got equipment that's a little bit dodgy, there is a lot of stress on staff. They're going to have somebody on the table and if they haven't got reliable equipment, they get very nervous"* (Informant BY001).

Another admitted:

> *"The workload implications of the new surgical technologies are easily overlooked because you think the time must be reduced by half so they must be able to put through twice as many. We forget that they have to set up for each theatre, they've got*

to clean up, and so on. It's very easy to think only of the efficiency and forget the people. I guess we are ignorant of that, and it's plausible, because it's such a closed shop" (Informant EY003).

Pre- and post-adoption evaluation of new intra-operative artefacts

In concluding the discussion on the actual and expected organisational outcomes of new intra-operative artefact adoption, attention is briefly focused on the topic of *post-acquisition evaluation*. Process and outcome evaluations are recognised elements of most organisations' strategies aimed at ensuring that they are "doing the right things, and doing them right" (cf. Ovretveit 1998). All managers were asked the question: *"Are you aware of any audit or formal assessment procedures which are in place in your hospital, to evaluate the outcome of any equipment purchases against proposals for their acquisition?"* In all cases, the answer was a categorical *"no"*.

Many replies drew attention to the fact that there are two dimensions of evaluation: the *clinical* evaluation and the *business* evaluation. Early in the present chapter I discussed how the main reason that new intra-operative artefacts are adopted is the expected clinical benefit. Cognisant of this, many of the managers articulated the view that the clinicians, particularly the procedural specialists, who are the end-users of the new intra-operative artefacts, are ultimately the ones who evaluate them, albeit informally, on the basis of whether or not they are actually helping them to achieve the desired clinical outcomes. This is consistent with my statement earlier in the chapter that procedural specialists will not continue to employ a technology that is not fulfilling their expectations. As an orthopaedic surgeon remarked, *"I'm always looking for a better way of doing something if I'm not happy with the previous procedure"* (Informant DZ001). This is, indeed, a continuous informal approach to process and outcome evaluation, not only of new intra-operative artefacts, but of the other non-artefact dependent changes in techniques that are a constant feature of their practice. Procedural specialists reported that their evaluations of their practices are also informed by the empirical clinical literature involving, for example, longitudinal clinical outcomes studies, randomised controlled clinical trials (eg. Hidlebaugh 1996; Majeed, Troy, Nicholl et al. 1996; Rhodes et al. 1998) and, in some cases, studies of the cost-effectiveness of one technology compared to another (eg. Ransohoff, Lang & Kuo 1991; Lieberman 1991, Williams et al. 1993; Bass et al. 1993; Mowschenson 1993; Traverso 1996; Tallon 1996).

On the *business* side, the explanations offered by the managers for the absence of any audit or formal assessment procedures had a common theme. It is stated succinctly by the CEO of an area health service:

> *"We don't do any evaluation of the technologies after we've bought them. Quite frankly, I think it would be a waste of time because the cost of doing the job properly would exceed the benefits of doing it. I think that if the evaluation isn't rigorous, you might as well not do it…and there'd be so many to do. So, no, we don't"* (Informant BY002).

Views such as this reflect the concept of *satisficing* that is central to March and Simon's (1958) "bounded rationality" thesis. Satisficing in decision situations involves accepting that the additional information required to achieve a state of greater certainty of consequence, is not costless, and consequently, a decision is made to accept a *satisfactory*, as opposed to a possibly *optimal*, alternative.

Overall, the managers concentrate on managing the financial and operational infrastructure necessary for the procedural specialists to treat their patients in the hospital. However, I propose that what is overlooked in such a situation, is that the organisational structural arrangements in which the new intra-operative artefact adoption decisions are made, are designed by the very people who do not undertake the post-acquisition evaluations. That is, the organisational guidelines on the content of proposals to acquire the new intra-operative artefacts are developed by the top managers. The applicants, usually a group of procedural specialists and OS nurses, are required to provide the information that the top managers need to assist them in their *business* decisions. These are predominantly details about the acquisition and operational costs, supported by the main expected clinical benefits of any proposed new artefact.

Clinicians are able to provide empirical evidence of the expected clinical benefits and to cite quoted prices for the new technologies they wish to adopt. However, it appears that in many cases there are no reliable data from any source that can inform on the likely impact of the new technology on the technical and human resource costs of operating it – a case of *imperfect information* or *unknowables* (Kuhn & Beam 1982). In practice then, the estimated operating costs are often the result of "informed guesswork" that possibly errs on the low side so that the risk of their proposals being rejected on *business* grounds is minimised.

The end result of this, in the absence of post-acquisition evaluation data to the contrary, is a *self-perpetuating myth* that the adoption of the new intra-operative artefacts are, indeed, achieving the improvements in employee productivity, OTS throughput, or cost-efficiency of producing surgical procedures that were probably articulated in the formal proposals to acquire them. One top manager offers some personal insights into this phenomenon in relation to colonoscopy:

"The more advanced endoscopes would probably be one where there was a suggestion that the procedure itself would be able to be done quicker, leading to more cases being able to be managed through the endoscopy suite. [However] I think that there is often, even amongst the staff who are putting forward the proposal, an over-estimation of the benefit to be gained in terms of productivity, or in relation to throughput, when these proposals are being put forward" (Informant DY001).

6.5.3 Summary: The actual and expected organisational consequences of new intra-operative artefact adoption

The fourth research question asked: "are the consequences for surgical production within operating theatre services of new intra-operative artefact adoption congruent with expectations and, if not, why not?" Section 6.5 has provided a comprehensive response to that question. It has reinforced the finding that an unexpected consequence of new intra-operative artefact adoption has been a substantial increase in the labour intensity of surgical production. It explored the congruence between managerial expectations and the actual consequences of these technological changes on OTS employee productivity, OTS throughput, OTS cost-efficiency, and the quality of work life of OTS employees. In the process, a conundrum emerged in relation to how significant increases in both operating times and perioperative human labour input to surgical production could occur at the same time as increased employee productivity and OTS throughput. The interpretation offered concerning the progressive elimination of slack in the OTS arising from changes in the relative throughput capacities of the hospital and its OTS over time, adds weight to the conclusion that surgical production in OTSs is a unique form of production whose structural and business consequences do not parallel those that are central to the theories and management perspectives to which I refer collectively as the techno-economic theories of production.

The following section is a response to the fifth, and final, research question. It explores and analyses the nature of, and influences on, the new intra-operative artefact adoption decision processes within hospitals. As mentioned at the beginning of the present chapter, the very asking of a question about decision processes assumes that human agency/choice is active in the new technology adoption activities that are the focus of the present research. Hence, the consequences of new intra-operative artefact adoption reported and discussed at length to this point in the thesis, cannot be regarded as having an inertia of their own (cf. discussion in Section 3.2). Rather, they are the products of the continuous interplay of new technological

potential and the human choices made to harness that potential and apply it to the surgical process.

6.6 The new intra-operative artefact adoption decision process

This section explores the various dimensions of the new intra-operative artefact adoption *decision process* within hospitals – a decision process in which a specific decision to adopt a new technology might involve a single intra-operative artefact or a collection of inter-dependent artefacts dedicated to a specific purpose. Central to the discussion is my conclusion that the way that individuals participate in any decision process is influenced by their vested interests in specific intra-operative artefacts, the formal structural arrangements within the organisation, and the informal relationships between stakeholders.

In the case of the decision processes discussed following, it is important to acknowledge that hospitals are categorically *professional organisations* in which, as the foregoing discussion has shown, managers and clinical professionals have distinct but complementary roles and responsibilities. The following discussion shows how their respective roles and responsibilities include participation in various ways in the new intra-operative artefact adoption decision process.

These roles and responsibilities are distinguished in a 7x2 matrix that I have entitled *a situational stakeholder participation and adjustment matrix of technological change*. The matrix, which is the theoretical outcome of my analysis of *participation* and *receiver status* in new intra-operative artefact adoption, provides an analytical framework by which to explain the specific *decision roles* and new technology *receiver status* of individual stakeholders in specific new intra-operative artefact adoption situations.

6.6.1 Stakeholders' vested interests in a decision process

There are potentially multiple stakeholders involved in the decision processes to be discussed here, but the interest of the present thesis is on the key four internal stakeholder groups represented by the informants in the present study. I explore the various ways that they might participate in a new intra-operative artefact adoption decision process, and it is useful to start by thinking about what are the dominant vested interest(s) of each in the adoption of new intra-operative artefacts. These "dominant vested interests" were discussed in Section 6.2 from the perspective of stakeholders' *altruistic* and *self-interest* goals in new intra-operative artefact adoption. Not unexpectedly, the dominant vested interests of each of the three stakeholder groups are representative of the issues that each brings to *influence* the new intra-operative artefact decision process.

As previously discussed, a procedural specialist's dominant vested interests in the decision process derive from both the clinical goals that (s)he wants to achieve with a new intra-operative artefact and various self-interest goals, such as what impact the decision not to acquire a new artefact might have on his/her professional livelihood as a consultant.

OS nurses' dominant vested interests in the decision process are predominantly *technical* and *operational*. They derive from the fact that they are categorically *receivers* of the new intra-operative artefacts, and have a number of roles and responsibilities associated with them. For example, when procedural specialists express an interest in trialing or acquiring particular artefacts, OS nurses tend to do most of the investigative work with the biomedical companies on the technical specifications and compatibility of new surgical instruments and enabling equipment with existing technologies, and on estimated costs. Operationally, they have a vested interest in the likely impact of technological change on staff, not the least being the numbers and skills of staff, and whether or not the OTS possesses the necessary reprocessing technologies.

Top managers' dominant vested interests in the decision process derive from their predominantly functional management roles and responsibilities related to the business side of the hospital. Their principal concerns are represented in the following questions: Do the proposed artefacts fit within the hospital's level and scope of services? Can the hospital afford to acquire, operate, *and* maintain them? Are the clinicians agreed that they are appropriate? Have the relevant policies been followed concerning supplier selection, and what are the opportunity costs for the hospital of acquiring an item for the OTS?

Overall, managers recognise that the clinicians have the expert knowledge that they lack, and will generally accept their advice on the clinical efficacy and between- and within-technology appropriateness of the intra-operative artefacts that they are proposing for adoption. During the mid 1980s, Brewer (1986:154) similarly observed that in the introduction of new medical technologies, in general, 'the power that medical decision makers have over others outweighs any reciprocal power relationship because their "clinical judgement", insight and expertise are accepted as being more important than any other group's capacities'. Nevertheless, managers, by virtue of their *ex officio* roles and responsibilities that cause them to focus on the *business* aspects of the adoption of new intra-operative artefacts, expect clinicians to have an appreciation of their hospitals' limited financial resources that should influence their new intra-operative artefact adoption decision behaviour.

Top managers talked a lot about the scarce financial resources available to acquire all of the artefact technologies requested by many hospital departments and of the difficulties they

experienced when decisions had to be made about what items could *not* be acquired. (I use the term, "acquire" here because new technology adoption could involve purchase or leasing arrangements.) In these ways, their roles and responsibilities are primarily those of resource allocator and gate-keeper (after Mintzberg 1998).

Typical of managers' responses to my question concerning which factor(s) carried greatest weight for them in the various new technology adoption decisions that they had mentioned during their interviews, is the following:

> *"I'd have to say that the financial one to us would be paramount in the sense that, not whether we have the money or not, although that obviously is an issue too, but can we justify the expenditure for the amount of work that the piece of equipment was going to be put to"* (Informant BY002).

Hospitals have different administrative arrangements concerning expenditure on capital equipment. The protocols vary according to (generally) three different levels of proposed capital expenditure. Each stipulates how many cost quotations for the same or similar artefacts are required, the details of the substantiation required in the purchase requisition, and who is authorised to approve the purchase. Overall, the greater the proposed level of expenditure, the more rigorous the process and the higher the level of management that is required to sign off on the purchase. The CEO of an area health service explained:

> *"Delegation of authority in accordance to the Delegations Manual allows a certain level of staff to secure equipment for the maintenance of the day to day services. In relation to operating theatres, even the run-of-the-mill equipment often costs a lot more than the delegated authority of the manager of an operating theatre or the hospital, so it usually is within only my delegated responsibility to purchase. I take advice from them before making some assessment as to whether it is a yes or no. Also, we have to be careful that we comply with our overall asset strategic plan and the role delineation of our hospitals before we approve or not approve any requests for equipment for the operating theatre"* (Informant AY001).

Identification of the vested interests of various stakeholders also serves to highlight that the decision processes under consideration have political dimensions. This phenomenon is not new. Brewer (1986), for example, during the mid-1980s, drew attention to the political nature of decisions concerning the introduction of various medical technologies in hospitals. The following extract from my interview with a top manager reveals that these political dimensions of committing hospitals' financial resources to new intra-operative artefacts extend beyond the OTS and hospital:

"Your staff are the ones that if you don't do the right thing they're going to come back and bite you, whether it's politics via the local Rotary Club, via the local newspaper, via the MP, via the secret letter. I don't see that as a threat, but it's a reality. We have also got VMOs who are a very articulate group, and if the right thing is not being done in their eyes, they have their own way of ensuring that [information] gets out" (Informant EY003).

6.6.2 Participation in a decision process

Participants in any decision process associated with the potential adoption of a new intra-operative artefact constitute the *decision set* (Hickson et al. 1986). Each participant might have one or more of the five *decision roles* that I have identified as a result of the present research as: *initiator, facilitator, influencer, enactor,* and *implementer*. The functions represented by these roles have been widely documented in the literature, but I propose that their synthesis as a set of *decision roles* is innovative, as is their subsequent incorporation into my *situational stakeholder participation and adjustment matrix of technological change*.

A *decision role* has two dimensions: *opportunity* and *capacity* to participate (or not to participate) in one or more ways in a decision process. These two concepts were defined in the context of my synthesis of the literature, in particular from the contributions of Hickson et al. (1986), Heller et al. (1988), March (1994), Thomas (1994), and Pusić (1998), on the topics of participation and influence in multiple-actor decision processes. *Capacity* derives largely from status and/or knowledge power, whilst *opportunity* may arise formally or informally and, if the latter, it may not come from a legitimate power base. Moreover, not everyone with a vested interest in a particular new intra-operative artefact is a member of the decision set, and I have identified two such stakeholder roles (or types) to accommodate this: *observer* and *non-participant*.

The *initiator* role parallels the start-up/identification phase of the decision process (cf. Mintzberg 1976; Heller et al. 1988) and pertains to stakeholders who formally or serendipitously initiate the decision process pertaining to a specific new technology by stimulating interest in it (Thomas 1994). I have defined an *initiator* as someone who has the capacity and opportunity to get an issue on the (formal or informal) agenda (cf. Thomas 1994; Langley & Truax 1994; McKenna 1999).

Contrary to the emphasis in the literature on the entrepreneurial role of top managers, the procedural specialists and the OS nurses are, with few exceptions, the initiators of the decision processes concerning new intra-operative artefacts. In other words, changes in surgical technologies are not driven "from the top". In fact, often the first involvement a top

manager has in the decision process is when a formal application to acquire a new intra-operative artefact "lands on his/her desk". This is congruent with Thomas' (1994:214-216) conclusion that many new technology decisions 'originate at some distance removed (in time and space) from the top of the organisation'. For example, an OS nurse who has just returned from a conference/trade display might, during the course of a surgical procedure, tell the surgeon about a new instrument that was demonstrated there. If the surgeon chooses to make further inquiries about that instrument, such that (s)he eventually adopts it into his/her practice, then the nurse would be categorically the initiator of the associated decision process.

An example of the surgeon as *initiator* is given by an orthopaedic surgeon in response to my question, *"what do you think is actually driving you to adopt new technologies?"* He replied:

> *"I'm the driver. I'm trying to get the best possible result predicably with the least effort for the patient and most efficiently in the shortest time frame. It's me driving that change. Technology never drives me. I can't think of a period where somebody came along and said I've got to adopt this new technology. It's usually me seeking out the technology"* (Informant DZ001).

The *facilitator* role relates to the formal and informal mechanisms within the organisation whereby the decision process is progressed. Consequently, I have defined a *facilitator* as someone who has the capacity and opportunity to facilitate the decision process. The literature implicitly attributes this role to top and middle managers by virtue of their *ex officio* strategic and functional roles within the organisation, particularly via their direct or indirect influence on the organisation's structural and policy arrangements (cf. Heller et al. 1988; Thomas 1994; Child 1972:13 citing Burns 1966). As discussed in Section 6.6.1 and, prior to that, when pre- and post-implementation evaluation issues were discussed, the present study found that this was true of the formal facilitation process in which managers establish the framework and criteria for *formal* applications to acquire a new technology. However, within the operating suite, one or more "champions" might adopt an *informal* facilitation role that would terminate only when most of the facts had been obtained and sufficient interest had been generated amongst the clinicians to get the issue onto the formal agenda. Often, a manager in the OTS adopts this facilitator role at some stage in the informal process.

I have defined an *influencer* as someone who has the capacity and/or opportunity to influence the issues considered in the decision process. In so doing they influence the range of possibilities considered by other members of the decision-set and/or the course of the decision process (cf. Heller et al. 1988; Thomas 1994). Implicit in my definition is the notion that an individual may have the opportunity to influence and, in fact, be influential, although

(s)he might be unqualified (ie. not have the capacity) to be a legitimate (ie. formal) participant in the decision process.

A top manager identified some of the stakeholders with influencer roles when he responded to my question about his reasons for supporting a particular equipment purchase. He said: *"The purchase was supported by the Medical Staff Council, the Director of Medical Services, the Biomedical Engineer, and they certainly had the CEO on side. So I was more than happy to accept their opinions"* (Informant AY002).

Influence can be exerted using techniques that are not limited to those identified by Thomas (1994), such as influencing the selection of what problems, or yet unrecognised problems, need a solution. For example, the OTS manager might both *initiate* a decision process and *influence* the choice of a new instrument by virtue of which biomedical companies (s)he invites, or otherwise does not invite, to supply their products for trialing by the surgeons. Furthermore, other OS nurses, the SD manager or senior SD technical aides might be influential on within-technology issues following their investigation of the reprocessing implications of the new intra-operative artefacts under consideration.

The *enactor* role involves the stakeholder as *the* decision-maker or as one of a group of people who make *the* decision to make a specific commitment to action (cf. Hickson et al. 1986; Thomas 1994; Nutt 1998). It parallels the selection/finalisation phase in the decision process (Heller et al. 1988; Mintzberg 1973). I have defined an *enactor* as an individual who has the capacity and opportunity to be a decision-maker on an issue. The pervasive theme of the literature is that top managers have an *ex officio* role to enact strategic decisions (cf. Mintzberg et al. 1976; Strauss 1998).

In the present study, decisions are regarded as being *enacted* when *the* decision is made to commit the hospital's financial resources to the acquisition. Which individual stakeholder(s) actually take on the enactor role in specific new intra-operative artefact acquisition decisions depends on the level of expenditure involved (as explained in the previous section). Consequently, the enactor role belongs to top managers in those decision processes that might be regarded as being categorically *strategic* (cf. Mintzberg et al. 1976; Strauss 1998) in as much as they involve a large commitment of financial resources. Otherwise, it belongs to the OTS managers or other OTS personnel who are authorised to take on the enactor role in lower-cost artefact acquisition decisions.

The *implementer* role relates to the implementation phase (Heller et al. 1988) when operational contingencies are resolved after "finalisation" (cf. Langley & Truax 1994; March

1994; Thomas 1994). I have defined an *implementer* as an individual who has the opportunity and capacity to put a decision into effect.

Even although the surgeons are the primary adopter/end-users, OS nurses are the principle implementers of new intra-operative artefact adoption decisions for two reasons. First, because they have ongoing dealings with the biomedical companies and, once a decision is enacted/authorised, they usually have the responsibility of ordering the new artefact from the supplier, receipting it, and advising procedural specialists when it is available for them to use. Secondly, their implementer role extends to their responsibility to ensure that staff are trained in readiness for its introduction, and that the requisite perioperative technologies (such as the appropriate cleaning and sterilisation technologies) are in place prior to adoption.

Some stakeholders might have capacity and opportunity to participate in a new technology adoption decision process, but elect not to (Heller et al. 1988; March 1994; cf. Ashmos & McDaniel 1996). I have described such a stakeholder as an *observer* for any occasion that (s)he could have participated in a decision process but did not. Finally, a *receiver* may have neither the opportunity nor capacity to participate in a decision process (cf. Heller et al. 1988; Ashmos & McDaniel 1996). Consequently, a seventh category of stakeholder is included in the matrix – a *non-participant*.

The following section brings together these seven categories of stakeholder (non)participation into one dimension of a matrix in which the second dimension is a stakeholder's new intra-operative artefact *receiver status*. As previously defined in Section 2.9, a *receiver* is an individual for whom the adoption of a specific new intra-operative artefact necessitates some degree of *adjustment* in the technique or organisational aspects of his/her work. In practice, a *receiver* of a particular new intra-operative artefact is someone within the OTS who uses and/or cares for it. The degree of "adjustment" can vary from minuscule to very large, although the magnitude of the adjustment is incidental here. What is important is that if some degree of adjustment in an individual's work, however small, is a consequence of a specific new intra-operative artefact being adopted, then that individual is categorically a *receiver*. If not, (s)he is a *non-receiver*.

6.6.3 Situational stakeholder participation and adjustment matrix of technological change

Earlier in the present thesis, I categorised the four stakeholder groups by their status as *receivers* or *non-receivers* of new intra-operative artefacts. Section 2.9 categorised top managers as *non-receivers*, and the other three informant groups as *receivers*. However, when the phenomena under analysis are reduced to the level of specific new intra-operative

artefacts and individual (anonymous) stakeholders, an OS nurse or procedural specialist may or may not be a *receiver* in a particular new artefact adoption scenario. *Receivers* and *non-receivers* alike might have no capacity or opportunity to participate in any way in a specific decision process. In such cases they are *non-participants*. Similarly, a non-participant is not necessarily always a non-participant, just as an *initiator* is not always an *initiator*, and so on. This is what is meant by the dynamic, situation-dependent nature of stakeholder participation represented in the 7x2 matrix, presented in **Figure 6(d)**, that I have entitled *a situational stakeholder participation and adjustment matrix of technological change*. It is the theoretical outcome of my analysis of *participation* and *receiver status* in new intra-operative artefact adoption. Consistent with my *mediated attribution perspective* on choices and consequences in technological change (presented in Section 3.2), it reflects:

(a) the dynamic multiple-actor characteristic of new intra-operative artefact adoption decision processes

(b) the characteristic that a new intra-operative artefact necessitates its receiver(s) to make some degree of adjustment in *technique* or *organisation* when it is adopted (otherwise there is nothing new about it), and

(c) the situation-specific nature of both *stakeholder participation* in the decision process and *receiver status* in any new intra-operative artefact adoption scenario.

The matrix provides a theoretical framework by which to explore multiple-actor participation in new intra-operative artefact adoption decision processes and to explain the specific decision roles and new technology receiver status of individual stakeholders in specific new intra-operative artefact adoption situations. Examples of each are now briefly discussed, using a scenario constructed from the qualitative data relating to the adoption of new intra-operative artefacts to undertake laparoscopic cholecystectomy.

First, the surgeons who perform the procedure, OS nurses who are members of surgical teams for laparoscopic cholecystectomy and/or have various perioperative roles associated with the associated intra-operative artefacts, and SD technical aides, were categorically *receivers*, whilst the top managers were *non-receivers*. Surgeons reported that they learnt about the new procedure from their peers, from reading journal articles, from representatives of biomedical companies, and/or from attendance at a professional conference. By-and-large, they *initiated* the decision process by expressing an interest in adopting the new technologies to, for example, the OTS manager. As a result of, possibly, independent fact finding, one or more surgeons might already have preferences for a particular configuration and/or manufacturer of the necessary intra-operative artefacts. Hence, they are likely to *influence* the between- and

within-technology choices by articulating their preferences, not only to the OTS manager, but to their peers, and to other OS nurses, particularly those in their surgical team for any procedure. Any of the latter might subsequently take on an *influencer* role.

Figure 6(d): A situational stakeholder participation and adjustment matrix of technological change

Stakeholder participation in the decision process	Receiver of new intra-operative artefact	Non-Receiver of new intra-operative artefact
Initiator	Has capacity and opportunity to get the issue "on the agenda" and Some degree of adjustment in *technique* or *organisation* necessitated by the technological change	Has capacity and opportunity to get the issue "on the agenda" and No adjustment in *technique* or *organisation* necessitated by technological change
Facilitator	Has capacity and opportunity to facilitate the decision process and Some degree of adjustment in *technique* or *organisation* necessitated by the technological change	Has capacity and opportunity to facilitate the decision process and No adjustment in *technique* or *organisation* necessitated by technological change
Influencer	Has capacity and/or opportunity to influence the issues considered in the decision process and Some degree of adjustment in *technique* or *organisation* necessitated by the technological change	Has capacity and/or opportunity to influence the issues considered in the decision process and No adjustment in *technique* or *organisation* necessitated by technological change
Enactor	Has capacity and opportunity to be a decision-maker on the issue and Some degree of adjustment in *technique* or *organisation* necessitated by the technological change	Has capacity and opportunity to be a decision-maker on the issue and No adjustment in *technique* or *organisation* necessitated by technological change
Implementer	Has capacity and opportunity to put the decision into effect and Some degree of adjustment in *technique* or *organisation* necessitated by the technological change	Has capacity and opportunity to put the decision into effect and No adjustment in *technique* or *organisation* necessitated by technological change
Observer	Has capacity and opportunity to participate in the decision process, but elects not to participate and Some degree of adjustment in *technique* or *organisation* necessitated by the technological change	Has capacity and opportunity to participate in the decision process, but elects not to participate and No adjustment in *technique* or *organisation* necessitated by the technological change
Non-participant	Has no capacity or opportunity to participate in any way in the decision process and Some degree of adjustment in *technique* or *organisation* necessitated by the technological change	Has no capacity or opportunity to participate in any way in the decision process and No adjustment in *technique* or *organisation* necessitated by the technological change

Notes: The decision processes relate only to those concerned with the adoption of new intra-operative artefact technologies. The terms, *technique* and *organisation* are the other two of Winner's (1977) three categories of *technology*, where *artefacts* are the tangible technologies and the others are the intangible technologies such as knowledge, skills, procedures, and work arrangements. The *technological change* referred to in this matrix is limited to changes that are consequences of decisions to adopt a new *intra-operative artefact*.

Due to the high acquisition costs of the artefacts involved, and also because of the potential ramifications for the hospital with such an innovation in this case, the OTS manager would consult with the relevant top managers, whose role at this stage is largely to confirm that the proposed new technology is congruent with the hospital's designated role. Some formative discussion on financial issues might occur at this stage. Overall, the OTS manager becomes the *facilitator* of the decision process – the individual who acts as the bridge between the biomedical companies, the surgeons, top managers and the relevant OTS personnel. In the process, (s)he has the potential to substantially *influence* the choice of artefacts because of his/her dealings with the various biomedical companies, the surgeons, other OS nurses, and SD technical aides.

A nurse who does not work in the specialty area might have nothing to do with the entire process and is, consequently, an *observer-non-receiver.* Some surgeons might be intending adopters but elect not to participate in the decision process, being content to leave it to their peers. Consequently, they are categorically *non-participant-receivers*, who, in another new technology adoption decision process, might take a participatory role, such that one could be, for example, an *initiator-influencer-receiver*.

Then, once the decision process within the OTS reaches a point at which the preferences of the stakeholders are known, a formal proposal to acquire the necessary artefacts is compiled. Contributors to the preparation of the proposal are categorically *facilitators* because, in so doing, they are progressing the decision process. Usually, after some consultation, the decision is *enacted*, in this case, by one or more top managers, who formally commit the organisation's financial resources to acquiring the new intra-operative artefacts by "signing off", or, alternatively, not "signing off", on the purchase order. In so doing, they also commit the organisation to a particular course of action (or strategic direction), which, in this scenario, is to commit (or not to commit) the hospital's future financial and human resources to the provision of laparoscopic cholecystectomy as part of its service mix. Subsequently, the OTS manager, by virtue of his/her staff management roles, carries much of the responsibility for ensuring a smooth implementation process, and so ultimately (s)he might be categorically an *influencer-implementer-receiver*.

6.7 Dominant research paradigm conclusion

The dominant *naturalistic* paradigm proposition of the thesis was introduced in Chapter 1, and was expressed in the following terms:

> *The characteristics of new intra-operative artefacts, the reasons for their adoption in surgical production in hospitals, the decision processes associated with their*

adoption, and their consequences for receiver stakeholders, cannot be explained using the set of theories and managerial perspectives, which I refer to collectively as "the techno-economic theories of production", that are typically operationalised in new technology adoption scenarios in organisations by strategies that emphasise return-on-investment.

The issues identified in this proposition have been systematically investigated, culminating in evidence from both the literature and the present empirical research that supports the proposition.

The literature reviewed in Chapter 3 explored the organisational, politico-economic, and techno-social literature that constitutes what I have referred to collectively as the *techno-economic theories of production*. It demonstrated the pervasive influence of these theories on managerial thinking and practice when new artefact technologies are adopted in organisations. It also highlighted the emphasis of the empirical and management practice literature on manufacturing organisations that have tangible products. The research findings reported in this and the preceding chapter combine to reveal the inadequacy and/or inappropriateness of these theories as a means of interpreting the process and organisational consequences of new intra-operative artefact adoption in surgery.

The topics covered in Sections 3.3 and 3.4 of the literature review reflect the content of the five research questions that were introduced in Chapter 1. The sequence in which they were examined parallels the sequencing of the same topics in the present chapter.

The first research question asked "what are the dominant technical characteristics and functional goals of new intra-operative artefacts adopted between 1988 and 1998?" I responded by showing that, despite the enormous growth in the application of electronic and digital technologies to intra-operative artefacts, especially those employed in procedures using MAS technologies, they are not designed to mechanise/automate the surgical process or displace human labour. I showed how the main functional goals of new *surgical instruments*, *surgical materials* and *enabling equipment* were to facilitate improvements in the quality of the process and/or outcome of an existing type of procedure or to introduce a new type of procedure which, subsequently, might replace a pre-existing technology. The dominant theme of the literature, however, is reflected in the sentiments expressed in 1776 by Adam Smith (in Skinner 1970:46) that machines 'facilitate and abridge labour, and enable one man to do the work of many'.

The second, third, and fourth research questions focused on the expected and actual consequences for surgical production within operating theatre services of new intra-operative artefact adoption. I explored the reasons for the expected consequences, and the congruence or otherwise between what was expected and the actual consequences. All of Chapter 5 was, and a large part of the present chapter has been, devoted to presenting the evidence that the adoption of new intra-operative artefacts, between 1988 and 1998, has increased the labour intensity of surgical production. In the process, the consequences for *receivers* have been thoroughly described and analysed. I have explained how the enormous growth in MAS procedures, along with technological changes in a wide range of non-MAS procedures, has resulted in a significant increase in the manual (as opposed to machine-assisted) perioperative processing of reusable surgical instruments, as well as a growth in inventory management activities associated with single use surgical instruments and materials. I have argued that these and other factors are contributors to the increases in the perioperative human labour input to surgical production.

I have reported that the average procedure in 1998 took about 15.85 per cent longer than it did in 1988, and explained why this shows that the adoption of new intra-operative artefacts has not provided the potential to increase OTS throughput, *ceteris paribus*. I have also explained the operational perioperative and intra-operative consequences for OS nurses of surgical production being customised to individual patients, and how the increased complexity and diversity of new intra-operative artefacts is resulting in the need for greater *specialisation* amongst both procedural specialists and OS nurses. These factors combine to demonstrate that new intra-operative artefact adoption has resulted in an increase in both the physical and mental components of human labour in surgical production (cf. Adler 1992; Zuboff 1988; Coombs 1985).

Overall, these consequences are inconsistent with the *strategic choice* outcomes expected by organisations (as reviewed in Section 3.3.2) that are reflected in the expectations of most top health service managers concerning new technology adoption. I propose that the actual consequences for OTSs of new intra-operative artefact adoption that I have reported are not the same as the dominantly self-interest-driven outcomes of most other types of organisations, largely because of the differences in the technical characteristics and main functional goals of their respective artefact technologies.

Although the acquisition and operating costs are not incidental to the decisions, the decisions to adopt new intra-operative artefacts are made by the procedural specialists whose motives are dominantly altruistic. The potential clinical benefits to patients, rather than the technical

characteristics of the artefacts, hold the greatest sway in their decisions. Top managers, on the other hand, rarely have any influence on the between- and within-technology aspects of new intra-operative artefacts. They focus largely on the business side of acquiring and operating new intra-operative artefacts – for the most part on the capital and recurrent costs, and the likely opportunity costs, given scarce resources.

In the latter part of this chapter, the different but complementary decision roles of the procedural specialists, top health service managers, OS nurses and SD technical aides were discussed, and I presented my *situational stakeholder participation and adjustment matrix of technological change*, which serves as part of my response to the fifth research question concerning the processes whereby decisions are made to adopt new intra-operative artefacts. The matrix provided a mechanism whereby I could show that these decision processes are not typical of new technology adoption decision processes occurring in manufacturing organisations, particularly in terms of who participates and what factors are influential. They are more akin to the multiple-actor decision processes occurring within professional organisations (eg. Mintzberg 1973; 1998; Heller et al. 1988; March 1994; Langley & Truax 1994; Ashmos et al. 1998).

In drawing this chapter to a close, I am reminded of the question that became the catalyst for the present research: "Is there actually an assumption abroad amongst health service managers that new surgical technologies employed in operating theatres should be reducing the demand for human labour, and, if so, is it a valid assumption?" On the assumptions of health service managers, the answer is "yes", and on the capacity of new intra-operative artefacts to reduce the labour intensity of surgical production, the answer is "no". These conclusions, along with the various responses to the five research questions, combine to form the body of evidence that supports the naturalistic paradigm proposition of this thesis.

6.8 Conclusion

The preceding section has summarised the content and conclusions of the present chapter and, importantly, the main conclusions of the present thesis. It remains, then, to advise that the following chapter provides a summative overview of the theoretical and practical contributions of this thesis and makes some recommendations for future research. It is the final chapter of the thesis.

Chapter 7
Conclusion

7.1 Introduction

The preceding chapters have dealt comprehensively with the conceptual, theoretical and methodological aspects of the present research, reviewed and synthesised a wide range of literature, presented, analysed and interpreted the data, and thoroughly argued cases in support of both the secondary (*positivist*) and dominant (*naturalistic*) paradigm propositions of this thesis. It is not the intention in this final chapter to continue those arguments, for they were brought to closure in Chapters 5 and 6 respectively. Rather, this chapter provides a summation of the outcomes of the present research and its principal theoretical and practical contributions. It concludes by making six recommendations for future research.

7.2 Thesis overview

This thesis has explored the process and organisational consequences of the adoption of new artefacts employed in the operative phase of surgical production within operating theatre services in hospitals. It has examined changes in both *intra-operative* and *perioperative* technologies, but has limited its analysis to the choice making process and organisational consequences (ie. those specific to operating theatre services) of technological changes that can be directly related to the adoption of new *intra-operative artefacts.*

The thesis was borne out of my working background in operating theatre services, which is the origin of my interest in both the quality of work life of people working in operating theatre services and the effective management of operating theatre services. The main question that provided the catalyst for the research was: "What are top managers' assumptions about, and expectations of their hospitals' investments in new intra-operative artefacts?" I initially hypothesised that they have an erroneous expectation that the adoption of new intra-operative artefacts should be increasing the time efficiency of surgical production and, therefore, increasing operating theatre services' throughput.

These formative ideas evolved into two research propositions, a dominant *naturalistic paradigm* proposition and a secondary *positivist paradigm* proposition, and five key questions that guided the inquiry. One question concerned the technical characteristics of intra-operative artefacts and their functional roles in surgical production. The others questions were: Why are they adopted? What are the actual organisational consequences of adoption?

Are the organisational consequences of adoption congruent with the expected benefits, and, by what processes are decisions made to adopt them?

The timeframe of the study was 1988 to 1998. The study sites were five categorically different hospitals in New South Wales, Australia. The key informants to the study were individuals who are members of four internal stakeholder groups who are *receivers* of the new intra-operative artefacts and/or are individuals who customarily have the opportunity and/or capacity to contribute to the new intra-operative artefact decision process. They are the doctors who carry out procedures (ie. procedural specialists), operating suite nurses, sterilising department technical aides, and top health service managers. Detailed study was done of six representative, high volume surgical procedures in which new intra-operative artefacts were employed during the ten-year period.

The research employed a mixed methodology, mixed methods, *collective case study* approach that combined both inductive and deductive reasoning to draw its conclusions. Its theoretical contributions have been derived using the methods and assumptions that are consistent with the *naturalistic paradigm*. It also drew some conclusions using the methods and assumptions of *logical positivism* that have significant practical implications for the management of operating theatre services in Australia.

I propose that the theoretical conclusions of this thesis are generic in nature. They represent contributions to the bodies of knowledge in organisation theory, the management of hospitals, and organisation research methodologies. However, the Australian context necessarily precludes the health care system-specific conclusions from being generalised to other countries, although the technology-specific conclusions could have wider applicability.

Numerous theoretical areas have informed the organisational issues explored in the thesis. Included are theories about:

- the selection, adoption, diffusion, and management of technologies in manufacturing and business organisations
- the economic principles applied to new technology adoption and the management of organisational technologies
- the labour process ramifications of new technology adoption
- technological determinism and human agency/choice/voluntarism, and
- decision-making in organisations and, in particular, the decision process in professional organisations, such as hospitals.

Extensive searching has found no prior research that has explored the adoption process or the consequences for surgical production within operating theatre services in hospitals of the adoption of new intra-operative artefacts. This is the unique contribution of the present thesis.

Its main conclusion is that, by-and-large, there is a lack of congruence between the central characteristics of what I have referred to, throughout this thesis, as the *techno-economic theories of production* and the actual outcomes for hospitals' operating theatre services when new intra-operative artefacts are adopted. Section 6.7 provided a comprehensive summary of the argument that led to this conclusion, which represents the dominant paradigm conclusion of this thesis. What I regard as the key findings contributing to this conclusion are now reviewed.

The first is that new intra-operative artefacts are adopted by procedural specialists principally for *altruistic* reasons that reflect their belief that their patients' best interests will be served if they do so. This expectation is founded primarily on the belief that the new technologies either enhance the process and/or outcome of an existing procedure or provide an *alternative, replacement*, or *complementary* technology for the diagnosis or treatment of a medical condition. This differs with the emphasis in the *techno-economic theories of production* on the *self-interest*, rational business goals in which managers typically choose strategies involving new technologies if they regard them as being in the organisation's best interest for future success and longevity. Such strategies are usually based on the assumption that a smaller labour force, combined with greater production efficiency and employee productivity, will increase the organisation's potential for lean production without increasing the human labour costs per unit of production. They reflect an *a priori* assumption that new technologies should displace some human labour, and that when they are adopted, the roles and skills of the workers who remain can be expanded without jeopardising their work performance. The underlying logic is that earlier technologies have deskilled them (because the work has been simplified) and/or that their labour input to the production process is no longer being optimised (because the new technology-enhanced work is quicker to accomplish), and so there is excess human capacity (ie. slack) which needs to be either redeployed or discarded. These perceptions are evident in the expectations of the managers in the present research.

That said, there is evidence in the literature that, during the latter decades of the twentieth century, deskilling, as a consequence of new technology adoption, may be limited to only certain non-managerial, non-professional, and non-technical occupations (Bradley et al. 2000). However, the expectation that new technologies will/should displace labour does not appear to have been refuted. Importantly, the present thesis does not support the labour

displacement argument. Rather, it has presented empirical evidence that the labour intensity of surgical production has substantially increased as a consequence of new intra-operative artefact adoption between 1988 and 1998. This has been demonstrated by evidence that:

(a) overall, between 1988 and 1998, the adoption of new intra-operative artefacts has contributed to a 15.85 per cent increase in the average time it takes to complete the operative phase of surgical production, thereby increasing the *intra-operative* human labour input requirements and reducing the average throughput potential of an operating/procedure room, and

(b) the adoption of new intra-operative artefacts has been an important contributor to the significant increase in the volume of human labour required to produce the *perioperative* phase of the representative set of procedures (summarised in **Table 5(f)**) that constituted over 20 per cent of all surgery during 1998 in the hospitals in this research.

The thesis extended the analysis of the data contributing to these conclusions to an analysis of pertinent aspects of the Australian National Operating Room Service (Funding) Weights (NORSW) data, and concluded that the OTS human resource costs reflected in the respective weights do not accurately reflect the volume of human labour required to produce the individual procedures in this study's representative set. This conclusion, which represents the secondary (*positivist*) outcome of the present thesis, has important practical implications for management practice in Australian hospitals, particularly for the funding of operating theatre services and the management of their human resources. My analysis has brought into question the reliability of the estimated costs of the human resource component of the production costs detailed in the NORSWs. The technique I used to do this involved an innovative measure, the *PI Ratio*. It served as a way of demonstrating a fundamental flaw in the logic that was used to derive the NORSWs when they were developed in 1994 under the auspices of the Australian Government, a logic that has not come under scrutiny since that time. I contend that it is a flawed logic that assumes, as the NORSWs do, that there is a direct relationship between *intra-operative* time and the *perioperative* human labour input to each procedure.

The thesis has argued that changes in intra-operative artefacts always result in changes in *techniques* – and, by implication, *knowledge* and *skills* – associated with surgical production, and sometimes provide the stimulus for other *artefact* change. It has presented empirical evidence that the various direct and indirect organisational structural consequences of new intra-operative artefact adoption between 1988 and 1998 arise from the high volume, diversity and technical complexity of the new, often highly specialised, sophisticated intra-

operative artefacts that have been adopted. Important among these consequences are the increased complexity of work content and task variability for the *receivers* of the new technologies (ie. the procedural specialists, operating room nurses, and technical aides who use and/or care for them), increased specialisation amongst clinicians, greater task interdependence (particularly between members of the surgical team), and changes in the perioperative division of labour. Here, again, these consequences are inconsistent with the dominant explanations within the *techno-economic theories of production* of new artefact technology adoption in organisations.

Another conclusion contributing to the dominant paradigm conclusion of this thesis is that new intra-operative artefacts are categorically more sophisticated tools of the surgeon's craft that have *not* automated the surgical process. Indeed, most intra-operative artefacts are manipulated by members of the surgical team, or, in the case of mechanical or electronic equipment, controlled by team members to perform their discrete *enabling* function when required. This characteristic of new intra-operative artefacts is in stark contrast to the large body of literature that assumes that new technologies have automating and, often, informating characteristics, and emphasises the strategic benefits accruing to organisations when, combined with various human resource management strategies and broader organisational restructuring (ie. changes in *techniques* and *organisation*), they adopt them.

Furthermore, changes in intra-operative artefacts have necessitated changes in the nature and volume of *perioperative technologies*. The resultant general trend in the latter has been an increase in *manual*, rather than mechanically-assisted, (re)processing of surgical instruments, more work involved with *inventory management* due to an ever increasing diversity and volume of *single use surgical instruments* and *surgical materials*, and an increase in the amount of point-of-use and periodic maintenance of a growing volume of *enabling equipment*. These have all contributed to the overall increase in the labour intensity of surgical production that has been reported herein.

Despite the increased labour intensity of surgical production between 1988 and 1998, the present thesis has shown that the customarily expected benefits of increased production output (ie. operating suite throughput) and employee productivity have actually occurred. However, it has been argued that these increases have eventuated, not *because of* new intra-operative artefact adoption, but *in spite of* it. This conclusion "turned" on two factors. The first is the convincing evidence of the increased labour intensity of surgical production, a consequence that, on the surface, appears to be incompatible with increased employee productivity and increased OTS throughput. The second relates to the phenomenon of slack

(ie. excess capacity) in the OTS, the extent of which, I have argued, cannot be ascertained, although the evidence that productivity and throughput has increased between 1988 and 1998 infers that the OTSs had some excess capacity in 1988. I have argued that, whereas hospital bed capacity (which has increased significantly during the ten years, due to significant reductions in length of stay and the enormous growth in day-only procedures) was the factor limiting OTS throughput in 1988, it no longer is.

The conclusion must *not* be drawn, then, that the OTS can keep pace with the hospital's increased capacity (without extending elective operating time and/or increasing human resources). Indeed, it cannot be emphasised enough that hospital throughput capacity is not an indicator of OTS throughput capacity – indeed, the two are independent of one another. The present research has found, however, that there is an expectation amongst top health service managers that this is the case. This expectation derives, I propose, from managers' erroneous assumptions about the technical characteristics and functional goals of new intra-operative artefacts that are reinforced by the "evidence" of the reduced lengths of hospital stay which are, I contend, largely only by-products of the technological changes that have occurred in surgery. I also contend that the rational, techno-economic explanation of these phenomena is the wrong explanation and that, in its ready acceptance by managers, it obstructs the acceptance of the types of evidence that I have presented throughout this thesis concerning the various consequences for *receivers* of new intra-operative artefacts.

The thesis has reported, described and analysed a range of other factors that have contributed to the increased labour intensity of surgical production, and some are now highlighted. One is that the intra-operative phase of surgical production is categorically *customised production.* There are two main reasons for this. First, each diagnostic or therapeutic procedure is likely to employ vastly different technologies to the procedures that precede and follow it in an operating room. Secondly, procedures that are identical in name will, more often than not, have process variations that may or may not involve the application of different intra-operative artefacts, and hence, techniques. Furthermore, much of the change is characterised by frequent, random yet deliberate, incremental changes in the surgical processes associated with a specific procedure or group of procedures, rather than the type of organisational/departmental system-wide technological change that is much reported in the literature. The type of change reported in this thesis is often localised and, consequently, difficult to predict and manage at an OTS level, particularly if it is under-resourced (possibly) as a consequence of the erroneous assumptions of top managers about the practical consequences for the OTS of new intra-operative artefact adoption.

Another conclusion contributing to the dominant paradigm conclusion of this thesis arises from the final research question concerning the process whereby decisions to adopt new intra-operative artefacts are made. The findings contradict the conventional notion that managers and/or owners initiate and drive the technological change, and choose what technologies will be adopted and how work will be (re)structured as a consequence of adopting them. This thesis has shown that the new intra-operative artefact adoption decision process is usually initiated, facilitated and influenced by clinicians (procedural specialists and operating suite nurses), with the result that clinical, functional and technical issues are accorded greater weight in much of the decision process than any return-on-investment logic. Financial considerations typically occur late in the decision process, as does the participation of top health service managers.

Along with these conclusions about the surgical technologies *per se* and their organisational consequences, this thesis makes several other theoretical contributions to the three areas enumerated earlier: organisation theory, the management of hospitals and organisation research methodologies. One, for example, is a reasoned contribution to the embryonic post-essentialist perspective on technological change in organisations that I have entitled *a mediated attribution perspective*. Another is an extension of previous empirical work on *multiple-actor decision-making* in *professional organisations* which identifies seven categories of *stakeholder participation* in the new intra-operative artefact adoption decision process in hospitals. These, and other contributions, are outlined below in the order in which they arise within the thesis. The assessment of their relative significance as outcomes of the present research will necessarily be contingent on the academic and/or practical interests of the reader.

(a) The thesis presented and explained a conceptual model, presented as **Figure 1(a)**, of the mixed methods, mixed methodology, collective case study research design employed throughout the research process.

(b) The thesis categorised and defined surgical technologies and modelled their process relationships in surgical production within operating theatre services. The model was presented as **Figure 2(a)**. I have classified the intra-operative artefacts that are manipulated by members of the operative team as *surgical instruments* and *surgical materials*; and the mechanical and electronic devices that function under the control of members of the surgical team as *enabling equipment*. I have categorised perioperative technologies as *instrument (re)processing technologies*, *inventory management technologies* and *equipment maintenance technologies*.

(c) The thesis presented a reasoned argument that the advancement of organisation theory in the domain of artefact/machine technologies is unnecessarily and inappropriately constrained by the broad and unresolved philosophical debate concerning determinism and voluntarism as it is articulated in the techno-socio-organisational literature. The *mediated attribution perspective* that I have presented represents one response to calls, since the 1970s, by numerous researchers who, in their various ways, have expressed the need for and/or proposed an integrated approach that accommodates both the technological determinism *and* human agency perspectives.

(d) The thesis analysed the notions of *choice* and *consequence* in relation to new intra-operative artefact adoption and concluded that capacity and/or opportunity to participate in the associated decision process does not preclude *receiver* stakeholders from the need to make *adjustments* in the way they do their work when a new intra-operative artefact is adopted. This led to the identification of seven categories of *stakeholder participation in the decision process* connected with new intra-operative artefact adoption. Five are *decision roles*, and the stakeholders who have one or more of these roles constitute the *decision-set*. I have identified these decision roles as *initiator, facilitator, influencer, enactor* and *implementer*. The other two categories are *observer* and *non-participant*. The latter two stakeholders are not members of a decision-set but they, along with the five participants in the decision-set, may be *receivers* or *non-receivers* of a new intra-operative artefact.

These stakeholder characteristics were synthesised in a *7x2 situational stakeholder participation and adjustment matrix of technological change*, which was presented as **Figure 6(d)**. It is the theoretical outcome of my analysis of *participation in the decision process* and *the consequences for receivers* in new intra-operative artefact adoption situations. The matrix is categorically *situational* because stakeholders' participation and/or receiver status (ie. receiver or non-receiver) may change from one new intra-operative artefact adoption scenario to another. It provides a framework by which to explore multiple-actor participation in specific new intra-operative artefact adoption decision processes – one that is congruent with the collective choice thesis articulated by Mintzberg (1998) in relation to *professional organisations.* It accommodates participation in the decision process as an activity that is not limited to people at an organisation's strategic apex, but one that extends to people at various levels in the operating core. It also accommodates the evidence that, in the new intra-operative artefact adoption decision process, top managers have predominantly functional management roles, including resource allocator and gate-keeper roles, whilst the clinical professionals, the

procedural specialists in particular, are the *initiators* of technological change in surgical production by virtue of their clinical/technical expertise. That is, clinical professionals (ie. the procedural specialists and the OS nurses) have, among other decision roles, an entrepreneurial role in the specific category of new technology adoption examined in the present thesis, that is conventionally attributed to top managers.

7.3 Principal theoretical contributions

The preceding overview discussed a wide range of outcomes of the present research. Given that these outcomes were not presented in any order of importance, I now highlight what I regard as the principal theoretical contributions of the present thesis. The first and foremost is that I have demonstrated empirical support for the dominant (*naturalistic*) paradigm proposition of the thesis that:

> *The characteristics of new intra-operative artefacts, the reasons for their adoption in surgical production in hospitals, the decision processes associated with their adoption, and their consequences for receiver stakeholders, cannot be explained using the set of theories and managerial perspectives, which I refer to collectively as "the techno-economic theories of production", that are typically operationalised in new technology adoption scenarios in organisations by strategies that emphasise return-on-investment.*

To organisation theory I have also offered an integrative *mediated attribution perspective* on the technological determinism and human agency perspectives on technological change within organisations, and devolved a *7x2 situational stakeholder participation and adjustment matrix of technological change*. The latter might have wider applicability to decision processes in other organisational contexts, particularly in professional organisations.

I have developed *a classification of surgical technologies and their process relationships in surgical production* that provides a useful way of conceptualising these phenomena. Such a model could provide a framework for teaching and future research on the topic of surgical technologies.

Finally, the mixed methods, mixed methodology approach of the present research is recognised by researchers as a relatively uncharted one, albeit one that is growing in acceptance. Consequently, I regard the conceptual model of the research process that was presented as **Figure 1(a)**, as a contribution to theory. I also advance the structure of this thesis document as an example of an approach to reporting mixed methods, mixed methodology research employing the collective case study design that could assist other like-minded researchers.

7.4 Principal practical contributions for health services management

The practical ramifications of the thesis for the management of health services, generally, and operating theatre services, in particular, arise primarily from the conclusions drawn in Chapter 5. One of my conclusions should be of particular interest to top managers and health care funding agencies, for I have provided empirical evidence that the net effect of new intra-operative artefact adoption has been an increase in the human labour requirements of surgical production. In this connection, I have also shown that:

(a) the Australian National Operating Room Service Weights might not be accurately representing the relative OTS human labour requirements (and hence, the true cost) of procedures, and

(b) the throughput capacity of an OTS is independent of the hospital's capacity to increase the number of surgical separations resulting, for the most part, from reduced lengths of stay. In other words, a hospital's technical efficiency in dealing with its surgical separations is unrelated to its operating theatre service's technical efficiency.

Another of my conclusions should be of interest to health service managers, including OTS managers. I have provided substantial evidence that the increased diversity, technical complexity, and volume of intra-operative artefacts dedicated to specialist applications have had a number of work-related consequences for OS nurses and/or SD technical aides. These, in conjunction with externally imposed throughput pressures, have increased the pace of work to levels that are sometimes distressing, and have negatively impacted on the capacities of OS nurses, in particular, to achieve and maintain the specialised knowledge and skills necessary to satisfy themselves that they are able to provide the best possible care for their patients. As a consequence, I propose that the levels of staffing within some operating theatre services need to be increased, and that all hospitals need to be more sensitive to the new surgical technology-related training needs of their OTS staff.

Finally, I have developed an innovative yet simple mathematical concept, the *PI Ratio*, that could be used in the future as a means of expressing the relativities of intra-operative time and perioperative human labour input to surgical production within OTSs. In view of my contention that the diverse *PI Ratios*, that were calculated for the six procedures examined in detail in the present thesis, have exposed a fundamental flaw in the Australian National Operating Room Service Weights, I propose that it should be among the measures applied to any future studies of the human labour input to, and funding of, surgical procedures.

7.5 Recommendations for further research

The following recommendations for future research arise either from one of the issues reviewed in this concluding chapter, or from phenomena that were observed in the course of this research but reported only in passing because the observations were not central to the goals and/or theoretical orientation of the present thesis. I propose that future research could include:

1. Studies of new artefact adoption in other clinical areas of health services, and other types of service firms.

2. A substantive study of the total human labour input to a wider range of surgical procedures than have been studied in the present thesis. Section 5.8 explained my contention that the Australian National Operating Room Service Weights for the selected procedures appear to be flawed estimates of the volume of human labour input required in their production. I propose that, because this could be having significant consequences for over- or under-funding of OTSs at individual hospitals, further research is required.

3. Evidence of the teamwork amongst the adjacent professional/occupational groups within operating theatre services presents a somewhat different picture of the relationships between doctors and nurses than is generally reported. Further research that explores and compares these relationships in various work contexts would be valuable.

4. The present research highlighted the increasing technical complexity of intra-operative artefacts and the associated increase in the requisite technical knowledge and skills of the OTS workforce, which is predominantly female. On the one hand, these conclusions challenge the widely held, but little contested contention of Phillips and Taylor (1980:63) that 'skilled work is work that women don't do'. On the other hand, evidence of the shortage of OS nurses and difficulties in recruiting new entrants to the discipline (NSW Health 2001; Meppem 2000) raises questions about whether the increasing use of diverse enabling equipment and their associated technically sophisticated surgical instruments are making OTS work less attractive to female nurses. I propose that any future research on the recruitment and retention of OS nurses should explore these issues, along with the issues raised in the following recommendation.

5. Cognisant of the high proportion of nurses who are female, evidence of the highly technical nature of OS nurses' work raises questions about the perceptions of outsiders to the OTS, such as the dominantly male top health service managers, of the work-related consequences of new intra-operative artefact adoption for OS nurses. Do "outsiders" ascribe to the notion that skilled, technically complex work is really the work that females

do not do? If so, does it influence their perceptions of the labour processes within this closed work environment and, hence, influence the way they interpret information that conflicts with such perceptions? These issues would likely be of interest to gender studies researchers.

6. Mindful that the literature identified new medical technologies as a major cause of increases in health care expenditures, future research could investigate the breadth of stakeholder participation in the research and development (R&D) phases of technological changes in surgery and what, if any, pressure is on developers to take more account, when designing new intra-operative artefacts, of the perioperative surgical production issues identified herein. The present thesis did not explore these R&D issues but the persuasive evidence of the increased labour intensity of the perioperative phase of surgical production, in particular, should be sufficient to demonstrate the need for such a study.

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