Preface

The sudden downturn of the wool market in the late 1980s was sufficiently severe to force the industry through another period of significant economic hardship and institutional change. The extent of the structural adjustment is still difficult to determine but it has already brought about major changes in the innovation system supporting the Australian wool industry. Wool research expenditures and activities were drastically curtailed, and the directions and focus of the research and development program have changed significantly. As a consequence, it appeared to the writer (in 1989) that this could be an appropriate juncture at which to reflect on the past and examine the innovation system processes, linkages, structures, events, and achievements stretching back over one hundred years on which the industry had prospered/survived. In particular the period from the 1950s was of interest because on quick investigation, it was one of extensive research investment as well as innovative outcomes. The technological achievements since the 1950s challenge perceptions that wool growing was not a major science based industry, or that investment in Australian research or the more general sentiment that Australian inventiveness was captured by overseas interests and was ultimately of little benefit to Australia.

In this respect, examining the background, the processes for achieving outcomes, and the results of the institutional wool R&D effort over an extended timeframe, has not been attempted before in the case of the wool industry. The thesis looks at the operation of the innovation system, the outcomes produced, and the difficulties experienced along the way. The rationale for doing this was simply a belief that understanding better what happened in the past has some bearing on what is possible in the future. Understanding the relationships and structures in the case of the wool industry has relevance for future policy both in the wool industry as well as other industries. To this end the thesis recounts the various changes to the statutory organisation created by the Commonwealth government to administer research funds, and comments on the strengths and weaknesses of advancing technological change when it is largely organised, funded and encouraged through government funding arrangements and institutional structures.

Another area of interest was to consider the extent to which the innovation produced by the public research programme have been important for the development of the grazing industry, the rural sector, and the economic advancement of the rural sector in Australia generally. This proved to be very problematic not least because of the scale and complexity of the considerations. Even with a focus on those innovations within purely an industry context, rather than on the impact of one or more technologies either as a select group or the impact

generated across a number of industries, this was a challenge which was never going to be completed to anyone's satisfaction. Exploring the changing nature of the wool innovative process on the effect of changes on the wool producing enterprise was also an important theme. In examining these issues in the post 1950 phase the attempt was to outline a number of the key innovations or groups of innovations produced, understand their impact, as well as the processes behind the development and dissemination of these wool industry innovations.

After an introduction, the thesis has five parts. The Introduction provides some background, an overview of the industry structure, an historical overview of the ebbs and flows of wool market, and its world trade context. Part I covers the 'pre-modern' period by giving some feel as to the nature of the industry during the nineteenth century, outlines the beginnings of the institutional wool research effort, and provides a survey of the main innovations developed for the industry prior to the 1930s. Part II covers the development of the modern innovation system and examines the part played by government in developing the infrastructure especially in the years 1930-1950 and again mentions the innovations introduced during that period. Part III discusses the expansion of the innovation system, surveys the results of the modern era and the production and textile innovation created by the Australian wool research effort after 1950 and prior to around 1969. Part IV generally covers the years from 1970 to 1989 when the emphasis moved from concentrating on increasing production or lowering transportation costs, to one of improving the efficiency of wool handling, the specification and measurement of wool, work which assisted the marketing and promotional directions of the industry, and textile research.

Part five takes the opportunity to review the operation of the innovation system in the post 1950 period and analyses some of the themes explored more briefly in the earlier parts of the thesis. It draws together issues such as the difficulties experienced in the delivery of the innovation generated, and gauges, in broad terms, the possible value of innovation and technological change to the industry post 1950.

Chapter 1

BACKGROUND

An industry that has ceased to concern itself with the progress of the past will soon lose belief in its capacity to progress in the future -Mokyr.[1]

The Australian wool industry has an long record of successfully adopting new technologies and innovations. Much of that success during the nineteenth century involved applying the innovations from individual inventiveness but as the twentieth century unfolded, increasingly the innovation was being created by scientists located in government research institutions. The beginnings of institutional wool research came at the close of the last century within the fledgling colony/state departments of agriculture, but these were miniscule undertakings especially when it came to pastoral research. Recognising the significant benefits to the rural sector that could be derived from scientific research, the Commonwealth created a national research organisation by enacting legislation to establish the Commonwealth Council for Scientific and Industrial Research (CSIR) on the 23 March 1926.

The industry contribution towards further establishing a focussed national innovative system in the wool industry came in 1936 when they asked the Commonwealth to legislate to create a statutory authority to collect as well as administer wool research levies. The flow of funds via the industry body ensured a specificity in the public rural research activity. The Commonwealth's sponsoring of wool research and industry levy contributions ensured a long-term commitment which could look well beyond the immediate needs of the current generation of woolgrowers. In so doing the government industry partnership was building the knowledge foundation for ameliorating the problems of all farmers and also protecting the long-run international competitiveness of the entire rural sector. Spillover benefits of this kind provided an important justification for the high level of government funding of rural and wool research from both Commonwealth and State governments.

The objective for such government investment was to maintain and improve Australia's competitive advantage in wool growing and prevent any decline in an industry so important at that time to Australia's economic development. The object was to improve industry productivity and maintain wool's competitiveness *vis-a-vis* synthetic fibres. As we shall

---

[1] Mokyr, J., *The Lever of Riches: Technological creativity and economic progress*, OUP, Oxford, 1990, p.304. This quote has been modified by the replacement of the word 'society' by 'industry'. Mokyr was paraphrasing Carr, E.H., *What is History?*, Vintage Books, New York, 1961.

discover, achieving this result involved considerable effort and expense, but for the first half of the twentieth century financial support for wool research was neither adequate nor automatically provided. Both government and industry prevaricated upon what the level of research and development expenditure should be and it could be argued that the 'critical mass' of investment into R&D was not arrived at until some years after the second world war. Nevertheless, in the years prior to the second world war a small strategic partnership was created between the wool industry and various governments which ensured the establishment of facilities for wool research and development (R&D) and the pastoral sector generally.

In the years after the second world war the wool related research infrastructure expanded rapidly and outlays were increased substantially by the Commonwealth. Buoyed by successes in the early period, and with the obvious spillovers to firms associated with the wool industry, other rural industries, and the community generally, the wool research effort soon became the largest research fund within the rural research area and certainly the most significant single contributor to locally-derived agricultural innovation. The expansion of the research system was essential for ensuring innovation maintained the wool industry as an economic force in the face of what became a competitive onslaught from the synthetic fibre industry. Increased assistance of this kind was needed even though wool producers enjoyed a natural comparative advantage in terms of environmental suitability, economies of scale, and benefits from long-term investments in overseas manufacturing infrastructure. These were not sufficient to ensure continued industry viability, and the partnership between industry and government maintained adequate levels of resources and infrastructure in the industry.

Continued international demand for wool could not rely on consumer loyalty, or world-wide advertising campaigns. Maintaining market share was fundamentally dependent upon improved productivity on the part of producers and processors and linking this to the organisational and qualitative changes in industry structures and practices. Many of the innovations arising from funded research were inter-related and built into a network or cluster of innovations producing substantial productivity improvements which came to be far more significant as the more tangible and farm specific innovations. In a number of cases these became large systems which changed totally the way the industry operated. The innovations were also very effective in sustaining international links and partnerships, and the move into textile research was especially important in this regard.

Key driving factors were long-term investments on the part of both state and federal governments, the creative energies of the scientists and technologists involved with the research, and the positive involvement of many innovative and adaptive woolgrowers who

funded and encouraged the investments into research. Together with other contributors to knowledge distribution the wool developed a very effective national innovation system.

Recognition by governments of the wool industry's importance to the economy and of the inability of the industry, or sections within the industry to provide the funds commensurate with the likely benefits, lead to wool research activity being almost completely funded by government (85 to 90 per cent - see estimates in Part V), and conducted within public sector research facilities. The investments into research since the second world war in terms of aggregate expenditure are estimated later in this thesis at over $3,355 million (1990 dollar values) which makes it perhaps the biggest research endeavour of any industry in Australia's history.

1. WOOL INDUSTRY NATIONAL INNOVATION SYSTEM, WOOL PIPELINE, AND DEFINITIONS.

> *Like Ian Clunies Ross, I believe it is more difficult to solve a practical problem and see its application to industry in the way Farrer did than to continue to make discoveries in plant physiology and biochemistry.* [2]

The wool innovation system

A central dynamic in economic development and productivity growth is technical change. The extent to which technology is transferred and utilised is dependent on the extent to which national innovation systems are attuned to commercial and economic needs. How industries and firms keep their knowledge base up-to-date and achieve real productivity improvements has a large bearing both on internal and international trading competitiveness. Forming the various components of an innovative system into an effective structure has in every country necessitated collective industry action and governmental cooperation. Innovation and technological change not only improved the economic competitiveness of enterprises but also cushioned rural adjustment both to the farmer and the society that relies on rural exports for its well being. The implications for sustainable land use were also increasingly important.

An innovation system typically comprises three interactive components: a knowledge network, a research network, and an extension network. These components are interconnected with both institutions and individuals supportive and dependent on each other and beyond the broader scientific and technological community were influenced by relationships with buyers, processors, garment manufacturers and promotional organisations such as the International

[2] *"Research and the Woolgrower"*, Moule, G.R., Director Production Research, Australian Wool Board, September 1969. Dr. Moule worked for the Queensland DPI and became the Director of Production Research for the AWB in the 1960s.

Wool Secretariat. [3] Diagram 1 (over the page) is a simplified linear map of the networks and innovation process of the wool innovation system. The knowledge network includes educational facilities, trained people, libraries, professional societies, government regulations (such as patents), and the mechanisms for giving effective access to all of these. The research network includes laboratories and field stations, researchers and a research programme that generate or manipulate ideas from either overseas or from local R&D to improve the knowledge-base. The knowledge network and research network together generate and store a pool of latent scientific information from which three broad groups of innovation are developed: either new products or processes, new organisational arrangements, or new knowledge.

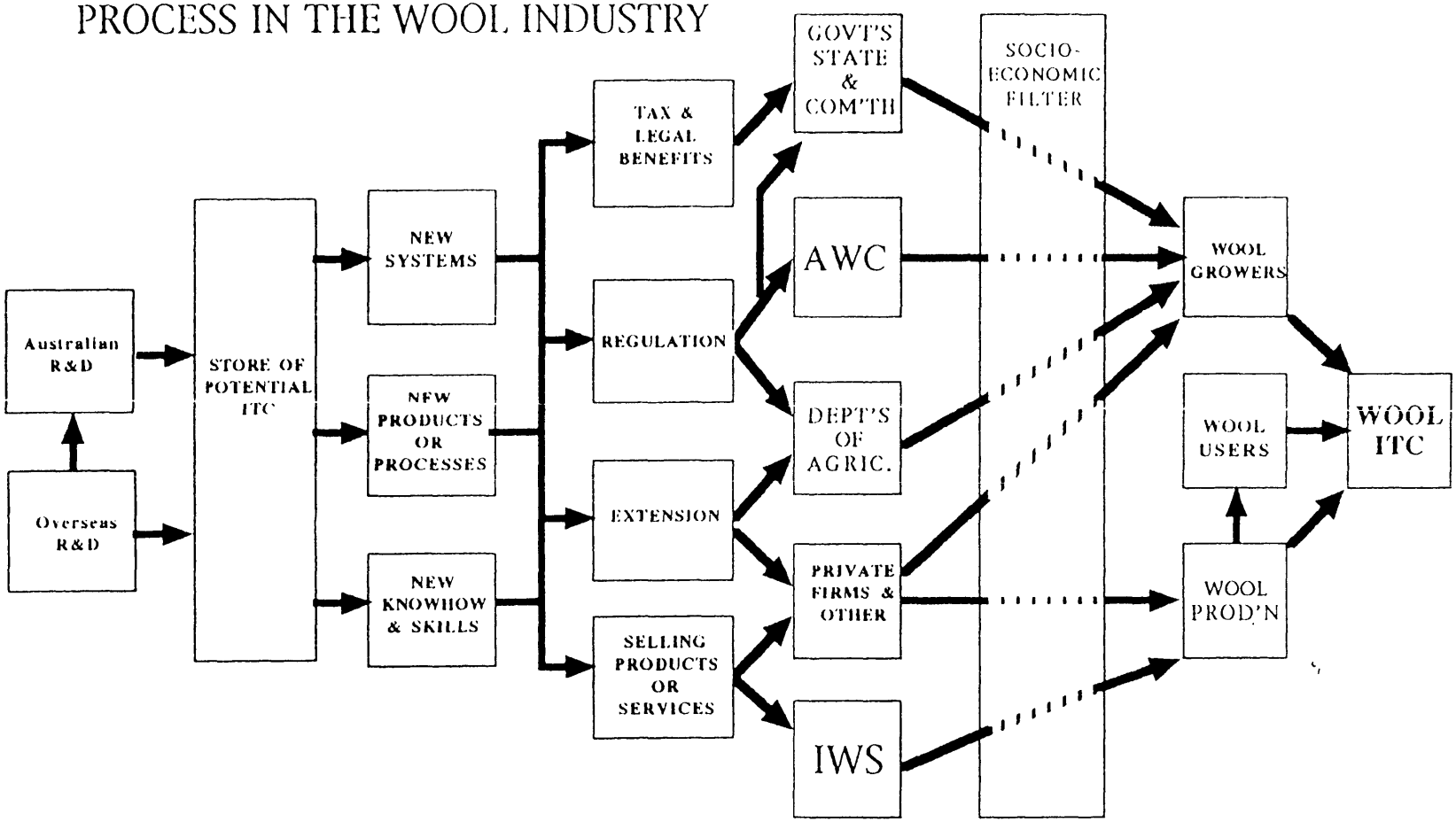
Innovations are then transferred to the woolgrower/processor/consumer either through the commercial sale of goods/services, the extension work by the departments of agriculture or if the innovation was embodied in a product and was therefore readily appropriable by private companies or consultancy firms. Technology transfer involves the linking of information about the existence and nature of an innovation with the person who might benefit from that knowledge. Innovations, derived from a number of sources, are tested for their effectiveness, and then communicated to the farmer to encourage increases in production, productivity, improvements in quality, the lowering of costs, or to promote conservation and sustainability in resource use. The main provider of agricultural extension was the state funded extension service located in the departments of agriculture (DAs) with important contributions coming from wool industry organisations, the private sector, as well as societies and associations founded on a cooperative basis.

The state-funded services had regional extension centres, and over time the emphasis moved from specialised animal husbandry and pasture extension work to encompass broader management and marketing aspects. To handle often very complex problems, extension officers needed to be well-trained and actively consult the research community as well as the farmer before an innovation was transferred to make sure many of the possible complications were understood in advance. The departments provided this service either through direct problem-solving on the farm by specialist officers in consultation with the grower, via commercially 'packaged' technology transfer, or else as a part of the training of farmers/processors in specialised management courses.

---

[3] With reference to the word 'institution' see the definitions of the concept by Black, A.W., in *Organisational Genesis and Development - A Study of Australian Agricultural Colleges,* University of Queensland Press, St.Lucia, 1976, pp 133-6. Blau, P., in *Exchange and Power in Social Life,* John Wiley & Sons, New York, 1964, noted that: "Institutionalization refers to the emergence of social mechanisms through which social values and norms, organizing principles, and knowledge and skills are transmitted from generation to generation." , p.25.

A SIMPLIFIED DEPICTION OF THE ITC PROCESS IN THE WOOL INDUSTRY



Definitions.

Mitcham defines technology as:

> *... the system of knowledge underlying the physical interactions that exist within the process for producing a particular output.* [4]

In this study, the 'output' takes three forms: the fleece on the sheep's back, the internationally-traded raw material in greasy or semi-processed form, and the finished product in the form of woollen fabrics and garments. Mitcham's notion of 'systems of knowledge' reminds us of the important fact that innovations are not isolated events, but rather packages of change that are fitted into existing physical and social systems. These 'systems of knowledge' encompass more than the physical innovations or what he referred to as material or production technologies. Thomas P. Hughes highlighted that apart from the physical innovations or technologies, such systems also revolutionize the organisational technologies. Hughes thus extends the concept of an innovation system to include educational infrastructure, legislative frameworks to cover everything from patent laws to state and federal legislation controlling land use, and the ways in which products are produced and sold including financial and commercial activities.[5] This focuses our attention on a broader range of activities than simply producing and processing the raw material (in this instance wool). Thus activities such as marketing and promotion can be treated as 'social technologies', become part of the 'innovative process', and subject to 'technological change'.

This accords with the wool industry experience of innovation this century because it has not been characterised by significant one-off inventions which have then revolutionised the industry, but rather by incremental problem-solving and careful system-building both in Australia and worldwide. The third idea needing emphasis is innovation and technological change itself as a 'process'. Although Mitcham was referring to the productive process, it is also the case that the achievement of innovation and technological change (ITC) is consciously nurtured and valued by advanced economies. Though outcomes are unpredictable, they are nonetheless the product of systematic efforts to discover useful information and inventions. The outcomes are regular enough to encourage individuals, society and industry to make large investments in an open-ended way even though the risk is considerable.

---

[4] Mitcham, C., in *Research in Philosophy and Technology*, edited by P.T. Durbin, Jai Press, Greenwich, Conn., U.S.A., pp. 229-294, p.256.

[5] Hughes, T.P., 'Evolution of Large Technological Systems' in Bijker, W.E., Hughes, T.P., and Pinch, T., (eds.), *The Social Construction of Technological Systems,* Cambridge, Mass., 1987.

When it comes to describing the nature and operation of the innovation process there are a plethora of terms and descriptions with very specific meanings used by historians of technology or theorists working to explain the process. To detail the kind of technological change, terms such as *core technologies*, *innovative capacity*, or *innovative complex*, are used to define the way in which change is brought about or manifests itself. They aim to describe how key technologies inter-relate, cluster, or feed off each other, either accidentally or by design.[6] What we can appreciate from surveying all these descriptions is that innovations do not have a predictable developmental sequence, even though many adoption patterns appear to have some regularity. In the case of the wool industry innovation it appears that adoption was largely countercyclical being bunched together during times of industry downturn, and, somewhat perversely, 'crowded out' during times of plenty. Often very good innovations experience extended adoption lags, even though the economic cycle would appear to be conducive to investment. This poses a curious situation for a industry body attempting to meet industry requirements and maximise outcomes, because the capacity to support research and extension is at its lowest point during these times.

In the literature on innovation, much is made of the differences between *invention* and *innovation*. These are usually differentiated by the separation of the act of discovering a new technique which could become an innovation, from the incorporation of the novel device or practice into the productive process. The time interval from when the improvement was first proposed or discovered, to when technical considerations give way to commercial ones, is the *technological lag*. In the wool industry, this distinction is often hard to sustain, because inventions often go through a number of commercial 'prototypes' before patenting or release or, in the case of scientific advice, modifying to suit regional variations before either a settled optimal form is realized or knowledge is able to be diffused. The existence of a prolonged lag does not indicate much in terms of system-efficiency, because delays may allow the development of supplementary or complementary innovation which more fully maximises the original potential of an innovation. Moreover, competition between innovations which seek to achieve a similar outcome may not always be conducive to industry-wide productivity outcomes. They could actually dilute the efficiency gain and increase costs, than if only the best option had been made available. Nor is competition necessarily the best way of determining which is the best option. A high degree of dissemination efficiency could result in premature adoption before it has been fully trialed and tested - causing significant losses and disenchantment on the part of the farmer. The slow and conservative industry approach may actually produce the most effective innovative result in the medium to long-term. The more

---

[6] Freeman, C., Clark, J., and Soete, I., *Unemployment ana Technical Innovation,* Frances Pinter, London, 1982.

gruelling dissemination path could mean nothing is adopted until its time has fully arrived, and the problems are fully catered for. On the other hand, the reverse could be the case where the extended adoption-path is a function of ignorance, shortsightedness or neglect.

Another definitional area revolves around the activity of *science* and the activity of *research and development* (R&D). The way in which science operates has probably engendered more debate than any of the concepts mentioned here thus far. Science and the scientific endeavour is basically an activity which lays a greater claim to apprehending truth (or reality) than other forms of belief. The activity which advances the objectives of both science and society is research and development. 'Research' can be broadly categorized into two forms of activity. The first is the exploration of knowledge only loosely related to economic problem-solving while the second tackles the activity of problem/opportunity formulation to come up with new solutions/combinations of new or existing knowledge, and to investigate their potential worth. This difference is referred to as that between pure/basic/fundamental/discipline-oriented/science-oriented research as distinct from strategic/applied/mission-oriented/technology-oriented research. Strategic research is often bracketed with 'applied', but is probably somewhere between basic and applied. Although not as open-ended as basic research because it seeks to find answers to specific problems employing any likely direction that could prove helpful.

Again, such distinctions are often hard to sustain, because a research project could move back and forth from strategic to applied as it develops. Similarly the distinction between 'basic' and 'fundamental' research varies depending on the situation. Some regard 'basic research' as more akin to strategic research, whereas 'fundamental' is seen as research which seeks to uncover new knowledge with no particular application in mind. A related term, sometimes used in place of fundamental, is 'pure science'. Pure science is regarded as an activity which asks questions, pursues knowledge, and undertakes problem solving exclusively for its intrinsic value, with only a very loose consideration of its immediate economic potential.

Whatever the label, it was rare for a fundamental breakthrough to translate immediately into a useable innovation (although it does happen), nor is there a neat sequence of research activity from basic to strategic to applied research and then to development. However, all the scientists interviewed during the research for this thesis outlined the same paradigm or developmental sequence for how innovation is produced. They saw the progress of research to innovation as a cycle of work which started with defining the problem, and then moving sequentially form pure research and the generation of foundation knowledge, through to applied research, followed by development and finally, extension. However, this evolutionary or cumulative method is an ideal and results were more often the outcome of sudden unlikely breakthroughs

at any point in the process. Once a breakthrough is made it can generate years of additional detailed research. In many cases even after an extended period of developmental work only a small proportion of the original inspirations actually culminate in a worthwhile innovation.

Many of the scientists interviewed for this thesis were critical of the Australian approach to research management arguing it did not conduct enough basic research, that it was insufficiently open-ended, and overly focussed on achieving short-term results. Others pointed to the failure to move beyond the 'seeking of knowledge' stage, and did not share a belief that unfettered basic research was science's greatest strength. Untangling this apparent inconsistency really depends on the branch of science in question, and the stage in the investigation process research has arrived at.

One consequence of such definitional problems is the difficulty in calculating what proportion of the wool research budget goes to each level of research and ensure there was a balance. It was often a matter of practical opportunism on the part of the researcher or funding body where the project fitted and how it would be described. Fundamental discoveries of importance to the world were rare events and the Australian research effort, in common with others, has mostly been derivative, incremental, and sought to apply or adjust basic knowledge uncovered elsewhere. The wool industry research effort was mostly strategic (as defined above) in its focus with only a small proportion of funds going to fundamental/basic/pure research or, for that matter, applied research. The applied work was largely the domain of the departments of agriculture or the IWS, and was therefore under-represented in the funds coming from the wool industry trust.

This brings us to the *development* side of the R&D pairing. Development involves the process of bringing a new product or technique to the stage where it is technically useable, progressively refining the technical aspects until commercially proven. In this respect, much applied research could more properly be called 'development work', yet it often comes to be labelled 'research', which is perhaps why many are left wondering where the development component of the wool R&D programme is. Many wool researchers commented that development was always a neglected area for funding.

> *There is little understanding by the public and even by many academic and government scientists of the complexity and the expensiveness of the "D" in R&D...*[7]

---

[7] Tishler, M., 'The Role of Industry in National Science Policy', *Perspectives in Biology and Medicine,* University of Chicago, Vol.13, No. 4, Summer 1970, p.531.

Knowledge is what people have in their heads and it is transformed into information for exchange between people and for storage. Hyland argues that: "The term 'agricultural extension' be used to describe the broad function of communication of information from all relevant sources to assist the process of change and innovation in agriculture including farmers capacity and self-sufficiency in resolving problems and making integrated farm management decisions'.[8] He further suggests that: "The term 'technology transfer' not be substituted for the term 'extension' and that it be used to describe specific objectives and activities of agricultural extension concerned with the communication of technology". In other words, the term 'extension' is differentiated from 'technology transfer' by virtue of the fact that extension describes the objective of the exercise, whereas technology transfer is only one component of that process. Extension is a interactive process, involving receptivity on the part of woolgrower/processor and a good understanding by those providing the service of what is possible. Although the extension services developed within the states assisted the grower's own capacity to information and solve problems, there was also the trap of fostering a delivery mentality because the services provide were at little or no cost. Waiting for the service to be brought to the attention of the grower could amount to insufficient interest, interaction, or involvement on the part of the wool grower.

The activity from the extension network was always subject to the interaction between the weather, internal and external economic circumstances and the social values, expectations and aspirations of woolgrowers. The farming community were well supported with ready access to the available scientific knowledge and flow of innovation through the funding and encouragement of research institutions, libraries, and agricultural/scientific societies. This helped them remain relatively prosperous, by keeping them literate about new techniques and skilled in applying them. They were also encouraged by government regulation via statutory authorities or through incentives from government provided through a range of financial subsidies and taxation incentives. Together these factors determine the rate of dissemination and eventual outcomes of the innovation process.

For this thesis it is the technological infrastructure that makes up the innovation system, how knowledge was distributed, the innovation outcomes, the levels of advantage achieved, and the role of government in developing and facilitating the wool industry's technological capacity that is of central interest.

---

[8] Hyland, P.G., "Report on National Survey of Goals for Improving Extension - A Follow-up to the National Conference on Agricultural Extension". *Journal of the Australian Institute of Agricultural Science*, 1991.

The wool pipeline, woolgrowers, and the wool industry.

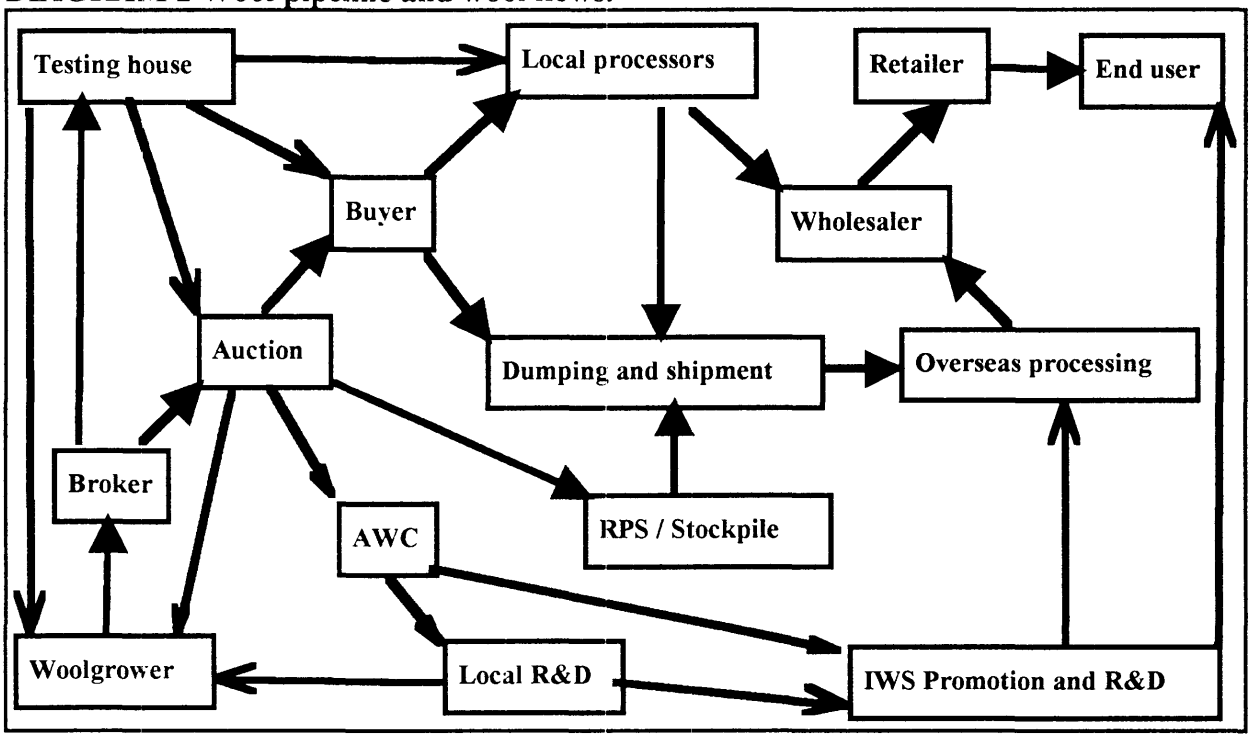
The nature of the wool technical support system needs also to be considered in conjunction with the industry structure, the various commercial relationships and technological spheres within the wool industry. The industry structure is covered shortly but what is often referred to as the 'wool pipeline' is outlined here as a mental map of the relationships between the various industry players. Once wool is removed from the sheep and packaged, it is put into the custody of the broker, to be presented for sale most of the time by auction. After the auction sale, wool is dumped and forwarded to local first-stage processors or to overseas processors or mills. Since the early 1970s the grower's broker arranged for samples of wool to be removed from each lot after arrival in the woolstore, and these were then forwarded to the testing house for analysis. This information and a representative sample of the lot were then made available before the auction, for international and local buyers to inspect. From the 1960s, testing information was transferred to the auction, and the facilities of the testing-house could be also used by processors after wool was purchased to verify the original tests or to analyse wool after it had been processed into scoured wool or wool tops. From 1974 until 1991, the AWC stood in the auction room purchasing wool if prices fell below the specified minimum.

At the processing mill, the wool is cleaned and freed of animal, soil, and vegetable matter impurities, then turned into textile yarns for fabric manufacture and jumpers, or left in semi-processed form and converted into other products such as carpets or felt. Therefore, the three main processes in the manufacture of wool are the woollen, worsted and felting systems - worsted fabrics are those such as serge, gaberdine or crepe; woollen fabrics are tweed, melton and velour.

In terms of the processing chain, Australian wool is predominantly manufactured in the worsted system which involves three distinct processing steps: early stage processing (cleaning and top making), later stage processing (yarn making and weaving), then fabric finishing and garment manufacture. Greasy wool requires cleaning to remove unwanted components such as yolk (wool grease and suint), dust or vegetable matter (twigs, seeds and burrs), either by scouring or carbonising. The washed fibre is then dried and carded to produce a uniform, clean fibre (tops) ready for spinning into a continuous yarn. From tops, wool fibres are combed and spun into yarn which proceeds through the rest of the textile process much like yarns made from any other fibre. Once fabric or knitting yarns have been created, it is then the domain of the special effects or performance enhancing chemicals to manipulate the chemistry of the fibre and create new products or materials that better matched the synthetic counterpart. The end-products are

handled by wholesalers and retailers, and the end-user is encouraged by these agents through branded advertising or by generic advertising conducted by the IWS promotional campaigns. Diagram 2 maps these relationships as well as the intermediate selling steps related to marketing, promotion and research.

DIAGRAM 2 Wool pipeline and wool flows.



This nature of the 'wool pipeline' and associated institutional involvements explains why it has always been difficult for the woolgrower to have precise knowledge of where the wool goes and to receive comments on its merits for manufacture. The dark arrows in this chart represent the movement of wool, while the hatched arrows indicate the direction of information flows, and the break up of monies from the sale of wool. The long and fragmented selling and processing-chain kept the woolgrower separated from the end-user and end-consumer by a series of steps in which wool ownership changed. The movement of wool between brokers, buyers, transporters, scourers, topmakers, spinners, weavers, knitters, dyers, finishers, manufacturers, wholesalers and retailers required long lead times. The absence of vertical integration (and of Australian companies processing wool products on an international basis) and the resulting poor linkages between the producers and consumers of raw wool meant most growers had no idea who bought their wool, what they thought of it, and what it was made into. Another consequence of this structure was that at each stage processors would expect a margin which added to the cost of production and kept it higher than with other textile fibres. The result of this inefficiency apart from increasing the input costs, the prices of products and

causing a reduction in total demand, was that it required the research community to create systems and technology which would address these difficulties.

The pipeline approach highlights the interrelationships and dependencies and breaks them into three broad areas. The innovation experienced falls into on-farm innovation, off-farm innovation, and processing innovation. Over the course of this century the research and innovation generated within Australia has since a gradual shift in emphasis from a focus only on production problems, to one that incorporated intermediate transport and materials handling and the beginning of textile research, to a situation where in the 1990s the level of textile research and that associated with processing was becoming the dominant area of research activity.

Before concluding this section, it might be useful to clarify what the terms 'woolgrowers' and the 'wool industry' mean in the context of this thesis. Although woolgrowers are often bracketed together as a homogeneous group, farm sizes, geography, climatic conditions and the problems they face vary enormously. In terms of sheep numbers, they range from very large enterprises with over 100,000 sheep, to an industry average of around 3,000 sheep. A significant proportion have 1,000 sheep or fewer. In all, around 50,000 farmers grow substantial amounts of wool in Australia. Around one-third are principally wool growers, and the remainder are mixed grazing or predominantly cropping enterprises in which woolgrowing represents a small part of total farm income. Geographically, woolgrowing enterprises vary from higher rainfall tableland country to very low rainfall inland plains. The importance of this diversity is that it creates differing expectations, and the nature of technology and innovation required will often be different for each group and geographical area. This makes it extremely difficult and only in a few cases will a research outcome be applicable in all circumstances. For example, pasture improvement innovation is of no value to the woolgrower in arid regions; breeding programmes or the work on quantitative-genetics is not of much direct use to wheat farmers who buy and sell sheep rather than breed their own. Given these circumstances the research programme has responded by looking to impartially fund research which best advanced total industry outcomes. Therefore, when the term 'woolgrowers' is used, it is merely shorthand for the overall position of growers in the industry and the sort of complexity mentioned above means that significant numbers of growers may not share the point of view or position.

The 'wool industry' comprises a network of people including growers, brokers, wool exporters, organisational people, shearers, supporting companies, early stage processors, spinners, garment makers, consumers, and so on. Rarely do such a collage of people speak with one voice, so the phrase 'the wool industry' when used here generally means the direction or

workings of the industry as intended or decided upon by organisational leaders in Australia operating on behalf of, or with the sanction (implicit or explicit) of woolgrowers and others collectively.

2. THE ECONOMIC CONTEXT - MARKETS AND INDUSTRY STRUCTURE

The structure of the international trading relationship and the economic circumstances of the industry had a considerable bearing on the nature and capacity of the innovation system as well as the capacity of wool growers to utilise new technology. The level of international demand for Australian wool, the prices received, and changes in world textile production had a determining influence on the sort of textile and production technology that would be appropriate and, therefore, on the kind of research the science community would undertake. In the short run demand for wool was a function of world and regional economic cycles which influenced the level of consumer spending World events such as wars also dramatically disrupted international trade. Over the longer term the wool trade industry experienced changes in the level and mix of world textile production as well as shifts in processing location around the world. These reflected changes in industry activity and structures in a number of countries and in particular the development of Asian economies. The outcome from these factors was that the dominant wool purchasing and processing economies of the first half of the twentieth century were no longer dominant by 1990. On an enterprise level, from the early 1950s declining economic circumstances placed severe constraints on the financial capacity of many processors to either develop or install new technology. In this environment researchers needed to respond to processor as well as woolgrower needs by tackling immediate problems, but at the same time working towards establishing the underpinnings of future success through a strong basic research effort. This necessitated a balance between properly meeting the long-term imperatives of specific markets and processors, as well as assisting growers who were anxious for early results.

The international wool trading environment.

The wool traded in the international market has hundreds of quality variables and subtle uses to which it can be put. The world clientele is similarly diverse with the complexity of consumer preference, levels of overseas tariffs, differences in inter and intra fibre competition, and cycles in economic activity, all having a profound effect on the levels of wool production, prices received, and changes in demand. This makes conclusions about overall buying intentions, the nature of, or trends within consumer markets, or the connection between these and final demand outcomes very complex to explain as well as difficult to predict. Nevertheless one

influence was particularly strong. After the second world war, the enormous growth of the synthetic fibre industry was the main element affecting demand for wool and other natural fibres. The workings of the synthetic industry not only changed the nature of consumer preferences but determined where the main textile processing centres worldwide and which countries would be interested in raw textile fibres.

The location of wool processing worldwide.

Locational shifts in international demand were a response to increasing production costs (especially labour costs) in processing countries. The dislocation to trading arrangements caused by world wars and "technological leapfrogging" as the equipment in some countries became obsolete either in terms of rate of productive output or the level of environmental pollution it created. This altered the nature of economic relations in world trade and caused extended periods of demand dislocation as the centre of processing activity shifted. In the nineteenth century the British textile industry eclipsed local and European cottage industry textile producers. By the beginning of the twentieth century, the Bradford system had made the British mills dominant in wool processing. In the years leading up to 1950, the 'Continental system' challenged this technological dominance and brought about a gradual shift to the continent (France, West Germany, Italy and Belgium). Just prior to the second world war, the largest buyers were the United Kingdom, France, Belgium, Japan and Germany. Japan was a large processor of cotton as well as wool and prior to 1939 was consistently buying over 20% of the Australian wool clip. In the years immediately after the second world war, the growth in processing capacity was experienced in the worsted industries of USA for a short time, and then Japan, Russia and China. In the last twenty years the growth has been with processors in East Asia such as Korea, Taiwan, Hong Kong, China, Singapore and Malaysia and the top five buyer countries for Australian wool were Japan, Italy, China, France and Taiwan, with China positioned to become the largest buyer in the years ahead. The Asian country purchases of wool since the 1950s has progressively increased from an average 20% to nearly 50% of the clip, whereas the United Kingdom's share of the Australian wool clip has fallen from 60% at the turn of the century to around 2.5% in 1991. The East Asian processing capacity made the region a major textile and wool textile processing centre.

Despite these changes in where wool was being exported and processed, the level of per capita consumption of wool product and where the consumers were located remained fairly stable. Together with the military needs in the former Soviet Union, consumers were principally in those cold climate countries with the highest per capita incomes such as Switzerland, Japan,

Ireland, Belgium, Germany, Austria, Britain.[9] With the exception of Japan, none of these countries processed sufficient fibre or clothing to meet their own consumption, so the shortfall was supplied by other wool manufacturing countries who generally produced the lower cost, less high-fashion oriented segment of the market.

The rapid decline in the British woollen industry and the growth of the synthetic industry caused the level of wool-specific textile machinery worldwide to decline as the emerging textile-producing countries elsewhere installed either fibre-neutral or synthetic-only equipment. The shift in wool processing locations also caused much specialist wool processing knowledge to be lost, which meant potential wool processors could not quickly enter into wool processing during times when wool prices were competitive with synthetics or profits for wool products were more attractive. On the other hand the shedding of generations of craft knowledge facilitated, to some extent, the introduction of scientific measurement and hastened the application of more efficient processing techniques.

After years of processing capacity being rundown in Europe, the 1980s witnessed a revitalising of the processing capacity through the installation of highly automated and was experienced during the 1980s. At the same time, countries such as China continued to utilise second-hand Bradford or Continental machinery, which kept equipment costs low complementing their competitive labour costs. Thus, by the late 1980s, a marked difference existed in the types and age of the machinery used in different parts of the world. As the wool textile industry was more and more located in former communist countries, the dissemination of new technology was slower. On the other hand, as wool processing moved into newly industrialising Asian countries (other than China) with a preparedness to make new investments, the reverse was also true. This demonstrates the duality of wool processing centres around the world between those more technologically advanced, capital intensive. fashion and promotion driven, with capitalist pricing structure and the previously communist countries which (until recent times) had low levels of technology, labour intensive techniques, with unrealistic pricing (to ensure foreign exchange receipts), and who have participated in or funded, very little or no IWS promotion.

These were important differences, because changes in the respective economic circumstances of these processing countries were soon relayed and came to impinge on investment capacity throughout the industry, and hence competitiveness. Large scale international relocations and restructuring impacted on demand, changed long-term commercial relationships and confused the market signals. On a farm basis it could be very disheartening to the producer striving to

---

[9] *IWS Facts*, International Wool Secretariat, London, 1990. In 1989, consumption was 723Mkgs, with 560 Mkgs processed in these countries.

export a high quality textile fibre, to find these efforts were dissipated through inefficient international processing arrangements or low levels of new technology adoption.

The synthetic fibre industry also experienced changes in location worldwide. The domination by the European and American textile fibre industry continued until the 1980s, when the shift in to the Asian region (especially Taiwan and South Korea) accelerated, based on a new generation of relatively low-cost smaller scale man-made fibre-technology. The other difficulty for the competitive position of natural fibres was that man-made fibres required specific machinery for processing which could not accommodate natural fibres. With continuing investment in these lower-cost facilities, over capacity, especially of polyester fibre production, maintained keen competition. However, greater flexibility in terms of fibre used on synthetic processing equipment presented the possibility of increased wool fibre usage.

Trade agreements and tariffs.

As with shifts in processing centres, trading barriers and constraints such as tariff settings, the Multi-Fibre Arrangement (MFA) and international trading relationships, influenced market circumstances and prices. For example, although access to markets has always been relatively open for greasy wool, the finished textile trade was highly protected which caused distorted access and higher pricing structures for imported product. As Table 1 shows, in 1993 no tariffs were applied to greasy wool by Australia's major customers, but tariffs did apply in most countries for tops or yarn. Once in fabric or garment form, the restrictions and tariffs were anything between 20% and 40% and higher. Imports of processed wool is banned are India unless re-exported in a finished form. China imposed quotas on a province-by-province basis, and a product duty as well as commercial taxes, so the effective tariffs were often as much as 30-40%.

Table 1.1 Tariffs for various stages of wool processing in major buyer countries - 1993.

Importing Country	Greasy	Scoured Tops	Yarn	Fabric	
EEC	Free	Free	2.5%	3.8-5%	13%
Japan	Free	Free	Free	4%	20%
Republic of Korea	Free	2%	2%	4%	11%
Taiwan	Free	Free	Free	15%	
United States	22c/kg clean	24.3c/kg	15-20%	15-20%	36.1%
India	40%	40%	50%	60%	
China	15%	15%	20%		
Australia	Free	Free	Free	15%	35%
C.I.S.	3-10%	3-10%	7-20%	7-20%	7-20%

Source: Australian Wool Corporation , *Wool Monitor,* 1993.

An important agreement shaping the textile trading environment, was the Multi Fibre Arrangement (MFA), which operated under the auspices of the General Agreement on Tariffs and Trade (GATT). The MFA consisted of a series of bilaterally negotiated agreements, which provided guidelines for the restraint of trade in textiles and clothing.[10] The MFA was a derogation of GATT. Wool was not included in the original GATT negotiations after the war. The MFA had its origins in the 1920s, and the objective was to control the cotton textile trade of Japan In 1936, Japan voluntarily agreed to limit textile exports to the U.S., and in the 1950's, both Japan and Italy voluntarily restricted certain products. In 1961-62, international agreements covering cotton products were renegotiated and became the forerunners of the MFA. The US and the European Community wanted to extend protective arrangements from cotton to other textiles, and in 1974 the first MFA to which Australia was a signatory, was created. The MFA has since been renegotiated in 1977, 1981, 1986 and in 1991, when it was agreed to phase out quotas over a ten-year period, beginning in 1993. Australia has not been included in the MFA since opting out in 1977. At this time Australia imposed a two tier system with a 'Base' tariff applied on imports up to a certain volume with a 'penalty' rate for goods above the quota. The Australian tariff was 60% for clothing and 40% for textiles, but these are now in the process of being reduced to much lower levels. The 1986 negotiation reduced the levels of tariffs under the MFA from the 20-25 per cent range to 10-20 per cent. The main effect for wool processors is to protect them from overseas competition and slow down the transfer of processing capacity to low-cost countries. In the early 1990s the MFA had fifty signatories; although authorised under GATT, it is regarded as a derogation from GATT (this permits practices which are contrary to the normal GATT rules). Around seventy-five percent of exports from developing to developed countries were subject to a MFA quota of one kind or another. Under the Uruguay Round the MFA is to be phased out. Most of Australia's largest greasy wool customers had their finished goods markets protected by the MFA. The MFA enabled developed countries to impose import quotas on textiles and apparel from lesser developed countries, which limited imports of cheap textiles. The effect on trade and consumption from tariff barriers is best evidenced by the long-standing high levels imposed on wool by the USA. The first duty on imported wool was imposed by the US in 1816, and except for two brief periods from 1894 to 1897 and from 1913 to 1921, the tariff has been in effect continuously. In 1921, the duty for medium and fine wools was set at three shillings per pound of clean wool at a time when wool was selling for 8 to 10 pence. It remained at 34 cents U.S. until 1948, when it was reduced by 25% to 2/6 AUS. Since then, it has gradually been reduced and made less important by the effect of inflation. This, of course, came after the period in which synthetics had come to dominate the American market. At the same time, U.S.

---

[10] Carlisle, C.R., 'Textile Trends Around the Globe: An Appraisal of Trade Negotiations', *The Australian Bicentenary Wool Conference*, 1989, p.29.

woolgrowers were protected. In 1954, the National Wool Act made it mandatory for the Secretary of Agriculture to support the price of wool for US growers to an average of 5/6 AUS. per pound of greasy. This was obtained by using not more than 70% of receipts from import duties. Thus, tariffs on imports of Australian wool were used to subsidize U.S. woolgrowers. This represented about a 50% direct subsidy to US growers. This situation kept wool prices artificially high, made woollen goods expensive, and also allowed synthetics to dominate what was potentially a very large market.[11] In developing countries the textile industry was a significant portion of manufactured exports, although Italy, Japan, and the Federal Republic of Germany, were the top three exporters of textiles, and ten out of the top fifteen were developed nations.[12] Protection from the MFA favoured the textile industry in developed countries familiar with using wool but at a cost to processing efficiently, cost competitiveness and the total quantity of wool that might otherwise be consumed. Whether this maintained the price to Australian growers is difficult to determine but it was probably positive.

Intra and inter-fibre competition.

Important for international cooperation in wool research was that the three main supplier nations in the southern hemisphere to the international wool trade, Australia, New Zealand, and South Africa, were also members of the "Empire", or later, the Commonwealth. Australia has always taken the lead in this grouping. In 1990, 83% of the Australian clip was between 19 and 26 microns, and Australia supplied around 65-70% of the world's apparel wool production (wool 30 microns and less). New Zealand exports were until around 1950 dominated by coarse apparel wool (32-34 microns); after this time. they increasingly produced carpet wools, with over 50% of the clip being of these types at one time. In the 1980s as a consequence of the wool carpet market suffering badly from strong synthetic competition, New Zealand has produced more apparel wools but still only a small fraction of the Australian production. Uruguay and Argentina export about 10% of the Australian export total, but the bulk of the wool is sold by forward or on long-term contracts. In the traded apparel wool market, only South Africa offered similar wool types as Australia (although without the very high levels of vegetable-fault contamination often found in Australian wool). However, as with New Zealand the South African production was comparatively small. Australia virtually monopolized the internationally traded greasy wool market for apparel wools, supplying over 80% of all apparel-wool fibres traded. It was therefore synthetic fibres and cotton that were the Australian

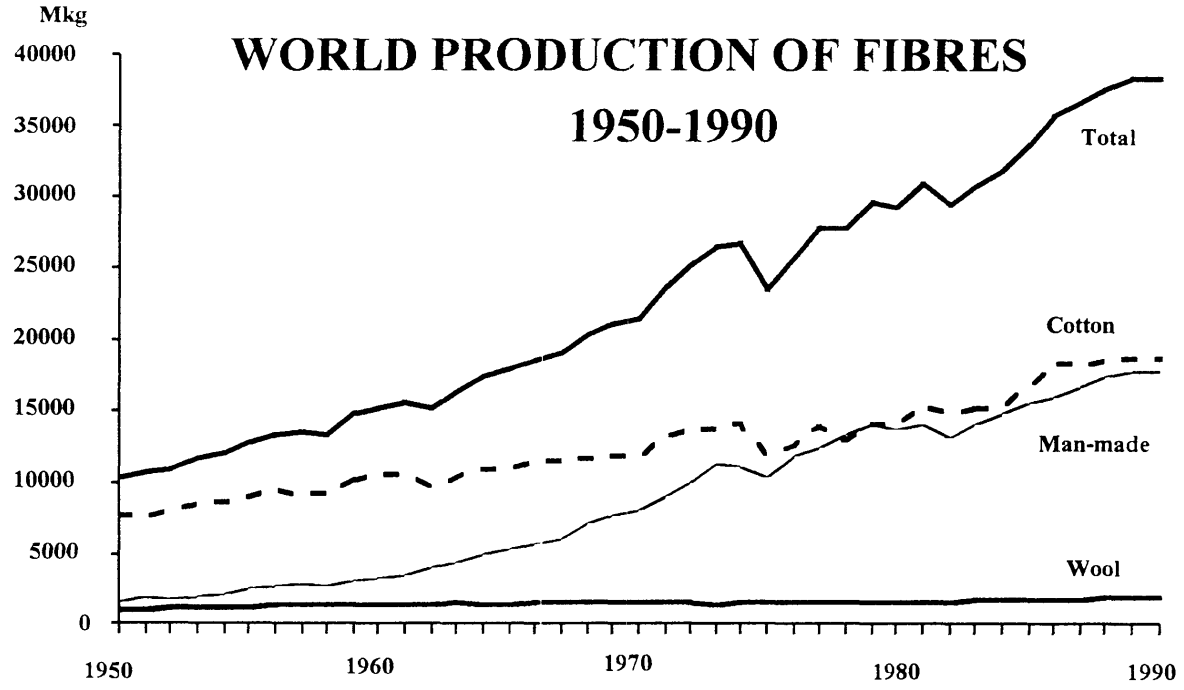
---

[11] Report from the Agricultural Attache of the American Embassy in Canberra, August 17, 1961, ANU Archives of Business and Labour, E256/1414.

[12] Carlisle, C.R., 'Textile Trends Around the Globe: An Appraisal of Trade Negotiations", *The Australian Bicentenary Wool Conference,* 1989, p.29-30.

wool trade's major source of competition, rather than other wool exporting nations. The aggregate comparison between the level of wool production shows these other fibres dominate world textile production (Figure 1.1) and that proportionally wool is both insignificant and declining proportionally. During the 1970s and 1980s the growth in production of synthetic fibres was somewhat slower.

FIGURE 1.1



Source: From the publication *Wool Facts*, International Wool Secretariat, 1990

While wool production increased gradually, total synthetic production and its share of the total textile market grew enormously.[13] Cotton was especially affected by the synthetic expansion, and its proportion of the total textile fibre market fell from 75% in 1940/41 to 52% in 1974/75.[14] In these circumstances, for wool to maintain or regain its former market share was never feasible and it is inevitable that wool would become more and more specialist textile fibre both in terms of the fineness of the fibre produced and in the uses to which it was put.

Apart from the volumes produced the main impact for wool markets was from the price impact. The pace of competition and methods of the synthetic industry was important to the wool textile research industry. When synthetics were first introduced, the prices were comparatively

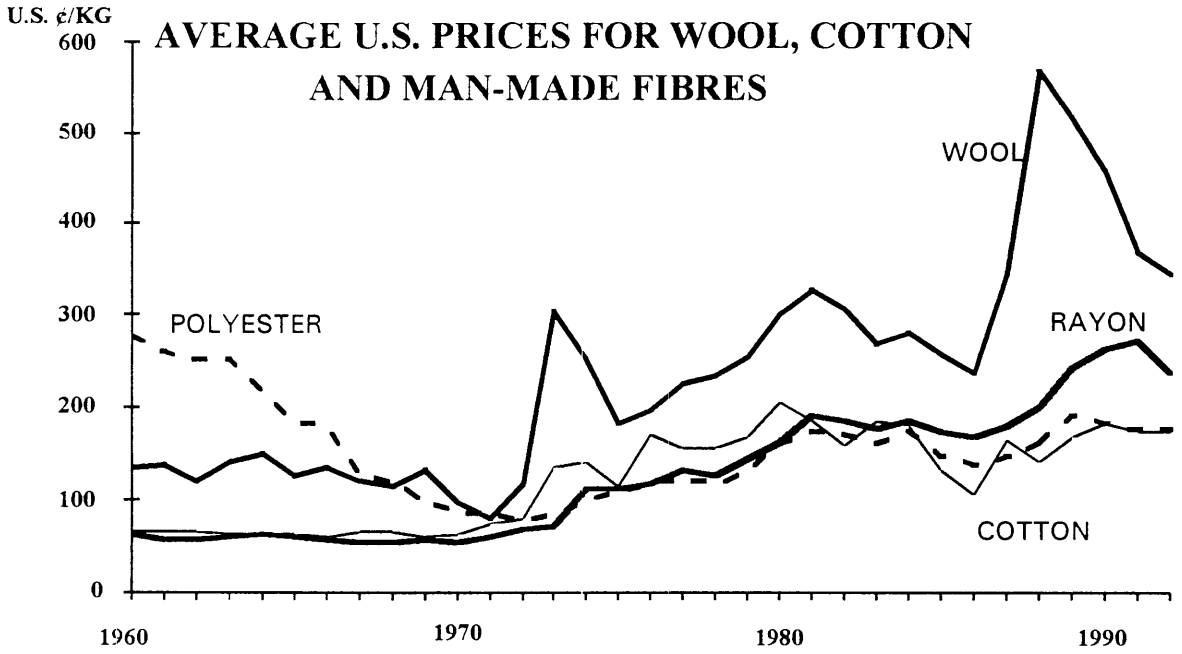
---

[13] Wool was delisted as a military fibre by the U.S. government in the early 1970s.

[14] Tisdell, C.A., *Economics of Fibre Markets: Price Fluctuations and Economic Interdependence Between Man-made Fibres, Wool and other Natural Fibres*, University of Newcastle, 1977, p.2.

high, because patents provided synthetic producers with market protection. Once many of the original synthetic patents expired, rapid expansion of productive capacity worldwide saw the price of synthetics fall substantially below that of wool (even though the price of wool - real and nominal - was also falling at the time). The fall in price encouraged the search for new synthetic fibres. The post-war increase in the use of man-made fibres in apparel production, from 16% to 21% precipitated the price slide during the 1950s.[15] The main competition (see Figure 1.2) came from polyester, which in 1960 was twice the price of wool; however, by the middle seventies, wool was averaging twice the price of polyester.

FIGURE 1.2



Source: Data on U.S. prices provided by the International Cotton Advisory Committee in 1992. Personal Communication.

Apart from the ratio change in the price of polyester, two crucial episodes of relative price changes *vis-a-vis* other fibres are shown in Figure 1.2. The boom periods of the early seventies and late eighties saw wool prices end up as much as four times the price of other fibres. When the price relativities of wool are at a high level it encourages a shift into more price-stable fibres, and also provides a price-incentive for the development of 'new generation' fibres with characteristics similar to wool. Despite the competition, synthetics did not eliminate the use of natural fibres and they held market share after 1974 when the increases in oil prices halted the

[15] The production of synthetic fibres grew at an annual rate of over 10% between 1960 and 1971, and the non-cellulosic increase was over 29%. In the U.S. the share of the textile market of synthetics rose from 29.4% in 1960 to 60.3% in 1971. 'A Review of Developments in Man Made Fibres 1969-1971', BAE Wool Economic Research Report No. 24, *BAE*, 1973.

steadily declining price of synthetic fibre previously experienced. Since then a balance in respective market shares between synthetics and natural fibres has been maintained.

It is worth reflecting for a moment how a textile fibre with a small market profile of around 4% could exert any market power. What needs to be remembered is that this percentage is misleading because it does not accurately measure wool's share of the apparel textile fibre market. The fact is that the introduction of synthetic fibres also expanded the range of uses for fibres and much of the total fibre market described above is actually destined for industrial or commercial textile uses for which wool is not suited and does not compete. In apparel uses, wool has around fifteen percent of the total market and much more in specific product categories. In 1990, the IWS estimated that wool's share of apparel fibre consumption in Japan, Italy, Germany, US, France and the UK was 17.6%. In some garments (suits and coats) the proportion is much larger again.[16] In 1991 the men's suits, women's clothing and knitted clothing-sectors in Japan saw wool account for 42.8% of total fibre consumption.[17] Realistically, wool was never going to retain its market share in an expanding textile market and if it had it would have required a land base three times that currently used in Australia.

Sheep Numbers, and wool production.

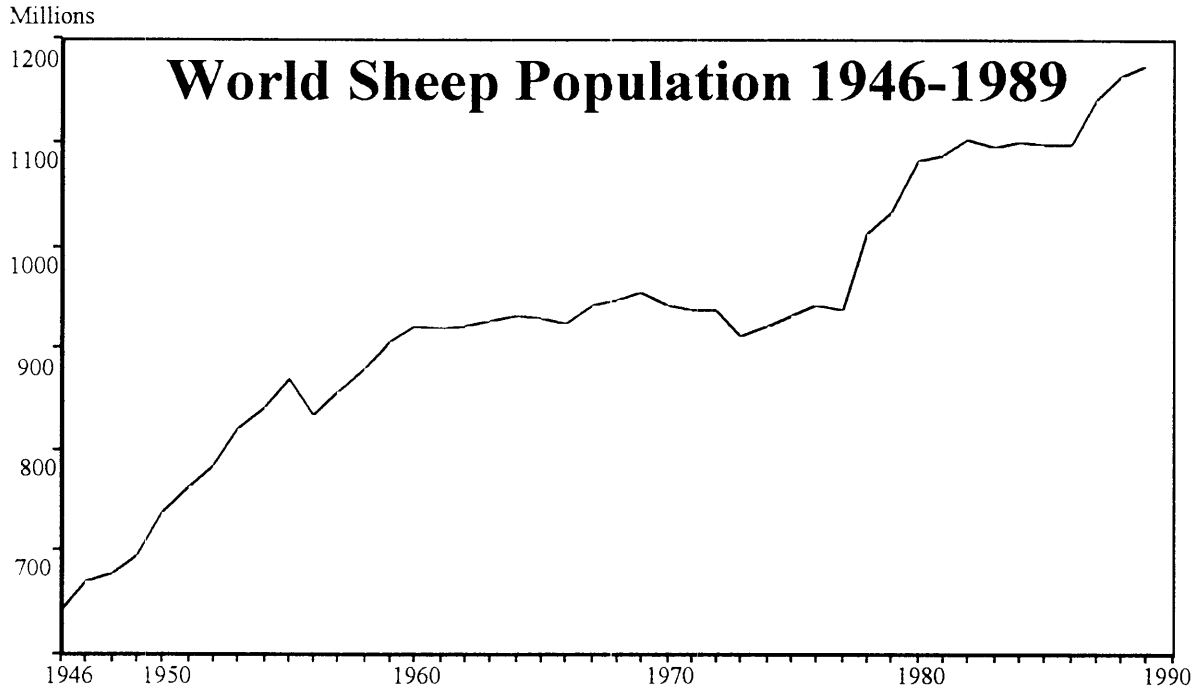
Across the world, sheep numbers have risen more-or-less continuously so that by 1990 they were nearly double the number of 1946. Of this increased number of sheep only a small proportion produced the fine to medium Merino wool suitable for apparel use (which Australia predominantly produced). Thus, world sheep numbers shown in Figure 1.3 are not an indicator of either pressures in the world wool trade or prospects for the Australian export market.

---

16 *Wool Monitor*, AWC, November, 1992.

17 *Wool Market News- Monthly Perspective*, AWC, July-August, 1992, p.7.

FIGURE 1.3



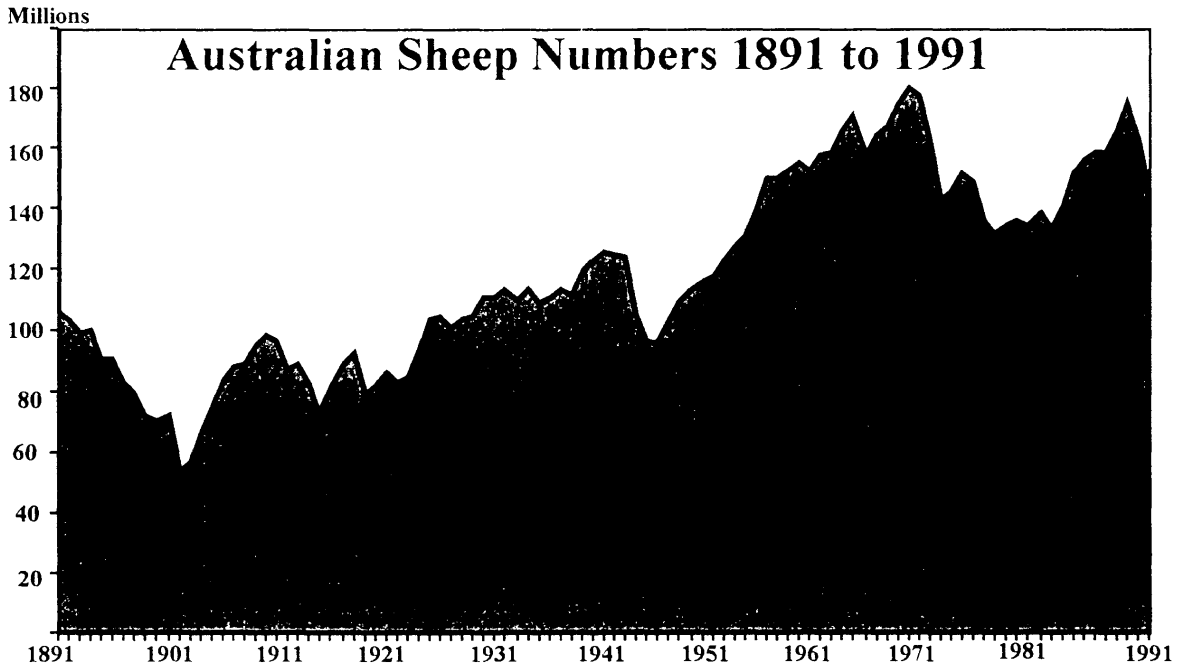
Source: *Australian Wool Compendium*, Australian Wool Corporation, 1990.

This is because the growth in sheep numbers and wool production has been in countries (Russia and China) with rapidly increasing human populations, who produce sheep for meat with wool only a low-quality by-product. Australian sheep numbers also expanded rapidly (Figure 1.4) after the war extending an existing pattern driven by expansion into new areas and land clearing.

A feature of the Australian pattern of change in sheep numbers was the effect of a larger proportion of sheep being grazed on improved pastures and the improved ability of woolgrowers to manage widespread droughts more effectively. Since World War II, recovery in livestock numbers was much quicker than before, which helped stabilize the production-base and helped reduce the potential for price volatility from extensive supply shortfalls. For example, the good recovery in wool production after the severe drought in the middle 1960s. Although at any one time there is a drought in progress in some part of Australia, those areas most prone only carry a small proportion of the total Australian sheep population. Even a halving of numbers in severely drought-prone regions does not affect overall capacity very

much. It takes widespread seasonal variation to have significant effect because the impact on the output of wool per head across a large proportion of the total sheep population.[18]

FIGURE 1.4



Source: *Wool Review 1990-91,* National Council of Wool Selling Brokers ,1991, pp20-21.

Once the postwar increase reached its peak in the late 1960s, a greater emphasis on achieving efficiency and cost reductions on an industry-wide scale was experienced. This moved the focus of the innovation effort from principally on-farm innovation which sought to expand production, to concentrate on cost reductions particularly transportation, selling and marketing systems. The shift to growing more wool from fewer sheep and saving costs partly explains the sustained downturn during the 1970s.

Changes in Australian wool production levels.

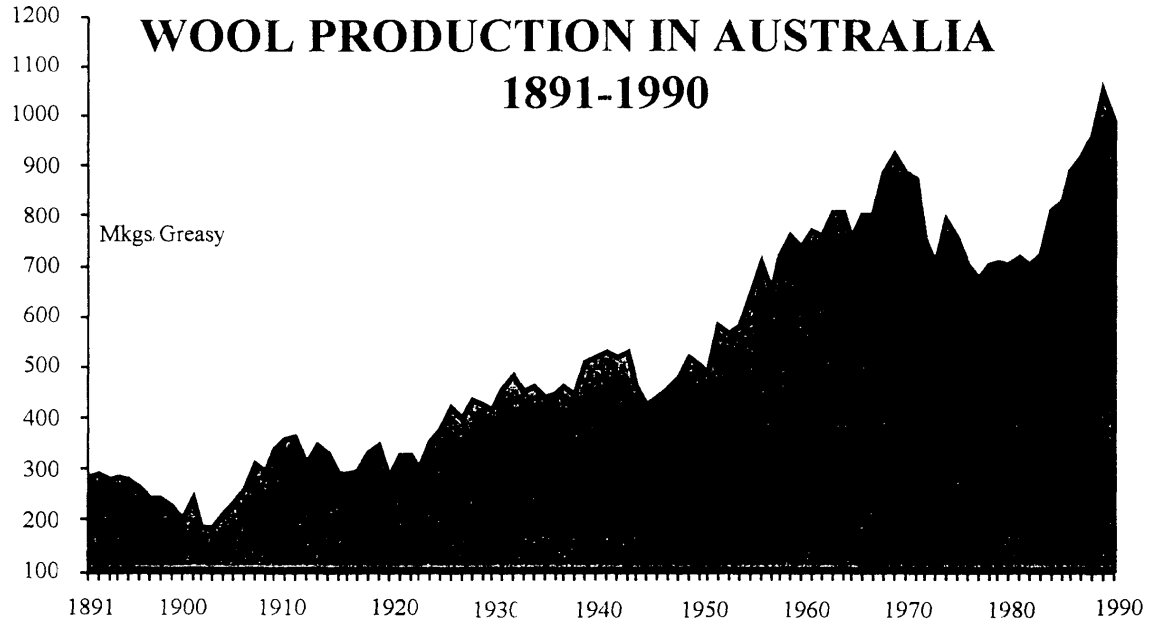
Taking a hundred year perspective (Figure 1.5), there have been four sustained periods of decline in Australian wool production. The first was during the depression of the 1890's and the subsequent drought which lingered on until 1903, accelerating the breakup of many large pastoral holdings (aided by government repurchase schemes or the reclaiming of pastoral

---

[18] In 1964-65 sheep numbers reached a record of 171 million, but the very severe drought of 1965-66 only pushed numbers back to 158 million by 1966-67. By 1968-9 they had recovered to 167 million, and in 1969-70 a record was again set at 174 million. This shows the improved ability to handle droughts. In the 1990 drought, the effect on wool production was a 20% reduction, which was the combined effect of a reduction in cut per head, and the reduction in sheep numbers

leases) into mixed farming enterprises, greatly increasing the number of smaller clips. The second and third downturns were both during the world wars, when the loss of farm labour, droughts or lower fertiliser usage created a decline. In 1944/45, the numbers of sheep fell largely as a result of the drought at the time, and sheep numbers continued to fall to 1947, when they were 25 per cent lower than in 1942. In none of these episodes was the downturn precipitated by market competition from other fibres, and in each case the total production recovered to a higher level of average production. However, the disjuncture at the beginning of the 1970s was the decisive check in the growth trend from the turn of the century.

FIGURE 1.5



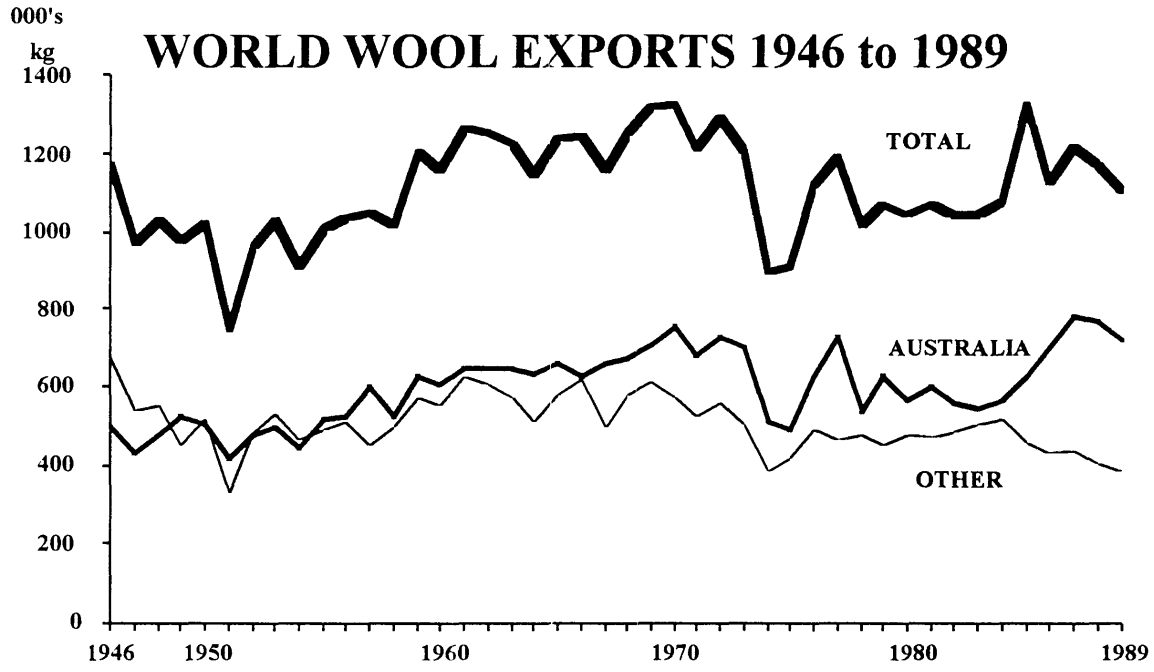
Source: National Council of Wool Selling Brokers, *Wool Review 1990-91*.

Conversely, during this century there have been four periods of growth in the industry. The first, between 1903 and 1911, was a rapid recovery from the effects of the 'long drought' at the turn of the century. The second phase ran from about 1920 to 1943, when land usage started to become more intensive, and cactus infestations were substantially reduced.[19] The third phase, from 1947 to 1969, was extraordinary when compared with the previous expansionary periods. With rabbits dying in their millions from myxomatosis in the early 1950s, and the rapid increase in fertiliser usage and pasture improvement activity thereafter, the rise of wool-output in some

[19] Based on data from the National Council of Wool Selling Brokers ,1991, this represented a compound rate of growth between 1920 and 1943 of about 0.5% annually. The compound average growth from 1943 to 1957 was about 4.5%, and from 1957-58 to 1964-65, about 1.4% annually. Based on data from the National Council of Wool Selling Brokers, 1991.

areas and on some properties was astonishing. This is a phase that the thesis will concentrate on in terms of linking R&D outcomes to increases of wool production. Apart from the drought in the middle 1960s, in twenty-four years production went from 425 mkgs to 923 mkgs or well over double. Therefore, in the period when the relative importance of the industry to the total Australian economy was declining rapidly, the industry underwent the largest productive expansion in its history. The last expansionary period came after the drought of 1982 and up to the close of the 1980s where wool production exceeded the previous highs although sheep numbers did not reach the levels of the late 1960s. In terms of Australian production it is more useful to concentrate on world exports of shorn apparel wool than sheep numbers or total levels of production (Figure 1.6).

FIGURE 1.6



Source: *Wool Facts*, International Wool Secretariat 1989

Here we find that the total levels of wool traded in the world have been steady since the mid-fifties, but the level of Merino wool as a proportion of that market has steadily increased with every downturn in the market, and as synthetics have forced a reduction in the flow of carpet wool from New Zealand. Thus, while innovation has been increasing the productive output in Australia, the industry has been faced with a traded wool market in which demand was stable or only slightly increasing. Long-run stability in world demand probably reflects the fact that the industry was a mature one, and also a stable (although moving) level of wool-oriented

machinery around the world. Substantial improvements in processing efficiency while available for fifteen to twenty years have not been taken up quickly. Therefore, the increase in Australian exports has involved an increase in market share of traded apparel wool, rather than a significant expansion of the total world export market. For example, Australia's share of the export trade of shorn apparel type wools has increased from 41 per cent of 1172 Mkg exported in 1946 to 65 per cent of 1107 Mkg in 1989.[20]

Australian wool prices.

The interaction of international demand and the level of wool available for export around the world determined the price received for wool. Wool prices were the most important issue discussed in the wool industry, and the factor that decided most of the institutional changes the industry including those associated with R&D.

Figure 1.7 traces the nominal seasonal average prices over the last two hundred years. The three extreme price-peaks relate to the Napoleonic Wars (which disrupted the Spanish wool trade), World War I, and the Korean War. In each of these, wool was a strategic commodity, and because it was sold on a free market basis, the price was bid up to extreme levels.[21] The impact on wool prices from war was lessoned when the sale of the entire clip to Britain was made part way through World War I. It was almost extinguished during World War II, when buying arrangements were put in place well before the commencement of hostilities. The short price-peak in the early 1970s, was created by the rapid decline in production and the sudden turnaround in world demand. The last peak, in the late 1980s, would appear to reveal an extreme rise in price, but much of this was the combined outcome of high rates of inflation in Australia during the 1970s and 1980s, as well as the substantial fall in the dollar in the middle to late 1980s.

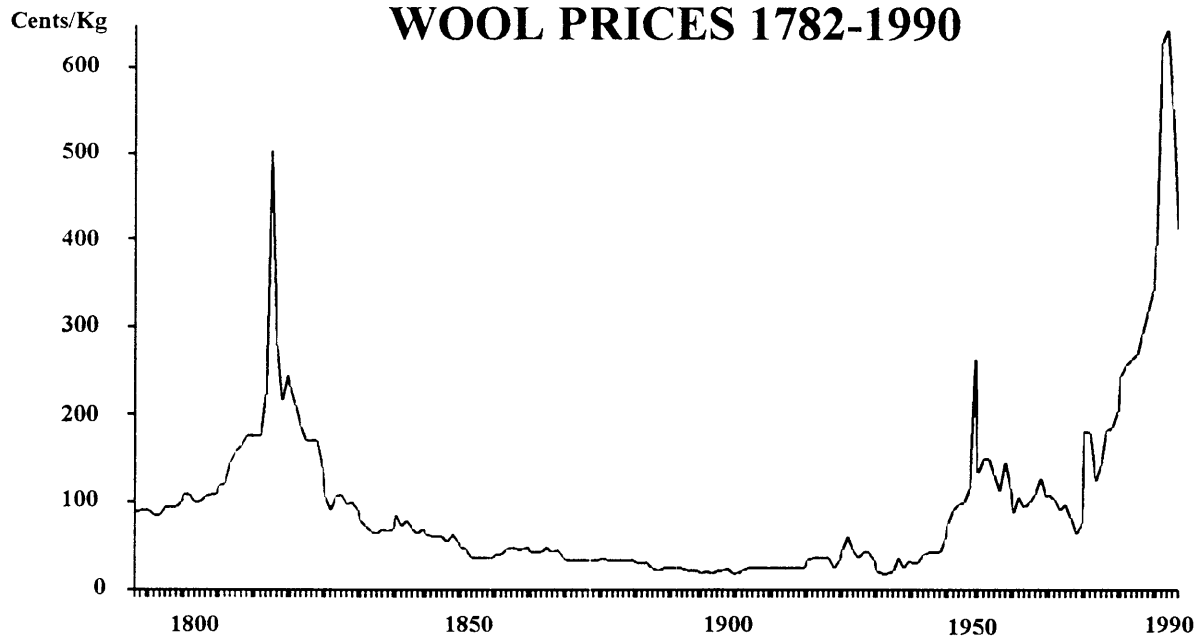
During the 1950-1990 period, only the Korean War boom and the late 1980s boom were years in which returns provided ample working capital to allow investment in capital-intensive improvements or costly new technology. Since early 1950s and before the late 1980s, the Australian woolgrower has been under considerable pressure in terms of the return for woolgrowing.

---

[20] Carpet wools not included.

[21] When comparing price changes over time, starting points and scale can easily distort the results. The main influences are the effect of exchange rate movements, inflation, technology improvements, as well as what wool price being quoted as the average. There is also tendency to equate nominal price changes with changes in profitability. The price being used here is the average for all wool sold across an entire selling season and in Australian currency. Other options include Market Indicators prices, trade-weighted prices, yearly average prices, micron or AWC type prices.

FIGURE 1.7



Sources: 1782 to 1930: Tooke's History of Prices 1782-1853, British Imports 1854-1870, Melbourne Wholesale Prices 1871-1930, all in the Archives of Business and Labour E256/1380. 1824 to 1861: Prices Current of Wool in Boston in *Fine Wool Sheep Husbandry*, by H.S. Randall, Orange Judd, Broadway, 1862. 1925 to 1935: National Council of Wool Selling Brokers, Report for 1934-35, E256/1383. 1929 to 1932: Australian Wool Prices, *Report by the Commonwealth Wool Inquiry 1932*, Commonwealth Printer, Canberra, 1932, p67. 1946 to 1958: *Wool in Wartime*, by Les White, Table 5, p156; *Tangled Skeins* by F.E. Hitchins, Robertson & Mullens, Melbourne, p111; "Wool in the Australian Economy, 1946-58", by L.J. Hume, in *The Simple Fleece*, Edited by Alan Barnard, p617; *An Investigation into Wool Marketing -1959*, by G. D'A. Chislett, p36. 1972 to 1990: National Council of Wool Selling Brokers, *Wool Review 1990-1991*, and personal communication, R.G. Levy. 1947 to 1989: Australian Bureau of Agriculture and Resource Economics, *Commodity Statistical Bulletin 1990*, AGPS, 1990, p27.

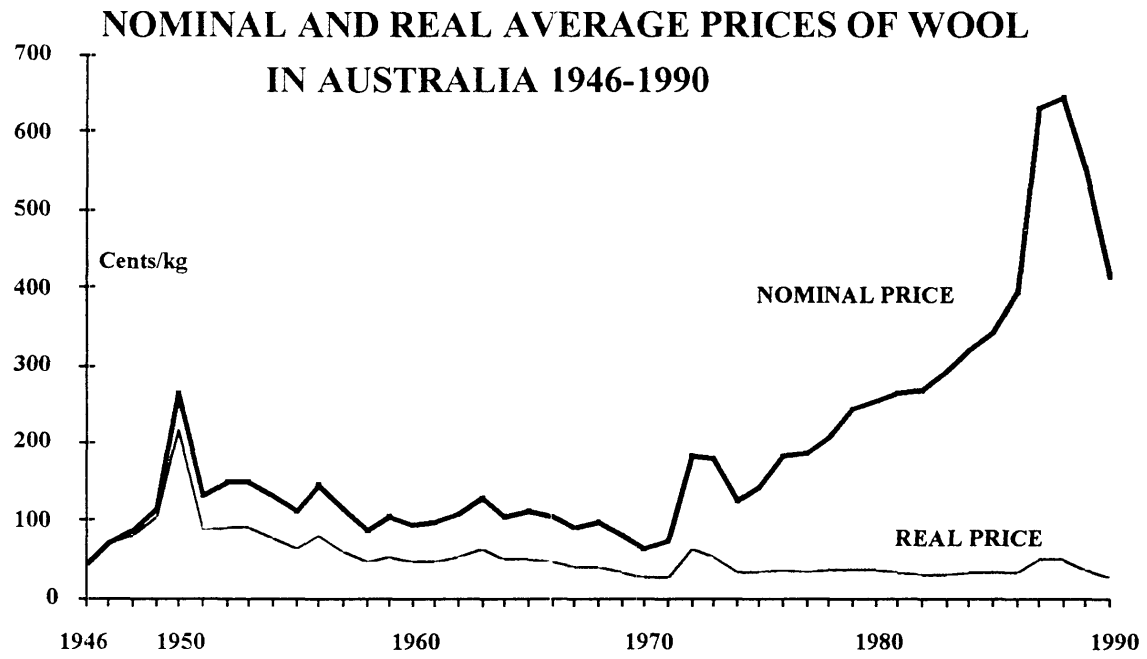
Adjusting only for the rate of inflation in Australia, Figure 1.8 shows the real price level for wool has been steadily declining since the Korean War, except for a short phase in the early 1970s and the late 1980s.[22]

One consequence of Australia's domination of the world traded wool market and its international exchange exposure is that all the cyclical shocks will be largely felt in the Australian market. International competitiveness can also be affected severely by short-run

[22] The wool boom of 1950 is not a good starting point so Figure 1.8 starts in 1946 when the price was close to break-even.

events in Australia such as increase in the value of the currency. This makes the wool from other suppliers relatively cheaper for a while. A similar competitive reaction overseas is created when reserve prices at auctions hold the price at a fixed Australian currency value, while the exchange rate moves upward.

FIGURE 1.8



Source: National Council of Wool Selling Brokers average seasonal price, then deflated by inflation rate (CPI) as given in the Australian Bureau of Agriculture and Resource Economics' *Commodity Statistical Bulletin 1990,* AGPS 1990, p15

The overall effect on international wool values during the 1980s is gauged by the wool trade-weighted index shown in Figure 1.9.[23] This makes for a considerable degree of short and long term volatility in the market. It should also be noted that, although the impact from the international market and trade arrangements on the greasy wool price were substantial, they were not reflected to anything like the same extent in top or yarn prices.[24] Therefore, it can be

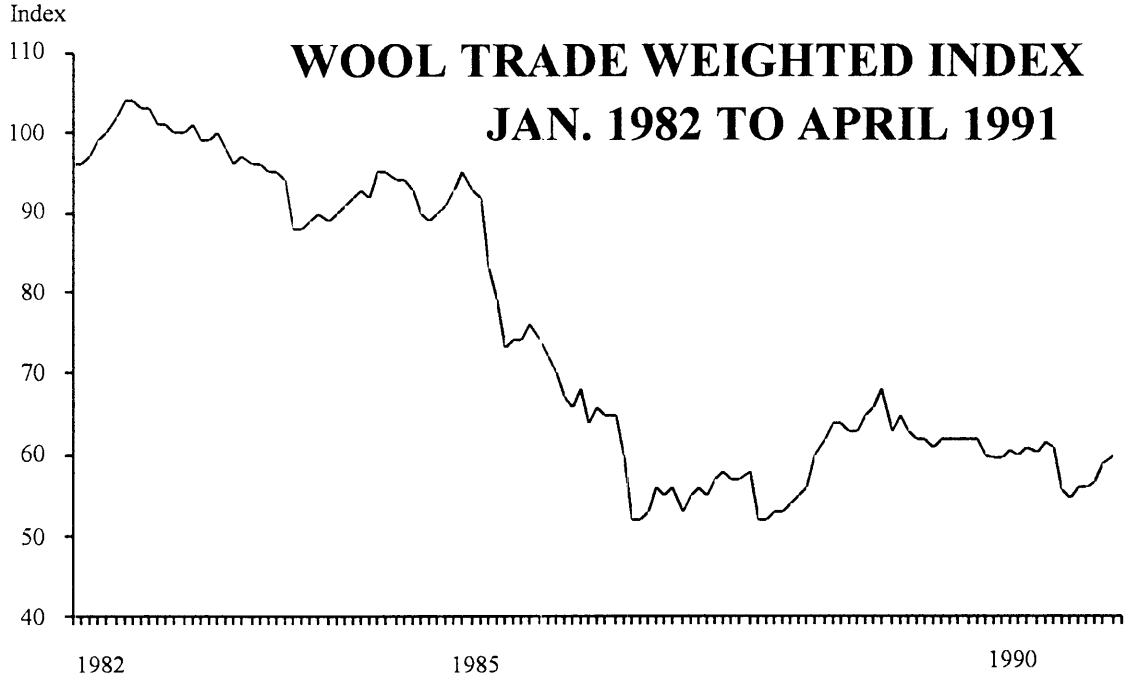
---

[23] This is a nominal trade-weighted measure which is preferable to the normal bilateral exchange rate between the $US and the $AUS. It is adjusted annually to reflect changes in wool-buying country profiles. Taking account of differences in inflation would again improve the measure, although with a floating exchange rate most of the difference is assumed to be adjusted into the changing value.

[24] Economists generally regard both the demand and supply of wool as 'inelastic'. However, modern equipment has improved the capacity of processors to switch fibres and change the fibre mix so demand could be regarded as more elastic than it was. On the supply side, the situation for alternative land uses seem to be the key determinant in setting supply elasticity. When land use has a viable alternative use, resources can move out of wool quickly. On the other hand, when wheat and beef returns are low, sheep numbers will rise quickly and stay high. Fine wools supply remains fairly inelastic because land that can grow fine wool is limited and it is less likely to be in drought. The broad wools can vary enormously; over the course of the century some dramatic changes in sheep numbers in drought areas have taken place. Caution thus

some time before changes in the greasy market are passed on in the finished item. In this way, changes in price in the greasy wool market are a means by which the processor can withstand lower consumer demand and lower returns. This is one of the strengths of the open market for wool selling, as opposed to the reserve price regime, because it provides a buffer for processors to survive downturns.

FIGURE 1.9



Source: Data derived from *Wool Weekly,* Australian Wool Corporation, years 1982-1992

The wool market - 1950 to 1990.

Summarising the details of market changes since 1950, we find that the post-war years were a time of rebuilding in many countries; it took time before the personal incomes of consumers were restored. This 'pent-up' demand eventually allowed an enormous growth in wool consumption, so that by 1950, demand for wool was thirty per cent above its prewar average. Although in the few years after the second world war a number of problems and uncertainties faced the industry, the initial expressions of concern about market prospects proved to be ill-founded. Against a background of rising apparel-wool production and sheep numbers across the world, the post-war stockpile was cleared rapidly, although this was at some cost to price,

---

needs to be exercised in differentiating a shift in the demand curve from an elasticity response. It seems demand shifts from cyclic changes in personal income are a far greater influence on demand than changes in real price. This is also true of elasticity responses.

with immediate postwar period prices falling sharply in the 1948-49 season. Not only were the wartime stocks disposed of quickly, but sales were profitable, and profits were divided evenly between the British government and Australian producers, as agreed to before the war. In the early fifties, demand continued to exceed supply, and the Americans were keen not only for regulated wool trade, but for preemptive wool purchases as well. When this was refused, they decided to assist the rapid expansion of the synthetic industry, for which tax incentives were created. In the meantime, the strategic purchases of wool by the American army during the Korean War combined with the world economic recovery, caused wool prices to increase dramatically to unprecedented levels during 1951. However, these enormous increases in price and the speculative demand which accompanied it, soon plunged the wool textile industry into a recession. World consumption soon fell by 15%, and stocks were again accumulating. Prices fell further during the 1952-53 season, and it was apparent that consumption was no longer exceeding production. After the boom period in 1952, prices remained in general decline apart from their following a well-defined cyclical pattern, with periods of falling prices from 1953 to 1955, and 1957 to 1959. Having enjoyed a strong period of growth, the international textile-trade started to lag behind the growth of other industries, which was reflected in an almost continuous fall in prices to 1960; then, after a more stable period to 1964, the price fell more-or-less continuously until 1970. Defying this market trend, and after a short period of hesitation after the war, sheep numbers and production in Australia began to grow strongly.

It was therefore during the 1960s that the most severe and prolonged downturn in price occurred (although the early 1990s downturn may be similar, it is too soon to know what the repercussions are). With the U.S. market effectively closed, the increase in synthetic fibre production, and the increase in wool production in Australia there was little prospect of a substantial recovery in prices during the 1960s. Moreover, this was compounded by episodes of over-capacity in the man-made fibre industry, which put enormous pressure on all fibre markets, as large volumes of discounted synthetic fibre swamped the processing sector.

Previous price-falls had been short-term and a confidence in the future was maintained. In the 1960s, a hysteria and pessimism about the industry's future was widespread, precipitating a move out of wool producing at every level of the industry. Many within the industry thought an unprecedented disaster was imminent. In this phase, investment into on-farm technology was non-existent, and even the capacity to pay research levies saw them reduced to a nominal level and covered by increased government appropriations. Then, unexpectedly the period 1972/74 saw natural fibres experience a short boom on the back of sudden increases in oil prices which halted the pattern of constantly falling synthetic-fibre prices. With the early 1970s being the beginning of a watershed period for controlled wool marketing, the industry slowly recovered, regaining and maintaining modest to low profitability levels until the late 1980s boom. The only

exception to the general upward pattern was the downturn experienced in 1982-83. Even though it coincided with a widespread drought, the wool stockpile reached a peak of 1.5 million bales by November, 1984. However, the stockpile was subsequently cleared during 1985-6, facilitated by a falling dollar value which made wool very cheap in key processing countries such as Japan.[25] Figure 1.4 on wool production in Australia shows the dramatic productive impact of the 1982-89 upturn, and the effect of a run of good seasons on the aggregate level of production.

The falling trend in real returns since the high levels of the 1950s, when combined with the declining terms-of-trade, produced a situation where the pressures on profitability were constant until the more buoyant years of the late 1980s. Even the 1980s boom, (shown in Figure 1.7 & 1.8) was not as profitable as it might first appear, especially if the high inflation, the differential between fine and broad wool prices, and exchange rate movements, are considered.

On the production side, variations in the aggregate level of Australian wool production were determined by the combination of seasonal changes, the attractiveness of alternative land uses, technical difficulties encountered, and the prices received for wool. At those times when more attractive options exist, woolgrowers could run fewer sheep in response to lower prices, but more often the reaction is to try and protect average incomes by running more sheep. This was the general reaction in the 1955-1970 period, with research at that time actively assisting this course of action. During these years, any decreases in aggregate wool production usually reflected the impact from poor seasonal conditions rather than the shifting of growers out of wool production. In fact, the rapidly expanding production during the late 1950s and most of the 1960s was instrumental in the price collapse of the late sixties. As good seasons rarely coincide with strong international demand, price variability already existed, so increased production was only of value in aggregate terms if the total market expanded or if increased production from Australia caused other producer-countries to go out of production increasing Australia's share of the internationally traded wool market. Given the way outside external events impacted on the circumstances for wool prices, wool research aimed at expanding production also had to be very careful about the price effects after the experience of the late 1960s. In the short term increases in output made up for falling prices.

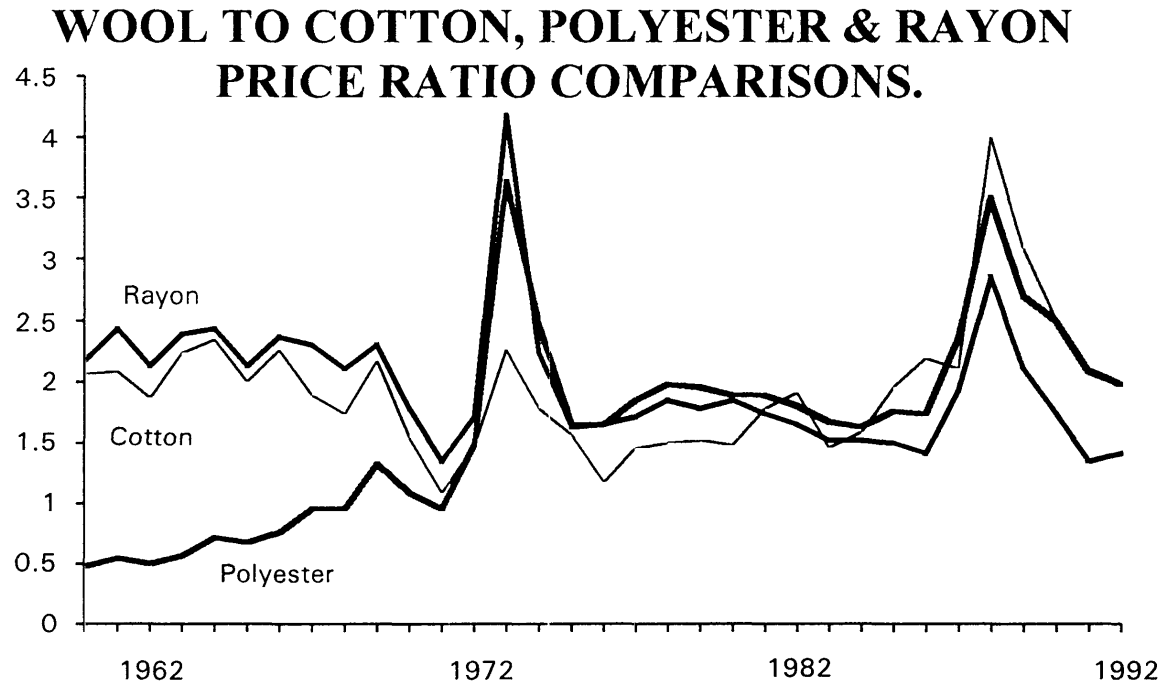
This is an important point to keep in mind, because innovation and technology which generates substantial increases in the levels of production while perhaps providing the competitive edge

---

[25] O'Mara, P., *et.al.*, 'Exchange Rates and the Farm Sector' *Quarterly Review of Rural Economy* Vol. 2, No. 4, November 1980.

for long-term survival, were created at considerable risk to prices and farm. The other part of this equation is that falls in current income constrains the level of farm investment in technology as well as the nature of the technology that was considered appropriate. From this time, efforts made to expand production had to carefully consider whether the market had the capacity to consume more wool without precipitating permanent price falls. On the other hand, the fear created by the price falls of the 1960s proved to be an important driving force for ITC on an industry-wide basis, not on the farm. The downturn produced a restructured selling-system, scientific wool measurement, and transport efficiencies, all of which increased productivity rather than production and helped the wool industry defy the pessimists. Another repercussion of the 1960s was that the advance of the rest of the economy and the mining sector in particular, meant the wool industry's place in the Australian economy declined substantially. In 1901, wool was 32% by value of exports from Australia, in 1951 it was 51.5%, (because of the Korean wool boom). It then steadily declined so that by 1981 it was down to 8.6% and under half that figure in 1991.[26] As a result, although remaining significant, wool has became far less central to Australia's economic well-being. The level of 'political clout' diminished correspondingly, which meant government assistance would be harder to secure from then on.

FIGURE 1.10



Source: Carlos Valerrama of the International Cotton Advisory Committee - Personal Communication.,1992.

---

[26] Maddock, R., and McLean, I.W., *The Australian Economy in the Long Run*, Cambridge University Press, Cambridge, 1989, Table 1.8, p.28.

This was the market milieu for the fostering and adoption of wool innovation, as well as the circumstances within which scientists had to work. In general terms they appeared to have done very well because notwithstanding the extreme markets pressures noted above, the demand for Australian wool was maintained and that relative to other substitute textile fibres it moved into a lucrative market niche. The price premium (or price uncompetitiveness), is shown in Figure 1.10 where the price ratios for similar fibres from the largest markets in the United States are compared. It was against this background and in response to all these circumstances that the wool industry sought to neutralize the technical advantages and market power of the new textile fibres by instituting and periodically increasing industry-levies in order to engage in international promotion and world class R&D.