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Roger Lloyd-Jones and M.J. Lewis

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Alfred Herbert Ltd and the British Machine Tool Industry, 1887-1983

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Modern Economic and Social History Series General Editor's Preface

Economic and social history has been a flourishing subject of scholarly study during recent decades. Not only has the volume of literature increased enormously but the range of interest in time, space and subject matter has broadened considerably so that today there are many sub-branches of the subject which have developed considerable status in their own right.

One of the aims of this series is to encourage the publication of scholarly monographs on any aspect of modern economic and social history. The geographical coverage is world-wide and contributions on the non-British themes will be especially welcome. While emphasis will be placed on works embodying original research, it is also intended that the series should provide the opportunity to publish studies of a more general thematic nature which offer a reappraisal or critical analysis of major issues of debate.

Derek H. Aldcroft
University of Leicester

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CHAPTER ONE

Introduction

The machine tool industry formed a small but vital part of Britain's manufacturing sector, and this study examines its development over the twentieth century. The importance of the industry's contribution to the health and efficiency of the manufacturing economy was reflected in the influential Mitchell Report of 1960. While the report was a public condemnation of the industry's technical record, it nevertheless recognised that the British machine tool industry had developed a reputation 'throughout the world as an excellent producer of standard machine tools of all categories: it supplies almost the whole home demand for such machine tools and exports approximately 30 per cent of its production'.[1] The industry exerted an influence far greater than its actual size, and consequently its analysis requires an engagement, at various points, with broad themes associated with the performance of British industry in the twentieth century. In particular, the industry is located within debates over Britain's long-run manufacturing decline and issues of modernisation, which from the late 1950s envisaged institutional reform, involving co-operation between business, labour and the state as a panacea for the declining competitiveness of manufacturing.[2] The machine tool industry at various stages of its evolution received scathing criticism over its performance, but, as we shall demonstrate, it also produced positive outcomes that marked it as an important sector of the British manufacturing economy.

The broad approach of this book is to examine the industry's development through the lens of its largest firm, Alfred Herbert Ltd. of Coventry, founded in 1887. In the years before the First World War Herbert's grew to be the largest machine tool maker in Europe, and by the 1950s claimed to be the largest machine tool organisation in the world. The role of this company is suggestive of Nelson's metaphor of the 'player and the game', and this is used in a reflective sense to generally inform the relationship between the firm, the industry, and the market-cum-technological environment.[3] Nelson acknowledges that 'what firms do often matters significantly', but in order to fully 'understand the players there is a need

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[1] Sir Steuart Mitchell (hereafter Mitchell Report), *The Machine Tool Industry: A Report by the Sub-Committee of the Machine Tool Advisory Council* (London, H.M.S.O, 1960), p. 32.

[2] For a broad general survey of these issues see M. Dintenfass, 'Converging Accounts, Misleading Metaphors and Persistent Doubts: Reflections on the Historiography of Britain's Decline', in J-P. Dormois and M. Dintenfass (eds), *The British Industrial Decline* (London, Routledge, 1999).

[3] R. Nelson, 'The Role of Firms in Technical Advance: A Perspective from Evolutionary Theory', in G. Dosi, R. Gionettie, and P. A. Toninelli (eds), *Technology and Enterprise in Historical Perspective* (Oxford, Oxford University Press, 1992), pp. 165-8.

to specify the game that is being played'.[4] Business does not work in a 'vacuum',[5] and to explore its evolution requires an understanding of how the firm evolves within the changing market, technical and institutional environment, which is the province of both the business and economic historian.[6] For example, one of the most astute observations of the British machine tool industry was made by Sir Alfred Herbert, the founder of the company, who claimed that 'nearly all machine tool makers were strong individualists, who preferred the private company with its many advantages of direct control and immediate response to stimuli'.[7] This observation reflects the long-run pattern of ownership and control in the industry, which fits Chandler's perception of the retention of personal capitalism in British industry.[8] By the 1950s, there was a general belief that large firms would provide the opportunity for greater productive efficiency, increase the level of standardisation, and would enable a rising curve of technological development to enhance the competitive performance of British manufacturing companies. Such assumptions underpinned the Anglo-American Productivity Teams of the early 1950s, a report of 1953 on the machine tool industry concluding that what was required was wholesale rationalisation leading to a significant reduction in 'the number of independent companies in the industry'. Large-scale business was seen as a counter to a business culture that protected its 'individuality and independence'.[9]

Yet a sub-committee of the Machine Tool Trade Association (MTTA), the main body representing the industry, while adhering to some of the recommendations of the report, nevertheless condemned a process of rationalisation. Echoing the views of Sir Alfred Herbert, expressed in the 1930s, the sub-committee accepted that individualism was deeply embedded in the industry, but that recommendations for a significant reduction in the number of firms suggested 'a certain degree of tolerance for the idea of the establishment of a monopoly'.[10] Rationalisation was a sensitive matter for an industry composed of large numbers of small firms, but even large companies such as Alfred Herbert remained committed to personal and independent control. While providing a balanced assessment of the industry in 1960, the Mitchell Report nevertheless highlighted a business culture which celebrated independence and resulted in a highly fragmented business structure.[11] In the same year the MTTA acknowledged that the large number of small firms in the industry were 'handicapped

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[4] Ibid., p. 165.

[5] D. J. Jeremy, *A Business History of Britain 1900-1990s* (Oxford, Oxford University Press, 1998), p. 1.

[6] For an explanation of the study of the business firm in the context of the market-cum-technological environment, see J. F. Wilson, *British Business History 1720-1914* (Manchester, Manchester University Press, 1995), pp. 83-4, 87-8.

[7] Machine Tool Trade Association (MTTA), Annual Report, 1935.

[8] A. D. Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass., Belknap Press, 1990), pp. 235-94.

[9] *Productivity Team Report on Metalworking Machine-Tools by Anglo-American Council on Productivity* (London, H.M.S.O., 1953), p. 46.

[10] *Engineer*, 26 June 1963, pp. 93-4.

[11] Mitchell Report, p. 21.

when it came to reducing costs of production, rationalising design, and marketing their goods in the most efficient manner'.[12] The process of rationalisation and concentration did not accelerate until the 1960s, and from 1945 to the late 1950s the number of firms in the industry remained more or less constant. A small number of firms employed in excess of 300 employees, while the vast majority employed less than 300. Large numbers of small, often family controlled firms, characterised the industry, and even in 1959 there were 200 firms in the industry with an average turnover of only £40,000 per annum.[13] As late as 1983 Kenneth Baker, the Minister of Information Technology, commented that a fundamental characteristic of the machine tool industry 'is that there are large numbers of family firms which tended to be dominated by strong characters', to which he added the proviso that there was 'nothing wrong with that as long as they move with the times'.[14]

Apart from the small-scale structure of the industry, the machine tool sector also displayed three other structural features, which are emphasised throughout this exploration of its business history. First, machine tool firms were not only makers of machines, but also acted as factorers for the products of other firms, both at home and abroad. This is strongly emphasised in our focus on Herbert's, which from its origins in the late 1880s developed an extensive network of sales agency relations. Second, machine tool firms transacted with each other for machine tools, and also engaged in extensive sub-contracting arrangements. Sub-contracting was particularly important in periods of high demand pressure, as we shall see in the case of Herbert's and other machine tool firms during the First World War, the recovery phase from the depression after 1934, and during the Second World War. Finally, machine tool firms evolved a relationship with customers that strongly emphasised the importance of meeting customer need, and leading manufacturers such as Herbert's placed an emphasis upon design based upon the requirements of British engineering.

The structural features of the industry set a context for exploring its performance, which itself opens up issues about British industrial decline. As Tomlinson has pointed out 'the idea that the British economy has in some sense declined in the past century informs most recent historical writing, especially economic'.[15] In particular, this applies to manufacturing,[16] and the centrality of

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[12] MTTA, Council Minute Books, 1946-70, 6 October 1960, 'Report on British Machine Tool Exports'.

[13] E. W. Evans, 'Some Problems of Growth in the Machine Tool Industry', *Yorkshire Bulletin of Economic and Social Research*, Vol. 18 (1966), pp. 46-7; H. A. Breeley and G. W. Troup, 'The Machine Tool Industry', in D. Burn (ed.), *The Structure of British Industry: A Symposium*, Vol. 1 (Cambridge, Cambridge University Press, 1958), p. 363; MTTA, Machine Tool Directory, 1966, produced by Miln and Robinson for private circulation, pp. 12-13.

[14] *Third Report of the Industry and Trade Committee: Machine Tools and Robotics*, Session 1982-3, p. 14.

[15] J. Tomlinson, 'Inventing "Decline": The Falling Behind of the British Economy in the Postwar Years', *Economic History Review*, Vol. 49, No. 4 (1996), p. 731.

[16] A classic example of this is contained in S. Pollard, *The Wasting of the British Economy* (London, Croom Helm, 1982).

machine tools to this sector positions the industry in this debate. Yet as Tomlinson argues, 'concern' with decline in the past is 'episodic rather than continuous', and the notion of a century of decline 'is the product of retrospective judgements'. Decline was specific to particular eras from the late nineteenth century, and was not a 'homogeneous problem'.[17] Our study confirms Tomlinson's proposition; the machine tool industry, despite the fact that it was emasculated by the 1980s, did not experience a slow linear decline. Prior to the 1970s, after which the industry and its largest producer Herbert's faced mounting problems, periods of business difficulties were followed by periods of renewal and optimism. For example we will show in Chapter Two that the industry did respond to the growing American challenge of the 1890s, and made positive advancements in the Edwardian years. Again, machine tool firms made positive contributions to munitions supply during the two world wars, explored in Chapters Three and Six. Without an adequate supply of machine tools, there could not have been an increasing production of shells and other munitions and armaments that characterised the two conflicts. Indeed, by the 1950s Britain could boast that in Alfred Herbert it had a national asset, the largest machine tool organisation in the world making a vital contribution to the nation's export drive. Our study of the industry highlights other examples of business success, and consequently notions of gradual long-term decline are not tenable. The industry defies a simple narrative framework and provides a reminder to the historian of the dangers of pursuing a teleological search for final causes.

Assessing the performance of the industry, and key firms such as Herbert's, is also complicated by the fact that the industry faced a number of constraints which were outside its control. A recurring problem concerned the shortage of skilled labour, especially during the upturn of economic activity. During periods of economic downturn, the obverse occurred, with firms facing difficulties in retaining their teams of skilled workers. The problem of labour supply was most acute during the First World War, the brief post-war boom, rearmament in the late 1930s and in the Second World War, and during the long boom of the 1950s and 1960s when it became a matter of deep concern to the industry's leaders. Even in the 1980s, when the industry was facing rapid decline, there were complaints that 'One of the factors holding back the U.K. machine tool industry is the shortage of trained personnel'.[18] Labour shortages reflected a long-term constraint facing the industry, relating to the cyclical pattern of demand. The historical evidence suggests that during recessions the level of orders for machine tools could be less than half that achieved during periods of rising economic activity, and the switch from downswing to upswing representing the volatility of the cycle was 'quicker' than in other industries.[19] This meant that firms were vulnerable to short-term movements in demand with its consequent volatility for turnover, profits and investment. The impact of the cycle on investment decisions

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[17] Tomlinson, 'Inventing', p. 732.

[18] *Industry and Trade Committee: Machine Tools*, 1982-3, p. xix.

[19] Ibid., p. 29.

was a long-term characteristic of the industry, and machine tool firms were frequently criticised for their failure to invest sufficiently during downturns in demand to create sufficient productive capacity to take advantage of rising orders during the subsequent upswing. Consequently, during periods of prosperity, potential customers faced lengthening delivery times and rising prices and firms such as Herbert's used their factoring and sub-contracting operations in an attempt to meet user need. Over the long-term, the cyclical pattern of ordering facing the industry had a ratchet effect. In each successive upswing British machine tool makers struggled to meet demand, and this led progressively to growing import penetration. The issue of import penetration was raised by users and makers of machine tools in the 1890s, and again became a matter of concern in the inter war years. By the 1950s and 1960s the degree of imports had become a major issue in the assessment of the industry's competitive performance, and a focal point for discussion at the industry level. Chapters Seven and Eight show that imports were central to the national debate over modernisation and the involvement of government in the industry's affairs.

The cyclical pattern of demand provided a convenient defence for the industry against its critics. A repeated complaint of British machine tool makers was that users tended to bunch their demand for machines during upturns in the cycle, a common feature of the industry's relations with an important customer, the motor vehicle industry. For example, between 1955 and 1957 British car firms were committed to heavy investment programmes in new plant, and their large and concentrated demand for machine tools meant that domestic suppliers were unable to meet orders, with the obvious consequence that delivery dates lengthened and foreign imports rose. In addition, British machine makers claimed that their customers in the engineering industries failed to modernise plant, illustrated in Chapter Four by problems in creating markets for British built special-purpose and automatic machine tools, in increasing demand by continuous production industries such as automobiles. This criticism reflected an important distinction characterising the products of the machine tool industry. General-purpose machine tools were regarded as the 'backbone' of the British engineering industry, as they could be adapted to a wide variety of uses. Conversely, special-purpose machines were designed 'either to perform one type of operation or to produce one type of component'.[20] The criticism of the customer by machine tool makers did not go unanswered. For example, C. R. F. Engelbach of Austin Motors complained in 1927 that machine tool firms were 'backward' in supplying modern equipment to British engineering.[21] In addition, the evidence from the inter-war years suggests that the trend towards the production of standard general-purpose machines by British makers was reinforced, opening a gap in the market for the inflow of American and also German special-purpose machines. Debates on the technical competency of the industry again resurfaced in the 1950s and 1960s, when it came under increasing scrutiny concerning its relative competitive position. Complaints abounded that the British industry was slow to develop modern machine

[20] *Machine Tool Review* (published by Alfred Herbert Ltd.), Vol. 47, 1959, p. 3.
[21] *American Machinist*, 8 October 1927, p. 104E.

technology, only to be countered by makers who responded that the machine tool industry was constrained by the limited investment of the engineering industry in modern equipment. Indeed, the maker's allegations were supported by a National Economic Development Council (NEDC) report on investment in machine tools in 1965, which observed that 'Methods of investment appraisal in use by most of the companies in the engineering industry are either non-existent or inaccurate or misleading'. The report also expressed 'surprise' at the lack of knowledge of users concerning tax incentives for purchasing modern machine tools.[22]

By the 1960s a particular concern involved the slow diffusion in Britain of numerically controlled machine tools, which limited the opportunities of domestic makers in this field. The NEDC report concluded that 'many firms in the engineering industry are failing to recognise worthwhile investments and are thus not availing themselves of the benefits which greater use of modern machine tools would bring'.[23] At times, the voice of the machine tool industry itself could take on a strident tone. As E. N. Addison, the chairman of Addison Tools Ltd., complained in 1983, 'it is not the machine tool industry that is inefficient, but the engineering industry. We cannot sell to them because they do not know how to produce. There is no demand because the engineering industry ... is run by accountants'.[24] Addison's statement symbolised the strong engineering traditions of the businessmen who managed the industry, as well as representing a long standing condemnation of the inadequacies of British engineering practices. With the industry facing crisis in the early 1980s, J. L. D. Gailey, the president of the MTTA had no doubt 'that a national engineering industry tends to get a machine tool industry as good as it deserves'.[25]

There is some justification in Gailey's complaint, but the blame for the industry's shortcomings should not simply be laid to rest with the users of machine tools. There is little evidence to suggest that the British machine tool industry was a technological leader, pushing user industries towards the technological frontier. Rather, it was essentially adaptive, responding to the needs of users via a path of incremental improvements to machine design. In the case of Herbert's, the company gradually evolved its technology through a process of experimentation, which by the inter-war years was already leading to issues at the boardroom level concerning their capability to build machines of original design. Incremental design improvements symbolised the company's technical policy in the 1920s, which adapted to customer needs, and this trend continued into the 1960s. By the late 1950s, Herbert's joint managing director, J. C. Blair, praised the accumulation of technical knowledge held in a 'Board of engineers', and the company's ability to respond to the changing demands of its customers.[26] The leading firm in the

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[22] National Economic Development Council, *Investment in Machine Tools. A Survey by the Management Consultants' Association* (London, H.M.S.O, 1965), pp. 2, 15.

[23] Ibid., p. 21.

[24] *Industry and Trade Committee: Machine Tools*, 1982-3, p. 38.

[25] Ibid., p. 44.

[26] Coventry Archive, 926/1/1/1, Minute Book of the Board of Directors of Alfred Herbert Ltd., 1944-60, 5 June 1957.

industry thus followed a pattern of 'design creativity and variety', which characterised British engineering practice in general, and forewent 'American style production engineering'.[27]

An adaptive response to design by British machine tool firms is also shown by their concentration of output on general-purpose machines, which could be adapted to a wide variety of uses. A consequence of this historical pattern of production was a reliance on imports of special-purpose machines by British users.[28] Indeed, the industry reinforced market specialisation, with merchant firms such as Charles Churchill & Co. and Burton, Griffiths & Co. acting as agents for imported machine tools, and machine makers themselves, notably Herbert's developing an organisational structure that reflected its role both as a manufacturing and factoring company. Herbert's developed market networks for the import of foreign, especially American machine tools, and this was a common feature of the industry. In turn, this reflected a strong commitment to the principles of free trade, and while American machine makers were not slow to call for protection at various times, the response in Britain was muted. Throughout the 1920s the industry remained committed to free trade, and only conceded on this point during the world depression of the early 1930s. The move to protection in 1932, however, did not settle the question, and as shown in Chapter Five the 'deficiency' of machine tools in the rearmament drive from the mid-1930s opened up the issue of importing vital equipment via the Import Duties Advisory Committee. The industry remained committed to free imports, and in 1964, when the Labour Government imposed a surcharge on imports the MTTA was bitterly opposed. This view persisted, the MTTA commenting in 1983 that the industry had a long-term commitment to defend 'free trade measures', ensuring that British manufacturing industry had 'access to the best available machine tools world wide'.[29] Such beliefs legitimated the international specialisation pursued by British machine makers, and tended to reinforce the position of the industry as primarily a provider of general-purpose machine tools designed to satisfy customer needs.

The 'game' facing British machine tool makers in the course of the twentieth century was conditioned by the relationships with user industries, the cyclical pattern of demand, a deep commitment to international specialisation via free trade, and a constantly changing technological environment. The 'players', notably Britain's leading maker Alfred Herbert, did believe that they made a positive contribution to the 'game', providing for customer needs and justifying international specialisation by asserting that it provided a major contribution to national industrial efficiency. Such a broad generalisation is open to question in the examination of the long-term development of the industry, but certainly it did respond with vitality during both world wars. During both conflicts there was a heavy reliance upon imported American machine tools, facilitated by the factoring

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[27] J. K. Brown, 'Design Plans, Working Drawings, National Styles. Engineering Practices in Great Britain and the United States, 1775-1945', *Technology and Culture*, Vol. 41, No. 2 (2000), pp. 224-6.

[28] *Machine Tool Review*, Vol. 47, 1959, p. 25.

[29] *Industry and Trade Committee: Machine Tools*, 1982-3, p. 29.

services of British firms such as Herbert's, but at the same time domestic makers did substantially increase output, which made a vital contribution to the war effort. For example, by 1944 American machine tool imports represented only 14.4 per cent of U.K. production, compared to 53.3 per cent in 1940, leading Sir Alfred Herbert to proclaim that 'there is no longer a possibility of the progress of the war being hampered by a lack of machine tools'.[30] In addition, firms did develop closer, if at times somewhat fraught relations, with the state. For example, during the Great War Sir Alfred Herbert promoted closer links between the industry and the Ministry of Munitions through his role as director of machine tool supply. Although this raised the national profile of the industry, there is little evidence that the war stimulated major technological advances amongst machine tool makers. As Joseph Pickin, a Herbert director, stated at the end of the war, amongst the company's machines 'there are none of any striking originality'.[31] Makers adapted to the intense demands of war, but radical technical change was limited. A similar pattern can be detected during the Second World War. Between September 1936 and the summer of 1944 the British machine tool industry 'built as many machines as were manufactured in the preceding 40 years',[32] but its capability to manufacture special-purpose machines was variable. By the end of the war there was a surplus of general-purpose machines but a continued serious deficiency in specials. As Chapters Three and Six show, the wars raised a whole series of other issues relating to the deployment of female workers, the initial reluctance of firms to invest in sufficient capacity, the problems of retaining a skilled labour force, and the sometimes volatile nature of industrial relations.

During the three peace-time phases, 1890s to 1914, the inter-war years, and post-1945, the machine tool industry made a positive contribution to exports, provided a wide range of services to engineering, and placed a high priority on meeting customer needs. Where firms were less successful was in developing organisational capabilities in response to the growing competitive pressures induced by the changing market and technological environment. The industry's long-term commitment to personal capitalism lends support to Chandler's allegations concerning the reluctance of British industrialists to build managerial hierarchies.[33] Business firms, according to Nelson, 'have a considerable range of freedom regarding whether, or just how, they can take advantage of the opportunities the environment affords'.[34] In turn, this raises questions about the capabilities of firms to adequately respond to their external environment. By the 1960s the leading British firm of Herbert's was characterised by a set of

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[30] M. M. Postan, *British War Production* (London, H.M.S.O and Longman and Green, 1952), p. 207; Coventry Archive, 586/11, Alfred Herbert, General Minute Book, 1894-1950, 16 July 1944.

[31] Coventry Archive, 926/1/4/1-3, Alfred Herbert Ltd., Minute Books of the Departmental Board of Directors, 1911-41, 9 September 1918.

[32] *Machinist*, 19 August 1944, p. 115E.

[33] See Chandler, *Scale and Scope*, pp. 235-6.

[34] R. Nelson, *The Sources of Economic Growth* (Cambridge, Mass., Harvard University Press, 2000), p. 104.

managerial and organisational deficiencies, which created problems for the company in meeting the challenges of changing markets, increasing foreign competition, and new technological developments. From the late 1950s, the 'game' changed rapidly, and the following two decades saw a sharp contraction in the industry as firms were absorbed into larger engineering groups or simply disappeared altogether.

The business history of Herbert's from the 1960s is one of frustrated ambitions. Its policy of acquisition, notably the take-over of the machine tool interests of Birmingham Small Arms (BSA) in 1965, and its development of numerical control through an association with the American company Ingersoll in 1967, proved quickly to be failures. The Herbert management were unable to re-organise the BSA companies, and they became a financial millstone around their necks, and the anticipated commercial success of the new Herbert-Ingersoll machines proved to be a major miscalculation. The British machine tool industry's flagship company, a symbol of the industry's ingenuity during the twentieth century, fell into a dramatic and sudden decline. In the mid-1960s the company's market capitalisation was £43.4 million, but by 1975 it had been acquired by the National Enterprise Board for £1 million, in fact a generous settlement given that the market value of its shares now totalled just £800,000. The demise of Herbert's fits the observations of Zollo and Winter that business success is determined by the ability of top management to understand 'the causal links between the actions' they take and 'the performance outcomes' they obtain.[35] Management expectations of a new era of progress for the company in the 1960s did not match performance outcomes. On the technical front, the capabilities of the Herbert management had been built upon the accumulation of tacit knowledge, which had enabled the company to follow a path of incremental product development with more or less stable business routines. However, by the 1960s and 1970s the company faced a rapidly changing technological and competitive environment, and were unable to adapt their organisational capabilities to meet the challenge. As Zollo and Winter observe, when 'technological ... and competitive conditions are subject to rapid change, persistence in the same operational routines become hazardous'.[36] Despite the search for strategies to survive, Herbert's lacked the managerial competencies to extract itself from its downward spiral.

Its fall symbolised the general decline of the British machine tool industry. During the 1970s there was a general reduction in both the number and the size of British machine tool firms, and Britain's share of world machine tool output fell from 8 per cent in 1971 to 5 per cent in 1977, and to just 3 per cent in 1981. Correspondingly, employment contracted from 53,000 workers in 1976 to 36,000 in 1982, a drop of 32 per cent. The reduction of the industry's capacity was accompanied by rising import penetration. Domestic makers were unable to meet demand and this led to a doubling of the proportion of imports in domestic

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[35] M. Zollo and S. G. Winter, 'Deliberate Learning and the Evolution of Dynamic Capabilities', *Organisation Science*, Vol. 13, No. 3 (2002), p. 340.

[36] Ibid., p. 341.

consumption over the 1970s.[37] By the early 1980s the industry was described as 'technologically rather backward', and 'too slow' in the development of advanced numerically controlled machine technology.[38] While a slow-down of world economic activity in the 1970s undoubtedly had a negative impact on Britain's machine tool makers, the British industry nevertheless performed relatively poorly compared to their major competitors. For example, a cross-national survey praised the Swiss machine tool industry for 'a timely introduction of new technologies', enabling them 'to remain in a leading position in the world market, whereas Britain's machine tool industry had 'with a few exceptions ... almost disappeared'.[39]

The gloom shrouding the British machine tool industry was evident in the findings of the Trade and Industry Committee of the House of Commons in 1983, which concluded that it was 'clear that the decline of the U.K. machine tool industry is only partly attributable to the current world recession'. Failures of management, innovation and marketing have resulted in a lack of competitiveness before the end of the last decade'.[40] By the end of the 1990s, the U.K. was highly dependent upon imports, the proportion of machine tool imports to total consumption standing at 82 per cent in 1997.[41] Nevertheless, the process by which the industry had reached this state of affairs was by no means straightforward, or a simple case of linear decline. In the course of the twentieth century the British machine tool industry had achieved some notable successes, faced formidable challenges and, despite its small size, played a strategically important role in the nation's manufacturing economy.

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[37] H. Arnold, 'The Recent History of the Machine Tool Industry and the Effects of Technological Change', University of Munich, Institute for Innovation Research and Technology Management (2001), p. 3; *Industry and Trade Committee: Machine Tools*, 1982-3, pp. x, 32.

[38] A. Daley and D. J. Jones, 'The Machine Tool Industry in Britain, Germany and the United States, *National Institute Economic Review*, No. 92 (1980).

[39] C. Ackerman and J. Harrop, 'The Management of Technological Innovation in the Machine Tool Industry: A Cross-National Regional Survey of Britain and Switzerland', *R&D Management*, Vol. 15, No. 3 (1985), pp. 207-18.

[40] *Industry and Trade Committee: Machine Tools*, 1982-3, p. xix.

[41] W. Ip and K. Vowels, 'The Machine Tool Market in the U.K.' (June 1999), www.dfait-maecl.ca/english/geo/europe@4208-e.htm

CHAPTER TWO

Technological and Business Development: British Machine Tools and the American Challenge, 1890-1914

'America beats the world.'

Introduction

This view of American technological superiority in machine tools, made by an informed immigrant engineer, Von Mayenberg, symbolised Britain's alleged backwardness in a key engineering industry.[1] On this side of the Atlantic, machine tool entrepreneurs, with knowledge of American practices, were equally critical of Britain's competitive performance. Charles Churchill, an American who had marketed and sold machine tools in London since 1865, alleged that the USA manufactured the finest lathes, planers, milling machines, and those tools used in the manufacture of other machines. In contrast, British makers were 'conservative and careful', and displayed 'very little disposition or inclination to copy American machine design'.[2] From the mid-1890s the British market was flooded with American machine imports, a response to the domestic boom in Britain, which was driven by investment in residential building, public utilities especially electricity and tramways, and the growth of new industries such as bicycles.[3] In this expansionary environment, what form did the American challenge take, were they better equipped to exploit the British market for machine tools, were domestic makers 'conservative' in their attitude to technological change, and how did British producers respond to the erosion of their competitive position?

British Industry and American Machine Tools

European manufacturing industry expanded rapidly in the mid-1890s, and machine tools were 'being bought in great quantities'. Unable to meet the demand, the European market provided American machine makers with a great opportunity,

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[1] *American Machinist*, 4 March 1897, p. 182.

[2] *American Machinist*, 12 October 1896, p. 987.

[3] See E. Sigsworth and J. Blackman, 'The Home Boom of the 1890s', *Yorkshire Bulletin of Economic and Social Research*, Vol. 16/17 (1965/1966), pp. 75, 82.

which was reinforced by the preference of European manufacturers for American designs. American machine tool exports rose sharply, especially from 1895, and kept American machine tool shops 'busy'. The British Tariff Commission,[4] an unofficial committee of manufacturers formed in 1904, considered that American machine tool imports had achieved a considerable hold on the British market. In 1908 Britain imported from the U.S.A. 798 tons of machine tools valued at £99,014, compared to just 189 tons valued at £16,494 from all other countries.[5] German competition also intensified, and together with rising American exports into European and third world markets, the upswing in economic activity after 1895 represented a major opportunity for the diffusion of new machine tools. This, it has been argued, was given an added impetus by the boom in bicycle sales in Britain and Europe.[6] The mid-1890s therefore marked a sudden change in the foreign trading pattern for American makers, and before this date the impact of American machine tools on 'British engineering practice ... was minimal'.[7] Charles Churchill, who imported large numbers of American machine tools through his London business, could claim that prior to the 1890s the trade had mainly consisted of single orders, or at best a few machines for an individual machine shop, but by the mid-1890s invoices 'often took the form of complete equipments for the production of a certain machine or article'. In 1896, for example, the Cleveland Machine Screw Co. sold 50 machine tools to an English manufacturer for installation in a single plant, and their sales in the English market were expected to be around 200 during the year.[8] The rapid expansion of American machine tools in North-West European markets in the 1890s is graphically represented by the sales of two leading American producers, shown in Table 2.1.

American imports opened up questions about the technical competence of British machine tool makers. *The American Machinist* commented that 'it is at least possible that the relative merits of English and American machine tools have an important bearing on the fact that our tools go to England, but that English tools do not come here'.[9] American superiority was carefully considered by Charles Churchill, who believed that British makers were 'conservative', preferring to embody their own ideas into machine tool design. Further, British production methods were unable to build machines which could compete in price with that of American makers. Britain's competitive disadvantage, claimed Churchill, was related to the insufficient scale of production in British machine tool shops, which meant that they could not match the lower costs of American makers. Indeed,

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[4] See A. Marrison, *British Business and Protectionism 1903-1932* (Oxford, Clarendon Press, 1996), Ch. 2.

[5] *American Machinist*, 4 March 1897, p. 182.

[6] J. Zeitlin, 'The Labour Strategies of British Engineering Employers, 1890-1922', in H. Gospel and C. R. Littler (eds), *Managerial Strategies and Industrial Relations* (London, Heinemann, 1983), p. 29; R. Floud, *The British Machine Tool Industry, 1850-1914* (Cambridge, Cambridge University Press, 1976), p. 73.

[7] Zeitlin, 'Labour Strategies, p. 29.

[8] *American Machinist*, 12 October 1896, p. 286; 12 July 1909, p. 987.

[9] *American Machinist*, 3 March 1898, p. 171.

Churchill was surprised at the inadequacies of the British in certain machine lines. For over 30 years, he claimed, his company had been distributing a variety of American drill and lathe chucks into the British market, selling between 500 to 800 per month, but he professed to know that there was not 'a single chuck maker in England'.[10] Churchill, as an American, may well have drawn too sharp a contrast between American and British practices, but he was not alone in his criticisms of the British industry.

Table 2.1
Foreign Shipments to North-West Europe of Machine Tools by Two American Machine Tool Firms, 1880-99

Brown & Sharpe		Bullard	
1880-4	84	1881-4	7
1885-9	633	1885-9	13
1890-4	431	1890-4	7
1895-9	2,560	1895-9	446

Source: Floud, *British Machine Tool Industry*, p. 82.

Joseph Horner, a practising engineer, was alarmed about the extent to which 'American machine tool builders had invaded the British market', especially to meet the rapidly growing demands of the booming bicycle industry.[11] Growing business confidence in the mid-1890s triggered a substantial rise in the number of bicycle factories from 497 in 1895 to 991 by 1897, and there was a corresponding doubling of the workforce from 20,923 to 42,775.[12] The bicycle boom opened up the market for American machine tool imports, but Horner was not impressed with the opinion that British makers were 'too busy to supply the requirements of the bicycle factories'. Passing this off as a 'mere excuse', he dismissed the allegation that British engineers and mechanics lacked the necessary skills and capabilities to compete with the Americans. Horner offered four reasons why the British machine tool industry seemed less adept at seizing the opportunity opened up by the bicycle boom.[13]

Firstly, Horner pointed out that in a world of growing international competition, in which Britain formed 'but one section of the world's workshops', it was not possible to maintain competitive advantage simply by relying on an endowment of mechanical genius'. A key capability of the machine tool maker was the importance attached to studying the 'precise work of users', and 'to cater for those wants as carefully as possible, unhindered by preconceived ideas and conservative prejudices'. Such an approach required concentrating on genuine

[10] *American Machinist*, 12 October 1896, p. 987.
[11] *American Machinist*, 30 December 1897, p. 969.
[12] R. Lloyd-Jones and M. J. Lewis, *Raleigh and the British Bicycle Industry, 1880-1960: An Economic and Business History* (Aldershot, Ashgate, 2000), p. 10.
[13] *American Machinist*, 30 December 1897, p. 969.

designs and a sharp attention to detail, and this included machine tool accessories, feeds and machine movements. The overall attention given to user needs would save time and contribute to raising the efficiency of machine tool manufacture. A second factor was the need to search for continuous improvement, and Horner urged British makers to recognise, as their American counterparts had apparently done, that there was 'no machine which is so good, but that it may be improved upon'.[14] Improvement innovations, a key feature of the process of technological change,[15] involved changes not only to the actual technical performance of the machine tool itself, but also to drawings, patterns, stamps and special tools which contributed to the overall efficiency of the final product. Thirdly, and echoing a comment of Charles Churchill, Horner stressed the importance of the relationship between the mechanical evolution of the machine and the scale of production. As mechanical complexity evolved, so an increase in the scale of production was needed to facilitate the implementation 'of a perfect shop system'. In turn, this would enable machine tool makers to develop the inter-changeability of parts, which would lower labour costs per unit of output. Fourthly, the available evidence showed that American machine shops were becoming increasingly specialised at a rate far greater than that of the British equivalent. American makers tended to focus their energies on a few types of machine tools, and Horner gave the examples of Warner & Swasey, brass-finishing tools, Gisholt & Co., heavy turret lathes, and Pratt & Whitney, lathes and screwing machines. In contrast, Horner cited the example of Tangye of Birmingham who, in addition to making machine tools, also manufactured 'cranes, engines, pumps, boilers and many other articles'. According to Horner, specialisation facilitated both innovatory improvement and more effective marketing. American firms accepted that there was no 'finality of design', and by dedicated marketing of machine brands innovative American firms, such as Cincinnati Grinders, 'became as well known by name and number as the Whitworth thread and the Morse tapers'.[16] In contrast, many of Britain's older machine tool firms by the late nineteenth century had evolved from general engineering concerns and continued to combine machine tool production with the manufacture of other tools, equipment and engineering products. In the British case, 'there is very little evidence of increasing specialisation on machine tool production alone'.[17]

The consequence of British deficiencies was an American assault on the domestic market. Horner, for example, claimed that not only had American makers ousted British screwing machines from the bicycle shops, but they were also able to supply a range of automatic machine tools which could be operated without skilled labour. Comparatively, British machine tool designs, to secure the best results, still depended upon the deployment of skilled operatives. As Horner

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[14] *American Machinist*, 30 December 1896, p. 969.

[15] N. Rosenberg, *Perspectives on Technology* (Cambridge, Cambridge University Press, 1976), p. 73.

[16] *American Machinist*, 30 December 1896, p. 969.

[17] Floud, *British Machine Tool Industry*, p. 42. See also S. B. Saul, 'The Machine Tool Industry in Britain to 1914', *Business History*, Vol. 10 (1968).

observed, Britain's hopes of recovering market share depended upon long-term investment in designing 'superior machines', and this meant they had 'a long leeway to make up' as it 'is vastly easier to lose a market than to recover it'. The Stanley Show of 1897, the main trade fair of the bicycle industry, demonstrated the competitive pressure on the British maker, the light lathes on display being mainly of American design. Horner observed that the American machines incorporated the latest designs, while the small numbers of British models displayed were 'much as they were 30 years ago'. More innovative British firms were not represented, and Horner noted that the best British lathes were made by firms who built their machines to 'a greater or lesser degree to American design', and followed 'American methods'. Welcoming the fact that replication of American practices had 'grown up in recent years', Horner also accepted that it illustrated 'the adage that imitation is the sincerest form of flattery'.[18] Assimilation of American technology, as we shall see later, was an important factor in the evolution of Britain's largest machine tool maker, Alfred Herbert.

Nevertheless, contemporary opinion in the 1890s projected an unflattering image of the British machine tool industry. Compared to their American competitors, the British were allegedly conservative in design, generalist rather than specialist, over-reliant on skilled labour inputs, slow to reap the benefits of economies of scale, and lacking in innovatory drive and marketing skills. Further, progressive firms in the industry were mere imitators of American designs and practices. Indeed, the American invasion set in motion 'some decidingly plain talk ... by English engineers'.[19] One such engineer, Herbert Austin, who in 1898 was the works manager of the Wolsely Sheep Shearing Co. of Birmingham, which he had joined in 1893 following a period in Australia where he had managed an engineering company, was to design the first Wolsley car in 1895, and in 1901 to combine machine tool manufacture with that of motor cars.[20] Austin did not mince his words when he remarked that the 'continued prattling about the ignorant conservatism of the English and the wonderful adaptability of the American is enough to make a man sick'. Accusations of conservatism, Austin claimed, were contradictory when British engineering firms purchased large numbers of 'improved' American machine tools. The British, he claimed, were not 'blind protectionists ... purchasing tools only of local make'. Cosmopolitanism, consistent with the principles of orthodox free traders, was Austin's vision: 'If the Americans have all the best factories for making tools, by all means let them make them and we will be content to use them'.[21]

Commenting on debates about the performance of the late nineteenth century engineering industry in Britain, Zeitlin has argued that the introduction of automatic machines can be 'seen as exemplifying a progressive entrepreneurial

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[18] *American Machinist*, 30 December 1896, p. 970.

[19] *American Machinist*, 20 June 1898, p. 59.

[20] Floud, *British Machine Tool Industry*, p. 44.

[21] *American Machinist*, 3 March 1898, p. 164. For a discussion on free trade orthodoxy see A. Howe, 'Free Trade and the Victorians', in A. Marrison (ed.), *Free Trade and its Reception, 1815-1960: Vol. 1, Freedom and Trade* (London, Routledge, 1998).

response to foreign competition'.[22] Indeed, James Vose, a Manchester engineer, commenting on the recent introduction of American machine tools, observed that 'I do not find any real jealousy of them on the part of most tool makers here'. British makers, he claimed, were quite prepared to accept the superiority of American machines in terms of design, but they were also able to show equally commendable aspects of British ingenuity. British machine shops widely employed American machines, and Vose saw this as good practice because 'the importation of American machines ... has caused and will continue to cause, discussion on the principles of tool making and tends to improve the design of tools on both sides of the Atlantic'. Implicitly raising the issue of technological transfer, Vose strongly advocated 'the best tools for any purpose can generally be selected from either one source or the other'.[23] The alleged conservatism of British makers was clearly challenged by contemporaries, and this is supported by Floud's examination of new entrants into the British machine tool industry at the end of the nineteenth century. Entrepreneurs such as Alfred Herbert, Coventry, James Archdale, Birmingham, William Asquith, Halifax, James Smith of Dean, Smith and Grace, Keighley, and Thomas Craven, Manchester, had a common characteristic in that they had 'served five years time as an apprentice mechanical engineer'. Consequently, Floud argues that successful entrepreneurship was related to the fact that managers acquired 'technical expertise and training', and this was related to the importance of innovation in the machine tool trade. Successful firms depended upon a flow of new ideas, new markets or sub-innovations in the form of adaptations to existing machines.[24]

The market environment conducive to the American 'invasion' of the 1890s was also prescribed by the short-run phenomena of the bicycle boom, but whether this represented a genuine long-run breakthrough remained an open question. Certainly, for Herbert Austin, the Americans had made only short-term gains, and he warned them against a belief that their 'product is ousting the home made article'. British makers were working at full capacity, 'three to six months behind in their contracts', but as Austin concluded, 'the present demand is a temporary one'. Further, while American makers might have been more adept at supplying the British market than domestic producers, they were not above rapprochement. A London agent importing machine tools in 1899 referred to delays in delivery, and of 'the unsatisfactory conditions of some American machine tools'. He asserted that previously it had been the exception for a British importer to receive a consignment of badly finished goods from the U.S., but he regretted to say 'that lately a very good deal of that shipped has been badly finished', and had been 'utterly rejected by buyers'. Although the agent

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[22] Zeitlin, 'Labour Strategies', p. 25. For a discussion on the performance of British engineering, see Saul, S. B., 'The Engineering Industry', in D. H. Aldcroft (ed.), *British Industry and Foreign Competition, 1870-1914* (London, Allen and Unwin, 1968); S. B. Saul, 'The Market and the Development of the Mechanical Engineering Industries in Britain, 1860-1914', *Economic History Review*, Vol. 20 (1967).

[23] *American Machinist*, 14 July 1898, pp. 524-5.

[24] Floud, *British Machine Tool Industry*, pp. 47-8.

acknowledged the general superiority of American machines to their British equivalents, he feared that the Americans were 'in danger of losing their reputation'. A key factor in breaking the resistance of British users to American imports had been the ability of the Americans to execute prompt delivery of superior finished machine tools. However, according to the London agent delays in contracted delivery time of between 6 to 9 months, and the 'strategy of sending over inferior articles' from America, did 'more damage ... in one month ... than could be repaired in 12'.[25]

Over-extended the American machine tool industry may have been in the British market, but more damning was the alleged 'economic gap' between machine tool makers in the two countries, a function, as we have seen, of the alleged reluctance of the British maker to specialise. British makers tended to build a wide range of different machine tools, while the Americans focused on the high volume output of a small range. Even a progressive firm, such as Alfred Herbert of Coventry, whose market reputation had been strengthened by the accolades it received in the trade press for its technical capabilities, rejected a strategy of concentrating production on a narrow range of machine tools. Its founder, Alfred Herbert, recounting his early days in the business, stated that:

> It has often been suggested to me that we should have done better if we had specialised more intensively on a limited range of machines. There is no doubt much force in this contention; but in the early days I doubt very much whether there was scope for a growing business, which confined itself to the production of one or two machines. Rightly, or wrongly, I was attracted by the idea of covering a fairly wide field.[26]

Alfred's business experience suggests that the distinction made by contemporaries between American and British practices may be too sharply drawn, and Floud has pointed out that there are different forms of specialisation. A maker might manufacture a wide range of machines, or 'a small number of types', or machines which were dedicated for use by specialised customers 'with particular technical requirements', and often situated in 'a particular geographical location'. The relationship between makers and users in Britain was different from that of the U.S.A., and according to Floud the British tended to design their machine tools to meet the requirements of the user who had a particular product specification to meet. Once the machine tool was installed, there would be little need for the user to modify it or adapt it. In contrast, the American system encouraged the maker 'to produce a range of machine tools, designed to perform particular operations, but not specifically designed to meet the specific needs of any one user'. Considerable contemporary discussion occurred concerning the relative merits of the two systems, but Floud maintains that the evidence available provides no clear indication of the greater efficiency of one system over the other. Acknowledging that the Americans probably produced higher volume output per

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[25] *American Machinist*, 14 September 1899, p. 874.
[26] Cited in Floud, *British Machine Tool Industry*, p. 53.

machine than did the British, Floud, nevertheless remains unconvinced that the resulting difference in unit costs were that significant. He speculates that the two systems may have been on a convergent path, with British makers beginning 'to specialise in fewer tools, and the American manufacturers to make more specialised tools'.[27]

Firms specialised along a customer and regional path, and four regional centres of machine tool production can be located in Britain, each specialising in different types of machine tools. Manchester, particularly Broadheath, was associated with the needs of textile machinery makers. In the Midlands, firms producing a large range of machines of the type required for repetition work evolved, suitable for small arms, bicycle and motor manufacture. The Glasgow region tended to concentrate on the heavier types of tools associated with shipbuilding and marine engineering, whereas in the Halifax-Leeds region, including Keighley, Huddersfield, Sowerby Bridge, local machine tools were generally regarded as 'being simpler in design' than their competitors across the Pennines. The pattern of specialisation in Britain took on a different form to that of the U.S.A., where there was a concentration on the 'manufacture of a restricted range'. American makers worked to a 'plan, to which all industries in this country tend', and this confined 'their energies and skills to implements of one kind, and in some cases to a few sizes of all kinds'.[28]

What was evident, however, was the enormous capacity that the American machine tool industry was developing, and this raised the importance of the British and continental markets as outlets to sustain the enlarged supply emanating from American shops. 'The gravest problem' confronting the American machine tool trade in 1900, was 'how to get the returns for its productiveness'. For example, in the machine tool centre of Cincinnati output had expanded by an estimated 40 to 75 per cent between 1898 and 1900, and not surprisingly the industrial markets of Britain and Europe were crucially important in keeping American machine shops at 'full' capacity.[29] It is too simplistic, therefore, to interpret the American 'invasion' of the British market as the outcome of specialist machine tool firms in the U.S. sweeping aside outmoded and generalist British makers. In part, the 'invasion' was driven by the needs of American producers for markets, and the fact that the mature British market offered rich opportunities. The significant question

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[27] Ibid., pp. 57-9, 61.

[28] Ibid., pp. 52-5; R. Lloyd-Jones and M. J. Lewis, 'Technological Pathways, Mode of Development, and the British National Innovation System: Examples from British industry, 1880-1914', in L. Tissote and B. Veyrassat (eds), *Technological Trajectories, Markets, Institutions. Industrialised Countries Nineteenth and Twentieth Centuries* (Bern, Peter Lang, 2001), p. 149; R. Lloyd-Jones and M. J. Lewis, 'Business Networks, Social Habits, and the Evolution of a Regional Industrial Cluster: Coventry 1880-1930s', in J. F. Wilson and A. Popp (eds), *Industrial Clusters and Regional Business Network in England, 1750-1990* (Aldershot, Ashgate, 2003), p. 233; A. J. Arnold, 'Innovation, Deskilling and Profitability in the British Machine Tool Industry: Alfred Herbert, 1887-1927', *Journal of Industrial History*, Vol. 1, No. 2 (1999); *American Machinist*, 17 April 1899, p. 351, 27 April 1899, p. 353.

[29] *American Machinist*, 10 April 1900, p. 340.

in the study of the evolution of the British machine tool industry is how did it respond to the entrepreneurial and technological challenge of the U.S.A.?

Declinism: Institutional Constraints and Path Dependency

Of all the debates in British economic history, that of the alleged relative decline of the British economy between 1870 and 1914 is perhaps the most enduring.[30] The debate stretches back to the period itself, an editorial in *The American Machinist* of 1901 enquiring 'What is the matter with British industry?' Despite the fact that there was no 'agreement' on the question, a list of deficiencies familiar to the modern economic historian was rolled out. These included a lack of adequate technical education, the resistance of trade unions to changes in technology and work practices, conservative entrepreneurs wedded to existing forms of business organisation, and a general unwillingness to adopt new methods or to be receptive to new ways of doing things. At the same time, the journal was obliged to point out that 'there is that contingent that contends that there is nothing whatever the matter with Great Britain's industries'.[31] In a modern interpretation, Elbaum and Lazonick have claimed that it was institutional rigidities and constraints that held back British industry, and consequently the root cause of the alleged decline could not be the quality of British entrepreneurship. The institutional constraints that are highlighted include industrial relations and technical education, enterprise and market organisation, and finance and international trade.[32] Informing this approach is the notion of path dependency, based on the assumption that contemporary entrepreneurs were constrained in their business behaviour by an 'institutional legacy' associated with an 'atomistic nineteenth century organisation'.[33] This raises the probability that there exist important diversities 'in the organisation of capitalist economies and the institutionally mediated paths of national economic development'.[34] That is, national economies may well experience more or less distinct national innovation systems, and consequently their responses to 'common

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[30] The literature is extensive, but see D. C. Coleman and C. Macleod, 'Attitudes to New Techniques: British Businessmen 1800-1950', *Economic History Review*, Vol. 24, No. 4 (1986); B. Elbaum and W. Lazonick (eds), *The Decline of the British Economy* (Oxford, Oxford University Press, 1986); Dormois and Dintenfass (eds), *The British Industrial Decline*; S. Pollard, *Britain's Prime and Britain's Decline: The British Economy 1870-1914* (London, Edward Arnold, 1989).

[31] *American Machinist*, 27 July 1901, p. 770.

[32] B. W. Elbaum and W. Lazonick, 'An Institutional Perspective on British Decline', in Elbaum and Lazonick (eds), *Decline of the British Economy*, p. 2.

[33] E. Abe, 'The Technological Strategy of a Leading Iron and Steel Firm: Bolkow Vaughn & Co. Ltd.: Late Victorian Industrialists Did Fail', *Business History*, Vol. 38, No. 1 (1996), p. 47.

[34] J. Zysman, 'How Institutions Create Historically Rooted Trajectories of Growth?', *Industrial and Corporate Change*, Vol. 3 (1994); Lloyd-Jones and Lewis, 'Technological Pathways', p. 118.

or related changes thrown up by the course of world technological development, such as the second industrial revolution', may well differ significantly.[35]

Empirical evidence in support of the diversity in technological response may be gleaned from *The American Machinist*, which was well aware of the importance of machine tools to the industrial advances associated with the second industrial revolution.[36] In 1900 *The American Machinist*, referring to an article in the *Engineer*, observed that the British trade journal initially responded positively to the American machine tool 'invasion' of the British market, and was somewhat critical of British machine tool practices. But the *Engineer* quickly indulged in 'backsliding' and articulated the view that 'Nothing that came from without the British Isles was of much account in its eyes'. According to the *Engineer*, the domestic machine tool industry, and indeed British engineering in general, produced work of the highest quality, and the established reputation of its firms meant that 'The best of everything is still made in England and those who want the best must come to us to supply their wants'. The *Engineer* accepted that some of 'our old works, our largest and most famous ... are antiquated in arrangement and design', but contended that so would 'hundreds of American works' be so in '50 years hence'. What, the *Engineer* speculated, should future American entrepreneurs do when they were faced by a new wave of technological change? Should they, for example, 'utterly cast out the ways of their fathers and grand fathers [and] will they be able to stamp out tradition?'[37] 'No' was the answer; the Americans would most probably do what the British were doing at the turn of the nineteenth century and make the best use of the means they had at hand. 'They would modify and renew just as our manufacturers do now, but with caution and discretion ... not with immediate haste ... which marks some of their movement today. That restless stirring for the foremost place will be a nightmare of the past'.[38]

In this scenario, the historical pathway of American industrial development would evolve institutional habits that would constrain its own capacity to adapt to future technological and competitive challenges. *The American Machinist*, however, was not convinced, and contended that the interpretation placed on the issue by the *Engineer* was a 'factual misconception of the conditions under which American methods have been developed'. Thus, the British tended to 'keep the old machinery turning over as long as it would be made to do the work'. In comparison, American methods were to scrap machines as soon as a newer one could be innovated that produced a 'sufficient increase of product to pay the required interest on the investment'. The difference in technical practice was put down to differences in the environment of the two countries, and the *Engineer*

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[35] Lloyd-Jones and Lewis, 'Technological Pathways', pp. 128-9. See also C. Freeman, 'The National Innovation System in Historical Perspective', *Cambridge Journal of Economics*, Vol. 19 (1995).

[36] See J. P. Hull, 'From Rostow to Chandler to You: How Revolutionary was the Second Industrial Revolution?', *Journal of European Economic History*, Vol. 25, No. 1 (1996), pp. 192-7.

[37] *American Machinist*, 6 October 1900, p. 895.

[38] Ibid.

itself mentioned that simply 'transplanting' American methods and technology to Britain 'could lead to no good results'.[39] This controversy in 1900 anticipates the observations of Rosenberg that 'today's technical possibilities are dependent upon yesterday's actions in the quality of factor endowments'.[40]

Concepts such as path dependency and national innovation systems carry considerable explanatory power in the study of the process of technological change, but there is also a need for caution.[41] Transplanting technology between British and American firms did occur during the second industrial revolution, and it did lead to some positive business results in key industries such as machine tools. At the broad industry level it is reasonable to suppose that British institutional attitudes to technological change were path dependent, but at the level of the individual firm there were a number of examples of good practice, not unrelated to American influence, that helped to establish a viable British machine tool industry by the eve of the First World War. The next section explores some of the business and technological responses of British machine tool firms to the competitive challenge they confronted in the two decades before 1914.

British Machine Tool Firms and American Practice

The surge of American imports to Britain and the continent from the second half of the 1890s has been explained on the one hand by American foresight in meeting the needs of users who had failed to acquire the machine tools they required from indigenous supplies. On the other hand, the American's 'inventive genius' enabled them to develop a range of products which could not be constructed abroad. While the Americans expected that Britain and Western Europe would react to their challenge and develop their own machine tool capabilities, they still took for granted that their machine makers would retain a technological lead. Indeed, American technological knowledge of machine tool production and design 'was not exported with the tools' that they produced, and the 'inventive facility' was retained in the U.S. This did not mean, however, that British firms were technically moribund, or were reduced to simple imitators of American designs and methods.[42]

Floud's analysis of the trade directories suggests that there were approximately 350 to 400 firms producing machine tools in Britain in the early 1900s, and this number probably fell to around 250 by 1910-13 (Table 2.5). The figures are problematic because of the difficulties associated with disentangling those firms who were specialist machine tool producers from those who produced machine tools as part of a range of engineering products, the latter typified by

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[39] Ibid.

[40] N. Rosenberg, *Exploring the Black Box: Technology, Economics and History* (Cambridge, Cambridge University Press, 1994), p. 10.

[41] For recent work in this area see R. Nelson, *The Sources of Economic Growth* (Harvard, Harvard University Press, 1996); D. Archibugi, J. Howells and J. Michie (eds), *Innovation Policy in a Global Economy* (Cambridge, Cambridge University Press, 1999).

[42] *American Machinist*, 1 December 1900, p. 1,076.

Greenwood & Batley of Leeds, the main case study employed by Floud.[43] Nevertheless, Floud's estimates are a useful benchmark and lead us to a key question. How many of the firms identified by Floud may be described as leading or entrepreneurial firms who adopted an innovatory strategy to meet the American competitive challenge? This in itself proves a major challenge, because as Floud observes, 'the evidence concerning the operation of individual firms comes primarily from the large and successful firms',[44] while, as Schumpeter informs us, the innovative firms associated with periods of rapid change were inevitably new and initially small enterprises.[45] Surviving business records of firms in the British industry, such as Alfred Herbert, Webster & Bennett, J. Butler & Co, and Greenwood & Batley do provide some useful insight into their evolution, but are too limited and fragmentary to make a case for a cluster of innovative firms at the beginning of the twentieth century. It is possible, however, to record those British firms which were reported to have introduced new products or sub-innovatory improvements, and new plant or extensions incorporating modern design and work practices. These were reported in *The American Machinist*, a trade journal not particularly receptive to British machine tool practices, but which fastidiously surveyed machine tool design in its pages. The survey enables the identification of a core of firms that were at, or close to, the cutting edge of machine tool design in the first decade of the twentieth century.

Taking the year 1903, and accepting the number of firms in the industry as 315 in 1900, Table 2.2 shows the number of firms recorded in *The American Machinist*, and also differentiates firms by the number of times they were reported in the journal. In total, 75 firms were recorded at least once, while 25 firms (Table 2.3) were recorded 3 or more times. Table 2.3 should be considered with caution, as there were no doubt variations between the regional correspondents in their recordings of the activities of firms, and there is, for example, a suspicion that the Birmingham correspondent was less adept at recording firms than in other districts, or at least recording firms in Coventry. The latter was a rapidly emerging machine tool centre at the end of the nineteenth century, boosted initially by the cycle boom of the mid-1890s, but apart from Alfred Herbert the only other Coventry machine tool firm recorded was that of Webster & Bennett. Nevertheless, the data does indicate a core of firms that were innovatory in 1903, and these range from a minimum of 25 to an upper limit of 70. Thus we can assume that nearly one in five British machine tool firms were sufficiently innovative and enterprising to draw the attention of *The American Machinist* at the beginning of the century. It would seem that foreign competition had stimulated British manufacturers, both machine tool makers and users, and there was at the beginning of the twentieth century both a 'steady demand for English made machine tools', in particular for lathes, planers, shapers and milling machines, and significant advances made in workshop

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[43] Floud, *British Machine Tool Industry*, p. 32.

[44] Ibid.

[45] J. A. Schumpeter, *Capitalism, Socialism and Democracy* (London, Routledge, 1994), chs. 7-8.

practices. In addition, new developments in tool steel provided a technological and business stimulus to British machine tool makers. Prior to the main breakthrough in high speed steel in 1900, the main production of high quality tool steel was provided by 'Mushet steel', produced by Samuel Osborn of Sheffield and 'other varieties of steel-hardening tool steel [that] held sway in the engineering workshops around the world'. This form of tool steel perpetuated a 'rule of thumb' approach as 'each mechanic was allowed to have his tools forged and ground individually, with no regard whatever to the earning power of machine tools'.[46]

Table 2.2
British Machine Tool Firms Recorded in *The American Machinist*, 1903

Times Reporting	No. of Firms	Total No. of Firms	% of Total
1	71	315	22.5
2	46	315	14.6
3+	25	315	7.9

Source: *The American Machinist* for 1903.

Developments in high speed steel, attributed to the Americans Frederick William Taylor and Maunsel White in 1899 ended the rule of thumb approach, but it was in Sheffield where the new alloys were rapidly exploited and diffused. In 1901 Seebohm & Dieckstahl of Sheffield became the first British company to produce high speed steel, and this firm was rapidly followed by Thomas Firth, Edgar Allen, Cocker Bros., John Brown & Co., Jones & Colver, Samuel Osborne, Vickers, Son & Maxim and Joseph Beardshaw & Co. The technical requirements of specialist steel production introduced a more scientific approach to steel manufacture, and its cutting power opened up new opportunities for British machine tool makers.[47] By 1905 British makers were sending high speed twist drill and other cutting tools all over the world.[48] The technical interdependence between high speed steel manufacturers and their users, the machine tool makers, was emphasised by H. Spear, the London agent of Joseph Beardshaw. In the 1890s the company had promoted the sale of its specialist 'Profile Steel' for machine tools, and in 1900 Spear informed the management that recent developments in high speed steel were receiving the attention of machine makers. The success of the steel business, Spear argued, now depended upon the 'recommendation' of

[46] *American Machinist*, 10 October 1903, p. 754E.

[47] G. Tweedale, *Steel City. Entrepreneurship, Strategy and Technology in Sheffield, 1743-1993* (Oxford, Clarendon Press, 1995), pp. 113-16; G. Tweedale, *Sheffield Steel and America: A Century of Commercial and Technological Interdependence, 1830-1930* (Cambridge, Cambridge University Press, 1987), pp. 34, 65; *American Machinist*, 27 February 1904, p. 117E.

[48] M. J. Lewis, 'The Growth and Development of Sheffield's Industrial Structure, 1880-1930', unpublished Ph.D., Sheffield Hallam University (1990), p. 148.

machine makers such as Alfred Herbert 'of your tool steel to the users of their machine tools'. The advent of automatic machine tools had given a new priority for steel manufacturers to develop specialist materials to meet the requirements of users.[49]

Table 2.3
List of Machine Tool Firms Recorded 3+ Times for 1903 by Region

Firm	Recordings	Location
		Yorkshire Region:
Maud & Turner	4	Halifax
C. Redman & Sons	5	Halifax
William Asquith & Co.	4	Halifax
Carter & Wright	3	Halifax
George Swift	5	Halifax
Ward, Haggis & Smith	3	Keighley
David Brown & Sons	4	Huddersfield
John Dickinson & Co.	3	Keighley
Darling & Sellers	3	Halifax
James Butler	3	Halifax
		Midland Region:
James Archdale & Co.	4	Birmingham
Taylor & Challen Ltd.	4	Birmingham
Charles Taylor	4	Birmingham
Tangye Tool & Electric Co.	4	Birmingham
E. G. Wrigley & Co.	3	Birmingham
Alfred Herbert Ltd.	3	Coventry
		Manchester Region:
Kendal & Gent	4	Manchester
Hulse & Co.	5	Salford
Hetherington & Co.	5	Manchester
George Richards & Co.	3	Broadheath
		Glasgow Region:
Louden Bros.	7	Johnstone
Jonathan Lang & Co.	7	Johnstone
Whyte & Waddell	5	Johnstone
Thomas Shanks & Co.	3	Johnstone

Source: *The American Machinist* for 1903.

High speed steel offered new design opportunities to British makers. American makers tended to build less robust machine tools than the British, 'who have perhaps always been more accustomed to heavy drives and course cuts'.

[49] Sheffield City Archives, MD7091 (5), Records of Joseph Beardshaw & Co., Minute Book of H. Spear, 28 December 1894, 20 July 1900.