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# THE FARMER'S CUTTING EDGE IN SOUTHERN NEW ZEALAND, 1864–1914<sup>1</sup>

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## Abstract

As a local node in an expanding global network, the agricultural implement makers Reid & Gray played a pivotal role in collaborations between 2 sets of actors: farmers and iron workers. Order books and correspondence identify suppliers of the Dunedin foundry and their strategies for adapting the horse-drawn plough to the requirements of a farming frontier. Between the colonial frontier and metropolitan centres, the firm relayed observations of ploughmen, landowners, blacksmiths, moulders and mechanical engineers. The flow of information back and forth across this network was essential to the rapid increase of agro-pastoral productivity in the region. The environmental challenge stimulated innovations that accelerated irreversible changes in the landscape.

**Keywords:** ploughs, agricultural machinery, tool steel, tacit know-how, southern New Zealand, innovation, technology transfer

To ‘speed the plough’—the urgent objective of landowners in the low hill country of southern Canterbury, Otago and Southland—it would be necessary for enterprises elsewhere to speed the melt and the chisel, to increase the flow of air in the furnace and the heat sustained on the machinist’s bench. These were not wholly independent suites of innovations, and the records of a Dunedin foundry provide evidence of continual interplay among several hundred specialised actors at locations remote from one another. As ‘tacit’ know-how was adapted to meet new demands, interaction between the 2 streams of innovation—in husbandry and metallurgy—sustained rising productivity over the half-century Vaclav Smil has called ‘the great technical watershed of human history’.<sup>2</sup>

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1 The authors wish to thank George Davis and Bill Smith for editorial suggestions, and to acknowledge the support of their university departments, the personnel of the Hocken Collections of the University of Otago Library, Papers Past, Wikipedia, Grace’s Guide and several hundred smaller nodes on the internet, where volunteers in local museums, archives and communities of craft and conservation have shared their resources.

2 Vaclav Smil, *Creating the Twentieth Century: Technical Innovations of 1867–1914 and their Lasting Impact* (Oxford: Oxford University Press, 2005), 1.

In 1868 Robert Reid and James Gray, having arrived in the colony 5 years earlier, formed a partnership for the importation, manufacture and assembly of agricultural implements. They immediately advertised a double-furrow plough based on Reid's own patent registered in New Zealand in 1867, with additional patents and imports from the factory of Gray's father in Uddingston, Lanarkshire. With the ambition of displacing the imported models, they opened a foundry and cart-making shop in Oamaru, South Canterbury, where grain cultivation was advancing rapidly, but after a fire in July 1872 moved to Dunedin where port facilities were more promising. The firm grew rapidly and stabilised at about 200 employees. Reid died in 1879, and Gray managed the enterprise until 1922,<sup>3</sup> maintaining always a high priority for their premier product—the horse-drawn double-furrow plough—which ensured that it was valued by the occupants of family farms in the region.

The functioning of this modest industrial node will demonstrate the variety of intermediaries between makers and users of an implement, as they manoeuvred to respond to new markets, new technical options and severe competition. Interpretation of the archival documents will draw us into a conversation launched by Joseph Schumpeter when he credited 'the intrusion of novelty' to the industrial entrepreneur and coined the term 'creative destruction' for the dynamic of the capitalist economy.<sup>4</sup> Analysis of engineering and machine tools as centres for the diffusion of new techniques to other manufacturing sectors inspired the interpretation of innovation as a learning process for both parties: 'Tool builder and tool user were not just supplier and customer but creative students of one another's methods'.<sup>5</sup> Observing the same kind of creative exchange among eighteenth-century developers of textile machinery, Maxine Berg and Kristine Bruland have paid close attention to the tacit know-how shared by the makers and users of a tool: 'Technology is a culture'.<sup>6</sup>

That culture—the skills and sensitivities of wheelwright or blacksmith—was never static. Mastery of 'tradition' began with patient apprenticeship of gestures and sensory cues and demanded lifelong learning in response to the variability of materials, scarcities, failures and demands of individual customers.<sup>7</sup> The need for

3 In 1912 Miss Reid, a daughter, sold out her interest to Gray, the partnership was formally dissolved and a limited corporation framed (*Otago Witness*, 1 May 1912, 36).

4 Joseph A. Schumpeter, *Capitalism, Socialism and Democracy*, 3rd ed. (New York: Harper, 1950), 83. See also Joseph A. Schumpeter, 'The Creative Response in Economic History', *Journal of Economic History* 7, no. 2 (November 1947): 152f.; Thomas K. McCraw, 'Schumpeter's Business Cycles as Business History', *Business History* 80, no. 2 (Summer 2006): 231–61; Nathan Rosenberg, 'Technological Innovation and Long Waves', in *Exploring the Black Box: Technology, Economics, and History* (Cambridge: Cambridge University Press, 1994), 62–84.

5 W. Paul Strassmann, 'Discussion', *Journal of Economic History* 23, no. 4 (December 1963): 444, summarising his agreement with Nathan Rosenberg, 'Technological Change in the Machine Tool Industry, 1840–1910', *Journal of Economic History* 23, no. 4 (December 1963): 414–43.

6 Maxine Berg and Kristine Bruland, eds, *Technological Revolutions in Europe: Historical Perspectives* (Cheltenham: Edward Elgar, 1998), 14 and 141.

7 E. D. Mackerness, ed., *Journals of George Sturt 1890–1927* (Cambridge: Cambridge University Press, 1967).

the face-to-face transmission of unwritten routines has led analysts to insist on geographical proximity and urban agglomeration as factors in the local capacity for innovation.<sup>8</sup> In stark contrast is the Dunedin foundry, whose clients were scattered on agrarian frontiers and whose suppliers—makers of bolts and springs and blades—were lodged in little clusters on 4 continents. Over distances as great as 10,000 nautical miles (18,500 km), the entrepreneur in New Zealand exploited innovations in telegraphy, and the operation of the Dunedin firm offers a model of the way novelty ripples through the global information network.<sup>9</sup>

Attention to the plough is a necessary complement to the story of the reaper, which dominates schoolbook accounts of the mechanisation of agriculture. To the popular account of harvest drama and heroic inventor, Zvi Griliches in the 1950s brought important correctives: evidence that a wide array of intermediate goods purchased by farmers embodies innovation, that the size of the farm enterprise affects the uptake of an invention, and that adaptations emerge in specific small regions.<sup>10</sup> 'In agriculture, the specific is often location-specific, indeed specific to a conjunction of resources of soil and atmosphere.'<sup>11</sup> The South Island case study therefore features the landscape-specific. On a frontier of 'land-breaking', the plough was the prime transformative tool, and landowners demanded tougher equipment to handle the rigours of first-ploughing, rough roads, masses of buried roots, and swampy and hilly terrain. The distinctiveness of the region, and the variation within it, made it a laboratory for the world's mechanical expertise.

8 For example, Nathan Rosenberg, 'Economic Development and the Transfer of Technology: Some Historical Perspectives', *Technology and Culture* 11, no. 4 (October 1970): 570; in contrast, Richard Shearmur, 'Far from the Madding Crowd: Slow Innovators, Information Value, and the Geography of Innovation', *Growth and Change* 46 (2015): 424–42.

9 David R. Meyer, *Networked Machinists: High-Technology Industries in Antebellum America* (Baltimore, MD: Johns Hopkins University Press, 2008); Gillian Cookson, *The Age of Machinery: Engineering the Industrial Revolution, 1770–1850* (Woodbridge: Boydell, 2008); Christine MacLeod, 'Strategies for Innovation: The Diffusion of New Technology in Nineteenth-century British Industry', *Economic History Review* 45 (1992): 300; Ian Hunter, 'Commodity Chains and Networks in Emerging Markets: New Zealand, 1880–1891', *Business History Review* 79 (2005): 275–304; Gordon M. Winder, *The American Reaper: Harvesting Networks and Technology, 1830–1910* (Farnham: Ashgate, 2012).

10 Zvi Griliches, 'Hybrid Corn: An Exploration in the Economics of Technological Change', *Econometrica* 25 (1957): 512; Zvi Griliches and Frank Lichtenberg, 'Interindustry Technology Flows and Productivity Growth: A Re-examination', *Review of Economics and Statistics* 66 (1984): 325–29. On the effects of farm size, for the case of the reaper, see Paul A. David, *Technical Choice, Innovation and Economic Growth* (Cambridge: Cambridge University Press, 1975), 240. The McCormick story is further deflated by Daniel P. Ott, 'Producing a Past: McCormick Harvester and Producer Populists in the 1890s', *Agricultural History* 88 (2014): 87–119. For a recent, more nuanced history of the plough, see Peter Dewey, *Iron Harvests of the Field: The Making of Farm Machinery in Britain since 1800* (Lancaster: Carnegie, 2008).

11 Paraphrase of Griliches, in Nathan Rosenberg, ed., *Perspectives on Technology* (Cambridge: Cambridge University Press, 1976), 78; echoed in Rosenberg, 'Economic Development', 571; for examples, see Leslie Curry, 'Regional Variation in the Seasonal Programming of Livestock Farms in New Zealand', *Economic Geography* 39 (1963): 95–118; Graeme Wynn, 'Remapping Tutira: Contours in the environmental history of New Zealand', *Journal of Historical Geography* 23, no. 4 (1997): 418–46.

Farming is a problem-solving activity, and every piece of land, distinct in location and resources, presents a new challenge, inviting adaptation of the available implement.<sup>12</sup> In agro-pastoral production, this view of the incremental innovation process suggests the benefits of recasting the full range of innovations as responses to environmental challenges; that is, the provocation of novelty through the extension of landscape frontiers.

This interpretation is grounded in 2 rich archives. Order books and correspondence in the Reid & Gray archive in Dunedin identify suppliers and provide evidence of the marketing strategies of the firm,<sup>13</sup> and from the digital archive Papers Past we obtain news coverage for the region where the firm made most of its sales.<sup>14</sup> We rely primarily on the *Otago Witness*, published weekly in Dunedin and posted to farmers, runholders, miners and shopkeepers beyond the reach of the daily mail service in Otago, Southland and South Canterbury. In addition to advertising and the biographical details of the actors, we extracted for 1864–1914 two annual series: column-length accounts of local ploughing contests and full-page reports of implement displays at agricultural and pastoral (A & P) shows (county fairs) in the 3 provinces.

This article is organised in 3 stages. To trace our way through the network, we first examine reports from local ploughing matches, to show the practices of experiment among farmers and their interactions with plough-makers. Second, published details of the A & P shows document the way manufacturers promoted their products. Like the winter ploughing matches, the summer farm shows were significant social events that encoded the channels of information flow into which manufacturers inserted themselves as essential relays. In the third section we mine Reid & Gray's order books to investigate its global supply lines for machines, materials and parts. In both the nearby and remote portions of the network, the firm was nourishing conversations between toolmakers and tool users.

Notwithstanding its small size, New Zealand at the end of the nineteenth century was a world leader in terms of inventiveness and economic growth per capita. Spectacular expansion of pastoral exports—wool, hides, frozen meat, butter and

12 Rosenberg, *Perspectives*, 108.

13 Reid & Gray Limited archive. MS-1165. Hocken Collections, University of Otago, Dunedin.

14 A full run of the *Otago Witness* is accessible as a searchable internet resource at [paperspast.natlib.govt.nz](http://paperspast.natlib.govt.nz) (National Library of New Zealand). Keyword searches (for 'plough', 'ploughing match' and 'agricultural and pastoral show') were followed by searches for missing events by dates. To test the coverage of the *Witness* we searched also 5 small-town newspapers founded in the 1860s: *Southland Times* (Invercargill), *Bruce Herald* (Milton), *Timaru Herald*, *Lake Wakatipu Mail* (Queenstown) and *Clutha Leader* (Balclutha). For shipping news we had recourse to the *North Otago Times* (Oamaru) and *Otago Daily Times* (Dunedin), the last a partner of the weekly *Otago Witness*.

cheese—was generating average incomes higher than in the United States.<sup>15</sup> In the region under analysis in the span of a generation (1881–1911), the number of farms doubled and acreage under cultivation tripled without a marked increase in the rural population.<sup>16</sup> Farms proposed as profitable for family enterprise—300 to 1,000 acres—were small in comparison with the better-known sheep runs and great estates, but they were decidedly larger than European peasant farms or homestead grants in the United States (the 160-acre quarter-section).<sup>17</sup>

By centring attention on family-sized holdings reliant on horse-drawn equipment, are we to assume these operations were old-fashioned? Correspondents of the *Otago Witness* and the well-capitalised high achievers they interviewed often expressed impatience with their small farmers as resistant to change: ‘In plain Anglo Saxon we call them “yokels”’.<sup>18</sup> Over the half-century, however, the family-sized farm emerged as a political and social goal of the colony. As early as 1881, closer settlement, with a better balance of cropping and pastoral activities, was argued as more efficient, and the same writer was urging a mix of products: ‘in fairly fertile land where wheat, barley, grass seed, butter and cheese, beef and mutton are all to be raised, his fortune rests with himself’. By 1911, the family-size farms amounted to only 13 per cent of the area under cultivation or improved pasture, but their numbers had doubled; they attained high levels of quality control and accounted for the expanding dairy production.

The South Island frontier differed from the classic portrayal of the vast and level wheat lands of the Great Plains of North America or Australia. From the late 1860s, as first-generation settlers consolidated their holdings, their offspring and immigrants were already moving onto second-choice land. At Waikaia, for example, in northern Southland, Joseph H. Davidson, who arrived seeking gold in 1863, invested 15 years in the development of his 500-acre farm, represented in the *Otago Witness* in 1880 as a model.<sup>19</sup> In 1914 his successors were still clearing remnant patches of bush, tall shrubs and tussock grasses; they were still in need of a cutting

15 Rebecca William and Les Oxley, ‘The Geography of Inventiveness in the Primary Sector: Some Initial Results for New Zealand, 1880–1895’, *Australian Economic History Review* 56 (2016): 151–73; J. B. Condliffe, ‘The External Trade of New Zealand’, annexed to *New Zealand Official Year-book, 1915* (Wellington: Government Printer, 1915), [www3.stats.govt.nz/New\\_Zealand\\_Official\\_Yearbooks/1915/NZOYB\\_1915.html](http://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1915/NZOYB_1915.html), accessed 30 October 2019; Michael Roche, ‘International Food Regimes: New Zealand’s Place in the International Frozen Meat Trade, 1870–1935’, *Historical Geography* 27 (1999): 129–51.

16 John E. Martin, ‘Whither the Rural Working Class in Nineteenth-century New Zealand?’, *New Zealand Journal of History* 17 (1983): 21–32. Statistics reported by provincial district (Canterbury, Otago and Southland) include portions of high country and the relatively level wheat lands of North Canterbury, beyond our target region.

17 For references to studies of the large sheep runs and wheat estates, see John E. Martin, *The Forgotten Worker* (Wellington: Allen & Unwin, 1990); James Belich, *Replenishing the Earth: The Settler Revolution and the Rise of the Anglo-World, 1783–1939* (Oxford: Oxford University Press, 2009).

18 ‘Yorick’, George Jacksons, Mount Hyde, first prize essay, ‘Small Farming in Otago’, *Otago Witness*, 19 March 1881, 6.

19 ‘Chats’, *Otago Witness*, 25 September 1880, 6; Joseph Davidson diaries. ARC-0724. Hocken Collections.

edge for strenuous first-ploughing and the demanding mole-work of drainage. A frontier persisted over the entire span, fragmented and spotty, certainly not the moving line of settlement that fired popular imagination in North America.<sup>20</sup>

Much of the low, hilly land brought under the plough in this half-century in Otago and Southland proved very productive, but the development of these acreages had been postponed because their cultivation required more years of labour, longer-term financing, collective works of drainage, public investment in railways and—the focus of this article—more effective equipment. The tempo of landscape change varied in response to the eager investments of Scots capital in the 1870s, a long depression in 1880–94, renewed investments in the mid-1890s and a briefer trough in 1908.<sup>21</sup> From the late 1870s, start-up farms coexisted cheek by jowl with well-established estates, run-down or weed-infested properties, speculations and burnt-over land.

Pressure for both new land and new techniques for managing it were responses to the demand for meat and dairy products in the fast-growing industrial centres of Great Britain. The new settler might catch a crop of grain, sow enough oats to nourish the team and turnips enough to secure some cattle and sheep through a dry or cold season of scanty pasture, but much of the initial investment in ploughing was to ‘lay down grass’—that is, to replace the native vegetation with palatable, fast-growing ‘English grasses’, a task that would require renewal after 6 to 10 years. This marked a distinctive stage in what was later called ‘the grasslands revolution in New Zealand’.<sup>22</sup>

In the annual routine, ploughing was interrupted only by extremes of cold or wet weather and by the compelling demands of the harvest (January and February), lambing (August) or shearing (November). At the Reid & Gray foundry, demand for harvesting equipment (reapers, binders, threshers) controlled the calendar of production, as is shown in Figure 1. In the off seasons, the firm manufactured iron fencing standards and tighteners, and stocked and sold wire for fencing. The same seasonal pressures governed flows of cash and credit on the farmers’ books, their scramble for information and the sociability they enjoyed at the ploughing match or the fair.

20 Frederick J. Turner, *The Frontier in American History* (New York: Henry Holt, 1921). The applicability of such a model is doubtful even for the US grasslands; for regional nuances see Donald W. Meinig, ‘Colonization of Wheatlands: Some Australian and American Comparisons’, *Australian Geographer* 7 (1959): 205–13; James C. Malin, *Winter Wheat in the Golden Belt of Kansas: A Study in Adaptation to Subhumid Geographical Environment* (Lawrence, KS: University of Kansas Press, 1944); Kenneth M. Sylvester, ‘Ecological Frontiers on the Grasslands of Kansas: Changes in Farm Scale and Crop Diversity’, *Journal of Economic History* 69 (2009): 1041–160.

21 For export volumes and prices, public investment and borrowing, see Condliffe, ‘External Trade’.

22 Tom Brooking and Eric Pawson, eds, *Seeds of Empire: The Environmental Transformation of New Zealand* (London: I. B. Taurus, 2011).

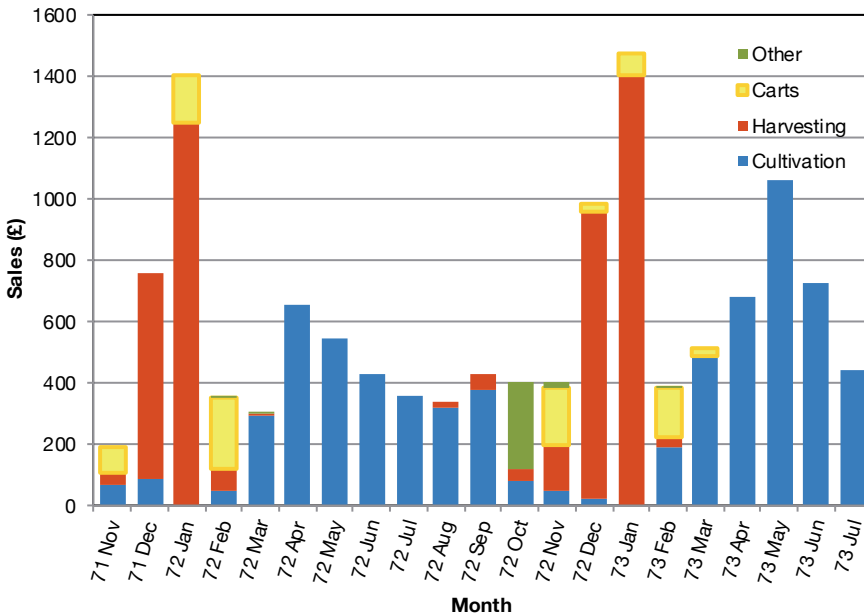


Figure 1: Reid & Gray sales (£ per month) 1871–73, by type of equipment.

Source: Reid & Gray Archive, Correspondence. Hocken Collections Uare Taoka o Hākena MS-1165/021.

## The purpose of the ploughing match

‘The avowed and ostensible object’, asserted a commentator in 1865, ‘is to train a superior class of ploughmen and to encourage them to put mind into their work’.<sup>23</sup> The competition satisfied the additional needs of the community for sociability, the transmission of tradition and the evaluation of novelty. An excursion to the ploughing match will acquaint us with the capillaries of rural communications and the experimental approach required in a new world.

Competitions in this region were systematised in the 1860s under rules derived from Scottish and English matches promoted by late eighteenth-century ‘Improvers’. From 650 newspaper accounts we identified 50 communities for which the ‘fixture’ remained popular throughout the half-century, despite local lapses of several years. Each year the first challenge of the organising committee was to find a piece of land large enough for laying out 10 to 20 plots that constituted a comparable challenge, 50 on the Taieri, Otago, in 1871. They typically assigned a third of an acre (0.14 ha) to the entrant with a single-furrow plough drawn by 2 horses, twice that to the competitor with a double-furrow plough drawn by a 3-horse team, and all were

<sup>23</sup> *Bruce Herald*, 21 September 1865, 5.



expected to finish within a 6-hour limit. An 1865 advertisement for Pomahaka, south Otago, specified furrows 8½ inches (21.6 cm) wide and 4½ inches (11.4 cm) deep, 'and no help to be given after the first furrow'.<sup>24</sup>

The Longbush Estate launched the Southland competition season in late June (the winter solstice), but most communities delayed several weeks to avoid interfering with ploughing their own farms. A timely start was often threatened by frost in the ground, leaving the crowd of onlookers restive to learn the results before dark and enjoy the celebratory dinner served by the local innkeeper. Even enthusiasts acknowledged 'the dull plodding routine',<sup>25</sup> and to distract from the tedium, informal races were 'extemporised'. 'Superior animals' were brought onto the ground for exhibition, and a nearby hunt club might be invited to set up jumps. A dance might follow the supper, but the ploughing match remained a very masculine activity and something of an initiation rite for sons.<sup>26</sup> The dinner began with 'the usual patriotic toasts' to the queen, the navy, the mayor and the society. The winners toasted the losers; the organisers toasted the judges. The best of the voices offered well-known songs, and the whole was 'full of good-humored banter and local allusions'.<sup>27</sup> Politics intruded, of course. 'Hints are sometimes dropped at the ploughing match which like seed corn, fall into some minds and bear fruit in after times'.<sup>28</sup> On the Taieri in 1876, Constable Clark collected a good many half-sovereigns owing for the dog tax; in 1909 the farmers of Timaru organised themselves on the spot to resist a manoeuvre of the threshers' union.

In addition to rewards for the skills displayed, there were prizes for the oldest participant and the youngest, or the award of a wedding cake to the handsomest contestant not yet married. In each province the champion match, with larger crowds and business sponsors from Christchurch, Dunedin or Invercargill, offered prizes 'such as to induce the presence of numerous ploughmen from remote agricultural districts, with whom it was almost impossible for local skill successfully to compete'.<sup>29</sup> The selection of judges from outside the district did not always succeed in restraining pride in place or family. In 1870 the Molyneux A & P Society in south Otago brought a court action against a contestant who, after he had been disqualified, 'detained' the Champion Belt with its silver buckle and engraved names.<sup>30</sup>

24 *Bruce Herald*, 26 October 1865, 7.

25 *Lake Wakatipu Mail*, 11 September 1872, 3.

26 In the absence or disability of a husband, wives and daughters sometimes ploughed. At Timaru 2 prominent local farmers offered prizes for a ladies' competition, but the mothers of would-be contestants objected (*Timaru Herald*, 1 July 1913, 6). On associations of male privilege with plough agriculture, see Fred L. Pryor, 'The Invention of the Plow', *Comparative Studies in Society and History* 27 (1985): 727–43; Alesina Alberto, Paola Giuliano and Nathan Nunn, 'On the Origins of Gender Roles: Women and the Plough', *Quarterly Journal of Economics* 128 (2013): 469–530.

27 *Southland Times*, 1 June 1866, 2.

28 *Bruce Herald*, 21 September 1865, 5.

29 *Otago Witness*, 26 July 1867, 17.

30 *Bruce Herald*, 7 September 1870, 3.



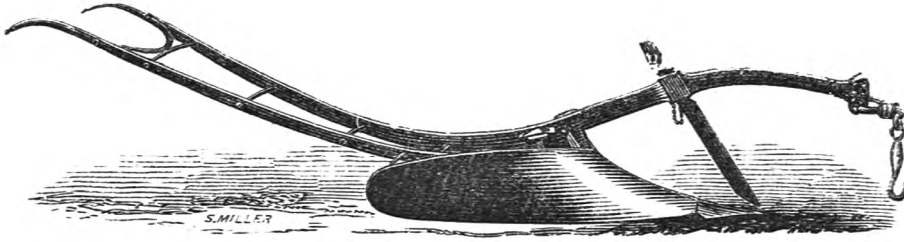


Figure 2: Single-furrow plough of 1862. The 2-horse plough displayed by John Gray of Uddingston in London, ‘strongly framed of wrought iron’, shows the knife-like coulter that made the vertical cut, the mouldboard curved to turn the slice, and at its tip the ploughshare that made the horizontal cut.

Source: The International Exhibition of 1862, 1:43. British Division, Class IX, No. 3: ‘can be used as a swing or wheel plough,—as swing plough, 95/-; as wheel plough, 102/6; with improved steel mouldboard, 7/6 extra’.

For his skill, a single individual might take several prizes: for his *fiering* (the setting of the first plough line), his masterly ins and outs, and his finish. The journalists competed in their critiques:

J. McRae’s *fiering* was rather too high. The angle of his work was not true, and the cut of his furrow was not clean, his coulter being set about two and a-half inches above the share. His furrows were well packed, but his last two were too high, and the last furrow was left too wide.<sup>31</sup>

Their judgements provoked responses from readers who proposed more elaborate regulations: ‘every man should enter the field with his coulter reversed, and not [be] allowed to touch a hammer until the signal is given for start’.<sup>32</sup>

Awards for the best-matched or quietest team and the best-kept harness reflect the importance of the care and character of the horses. Southland took increasing pride in the breeding of Clydesdales for the world market, where the cavalryman and the urban street railway driver, like the frontier farmer, valued the ability of the horse to respond instantly to a variable load, its tolerance of uneven terrain and sharp turns, and its equine skill in negotiating obstacles. Compared with a yoke of bullocks or any of the available steam engines, draught horses were a farmer’s most mobile and manoeuvrable power source.<sup>33</sup>

Conditions of weather, soils, drainage and terrain affected the competition. At Matura, Southland, in 1886 the junior class felt disadvantaged: ‘The young ploughmen had to wade through a bit of a swamp at the bottom of this dip, knee-deep

31 *Timaru Herald*, 10 August 1874, 3.

32 ‘A Ploughman’, *Bruce Herald*, 9 August 1866, 3.

33 Bullocks had gone from ploughing matches in the South Island by 1870. See Nigel E. Agar, *Behind the Plough: Agrarian Society in Nineteenth-century Hertfordshire* (Hatfield: University of Hertfordshire Press, 2005).

in water, and then ascend the face of a small but steep hill'.<sup>34</sup> Because the layout was intended to minimise such topographical variations and standardise the challenge, the outcome was a studied and artificial contest. From 1867 onward, objections were voiced: 'The ploughing that is done at many matches is not in accordance with every-day work, and is therefore not a fair criterion of the ploughman's skill'.<sup>35</sup> For some, the round and round 'plain ploughing' of ordinary farm work 'was thought of more highly than high cut or fancy ploughing by reason of the fact that with it there is no ridge left in the bottom of the furrow, and the soil is opened up to the influence of sun and air'.<sup>36</sup>

The environmental variability that interfered with a match was in fact the source of problems in everyday practical ploughing as well, and the stubborn survival of the match is evidence of the lifelong learning process in which farming communities were engaged. The competition promoted attentive observation of the animal, the actor, the implement, the weather and the soil. For the farming entrepreneur who was selecting a piece of land, remaking a landscape, or trying to extract sufficient profit to pay off debt, these were vital habits.

## Improving the plough

As an arena for competition among plough-makers, the match spurred innovation to make ploughing faster and less strenuous for ploughmen and horses alike. Local blacksmiths competed in matches of the 1860s and 1870s, and from their experience in repairs, adjustments and management of horses, made improvements; some took out patents, some purchased foreign rights, some ignored them. Reid and Gray formed their partnership at precisely the moment when, in the South Island as well as England and Scotland, foundries and small factories were taking over the role of producing the implement. Their promotion of the double-furrow model, their attention to its vexed licensing context, and their keen presence at ploughing matches were consistent with practices of the parent Uddingston firm that had made a speciality of setting ploughs for competitions.<sup>37</sup> At the 1872 match

34 *Southland Times*, 15 July 1886, 3.

35 'Agricola', *Otago Witness*, 15 March 1911, 6.

36 *Timaru Herald*, 26 August 1910, 6.

37 John Gray of Uddingston had been forced to compensate Thomas Pirie of Aberdeenshire for patent infringement and had claimed further improvements; see Heather Holmes, 'A Relationship to Deliver Agricultural Innovation in Scotland: Thomas Pirie, George Greig and John Fowler & Co., 1869–1884', *Scottish Business and Industrial History* 30 (2015): 42–72. The horse-drawn ploughs advertised by Gray in Scotland and by Reid & Gray in Oamaru were identically fitted that year with malleable steel shares and circular steel coulter: *North Otago Times*, 25 March 1870, 2, and 20 May 1870, 2. James Gray had reached the status of engineer in the Uddingston ironworks, where Reid also had gained experience. *North British Agriculturist*, 19 July 1893, as reprinted in the *Otago Witness*, 17 August 1893, 8.

in Oamaru, Reid & Gray had made all the ploughs in the double-furrow class, and 'as those gentlemen were on the ground examining the practical working of their implements, it may safely be inferred that other improvements will yet be effected'.<sup>38</sup>

By 1874, many of the double-furrows entered in matches across the southern South Island carried the Reid & Gray label, while most of the single-furrow, wheeled ploughs were imports from George Ponton of Linlithgow, West Lothian, or assembled 'with a good few imitations and parts of local manufacture'. The trend in sales, as shown in Table 1, confirms their success in promoting an implement that would cut a broader swath. Replacing the single- with the double-furrow required double the initial outlay and a larger team to draw it, but by doubling the output of the driver saved its cost in 5 or 6 weeks.<sup>39</sup>

Table 1: Numbers of ploughs sold by size and type 1911, 1914 and 1917.

	Numbers sold (n)			Percentage		
	1911	1914	1917	1911	1914	1917
Single-furrow	171	260	113	16.9	25.0	20.3
Double-furrow	476	422	180	47.1	40.7	32.3
Three-furrow	123	137	88	12.2	13.2	15.8
Four- or five-furrow	4	1	24	0.4	0.1	4.3
Hillside plough	61	74	26	6.0	7.1	4.7
Drill or swamp plough or subsoiler	90	68	45	8.9	6.6	8.1
Cultivator & other	86	76	82	8.5	7.3	14.7
<b>Sum</b>	<b>1,011</b>	<b>1,038</b>	<b>558</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
Disc ploughs (included above)	94	84	29	9.3	8.1	5.2

Source: Reid & Gray Archive. Hocken Collections Uare Taoka o Hākena MS-1165/007.

The advantages of the wider plough would pay off only if the other 'desiderata' were achieved: greater strength and reliability of the implement, along with lighter weight and ease of manoeuvre. To marry these contradictory properties would require, as will be explained further, access by the manufacturer to improved materials. While the horse-drawn plough could last many years, it required frequent sharpening, repair and replacement of parts broken by stones and stumps, and the double-furrow was even more vulnerable. A 14-year-old ploughboy in 1906 described his latest trip to the blacksmith: 'About once a week I break the plough, I have just come back from Ranfurly to-night.'<sup>40</sup>

<sup>38</sup> *North Otago Times*, 3 September 1872, 2.

<sup>39</sup> *North Otago Times*, 25 March 1870, 2, citing John Gray of Glasgow to a Oamaru correspondent, presumably Gray or Reid. Prices according to breadth (per 'furrow') at £10, £20 and £30 from Reid & Gray Day Book, 1871 to 1873. MS-1165/008. Hocken Collections. As in Britain, improvements in the strength and reliability of the plough were not accompanied by detectable increases in price. See Brunt, 'Mechanical Innovation'; Wray Vamplew, 'The Progress of Agricultural Mechanics: The Cost of Best Practice in the Mid Nineteenth Century', *Tools and Tillage* 3 (1980): 204–14.

<sup>40</sup> 'Oscar Wilde' (pseud.), 'Letters from Little Folk', *Otago Witness*, 24 October 1906, 74.

Competition with importers and local smiths demanded continual innovation. The partners maintained their licences for the Uddingston models and produced a stream of patents of their own. About 1880 they introduced the equalising chain yoke, decisive for working a team larger than 2, and in 1890 a new lever for control of depth of furrow.<sup>41</sup> Over 30 years the firm registered 45 patents, including shares and points of ‘unbreakable steel’. They spent more on the patent process than any other enterprise in the colony.<sup>42</sup>

Although the steam-powered plough was much discussed, it did not show up at the local matches.<sup>43</sup> The British-made Fowler No. 1, which resembled a system of 2 small locomotives, was steadily advertised in New Zealand from the 1850s, and several large landowners acquired it. Gray’s first assignment in New Zealand, in 1868, had been a contract on the Morton Mains estate, Southland, where he delivered and operated a steam plough whose assembly he had supervised in the Uddingston plant, according to Fowler’s patents, under contract with Fowler, and powered by a 20 hp Aveling & Porter engine.<sup>44</sup> By 1885 the ‘hissing monster’ at Morton Mains was rusting behind a screen of long grass, a ‘relic of a time when the wealth of the City of Glasgow was poured out over these plains with the lavishness of gold digging times’.<sup>45</sup> The £600 steam plough would exceed by 40 per cent a small farmer’s entire start-up lump estimated in Table 2. The plough scaled to the family farm was the Reid & Gray double-furrow, at £20.

41 B. L. Evans, *A History of Farm Implements and Implement Firms in New Zealand* (Feilding: privately published, 1956), 8; *The Press* (Christchurch), 10 November 1899, 9.

42 Matthew Gibbons, ‘Patenting in Nineteenth Century New Zealand: An Economic and Historical Analysis’ (MMS diss., University of Waikato, 2016), 101 and 103; ‘Annual Reports of the Registrar of Patents, 1880–1911’, in *Appendix to Journals of the House of Representatives*, series H–10, [atojs.natlib.govt.nz](http://atojs.natlib.govt.nz), accessed 30 October 2019.

43 An exception, J. Withell exhibited a steam plough he had recently imported: *Timaru Herald*, 25 July 1910, 2. On the limitations of steam ploughing elsewhere, see Michael R. Lane, *The Story of the Steam Plough Works: Fowlers of Leeds* (London: Northgate, 1980); Annie Tindley and Andrew Wodehouse, ‘The Role of Social Networks in Agricultural Innovation: The Sutherland Reclamations and the Fowler Steam Plough, c.1855–c.1885’, *Rural History* 25 (2014): 203–22.

44 *Southland Times*, 12 May 1863, 2; 7 August 1864, 2; 26 December 1866, 2; 4 January 1867, 3; *Otago Daily Times*, 11 November 1868, 3. Holmes & Co. was one of 18 Scottish firms amalgamated as the New Zealand and Australian Land Company. For the simultaneity and logic of John Gray’s push into colonial markets for the horse-drawn double-furrow and Fowler’s push for the steam plough in foreign markets (France, Egypt and Algeria) see Holmes, ‘A Relationship’, 61.

45 *Southland Times*, 31 December 1872; *Otago Witness*, 16 November 1878, 4, and 10 September 1881, 7; *Otago Witness*, 20 June 1885, 12. See also Kevin Tennent, ‘Management and the Free-Standing Company: The New Zealand and Australia Land Company c. 1866–1900’, *Journal of Imperial and Commonwealth History* 41 (2013): 84.

Table 2: Estimates of start-up investment for a small farm, 1881.

Recommendation of	Murray	Agricola		Grigg	
	£	£	s	£	s
Double-furrow plough		18	0	18	
Set of swingle trees			15		
Harrows, 4 leaves			15	10	
Dray		8	0	20	
Bars – one for 4 leaves, one for 3 leaves			12		
<b>Subtotal plough, harrows &amp; dray</b>	<b>45</b>	<b>66</b>	<b>2</b>	<b>48</b>	
Team of 3 horses	100*	120	0	90	
Harness for 3 horses, plough & cart		7	14	20	
Oaten chaff, 1 ton		2	10	15	
Chaffcutter	13			7	
Roller		5	0	20	
Horse-hoe with scarifier, drill, rake				45	15
<b>Subtotal implements &amp; team</b>	<b>158</b>	<b>211</b>	<b>6</b>	<b>245</b>	<b>15</b>
Rent of land	40				
House and outbuildings	60				
Fencing material	45				
Sheep	25			7	10
Cows, pigs & poultry	20			125	
Seed	12			34	
<b>Total capital</b>	<b>518</b>	<b>440</b>	<b>15</b>	<b>702</b>	<b>0</b>

'Agricola' proposed his own design—'about the size and weight of a wheelbarrow'—for a wheeled plough with attachments for hoeing, grubbing and lifting potatoes.

\* Harness included

Sources: J. U. Murray, 'Small Farms Prize Essays', *Otago Witness*, 26 April 1881, 6, and 'Agricola', *Otago Witness*, 23 and 30 April 1881, 7; 'Address of John Grigg', *Ashburton Herald*, 23 June 1880, 2.

In the mid-1890s, as more favourable commodity prices hastened the speculative subdivision of great estates into family-size enterprises, purchasers of land pressed for ploughs that could operate on steep hillsides, turn without bogging or capsizing, cut into matted wetland vegetation, or burrow through heavy clay.<sup>46</sup> Reid & Gray was already offering hillside ploughs and ploughs 'convertible into diggers', able to give the roots 'access to the whole strength of the soil'.<sup>47</sup> At Wairio in western Southland, the heavy work of ploughing drains had required a team of 18 horses, but farmers

46 J. D. Gould, 'Pasture formation and improvement in New Zealand, 1871–1911', *Australian Economic History Review* 16, no. 1 (March 1976): 1–22.

47 'Yorick', *Otago Witness*, 19 March 1881, 6.

reported in 1897 that the improvements had reduced that to 12: 'All the farmers go in for draining their land with it, and crops they were satisfied with before the drain plough came in, they would scarcely think worthwhile cutting now'.<sup>48</sup>

None of those features was entirely new. The eighteenth-century improvers in England and Scotland had urged deeper ploughing, reshaped the mouldboard on physical principles and introduced the dynamometer to measure draught.<sup>49</sup> Each new type of plough had emerged in a different agricultural region—in response to the 'sticky soils of Essex', the 'stiff tenacious clays' of East Lothian, or the boulder-strewn slopes elsewhere in Scotland. Liam Brunt has documented a slow diffusion across Great Britain of improvements first adopted in local centres, and by the 1850s many models were available as off-the-shelf factory products both there and in North America.<sup>50</sup>

Despite the increasing range of options, farmers on successive agricultural frontiers—the Shenandoah Valley in the 1820s, bottomlands along the Ohio and Mississippi Rivers in the 1850s and wetlands of the South Island of New Zealand in the 1870s—resisted the wider and heavier deep-cutting plough. Satisfied with a shallow first ploughing of the top 3 or 4 inches, they left it to the next generation to deepen the ploughed layer to 5 or 6 inches.<sup>51</sup> Each advance of the technical frontier—stronger beam or lighter draught—opened more land to levelling, draining and cropping; each advance of the geographical frontier imposed a new test of the implement and another round of experiment and adaptation.

## A manufacturer's pitch

How South Island manufacturers and importers promoted their wares provides evidence of feedback of economically important information to manufacturers. Reid & Gray, in addition to the competitions among ploughmen, arranged demonstrations with rival implements and 'trials in motion' at the annual A & P shows. Like so many of their customers in Otago and Southland, the 2 men were offspring of 'agricultural improvement' and 'industrial enlightenment' in their Scots

48 *Southland Times*, 1 August 1890, 3.

49 G. E. Fussell, *The Farmer's Tools, 1500–1900* (London: A. Melrose, 1952).

50 H. Stephens, 'The Yester Deep Land Culture', *Journal of Agriculture* (Edinburgh), new series 52 (July 1855): 1–16; Liam Brunt, 'Mechanical Innovation in the Industrial Revolution: The Case of Plough Design', *Economic History Review* 56 (2003): 444–77; J. A. Symon, *Scottish Farming, Past and Present* (Edinburgh: Oliver & Boyd, 1959); Heather Holmes, 'A Neglected Innovation: The Double-Furrow Plough in Scotland, Its Early Adoption and Use, 1867 to 1880', *Agricultural History Review* 64 (2016): 54–80; Heather Holmes, 'Agricultural Implement Makers in Scotland during the Late Nineteenth and Early Twentieth Centuries', *Folk Life* 51 (2013): 44–74.

51 Steven Stoll, *Larding the Earth: Soil and Society in Nineteenth-Century America* (New York: Hill and Wang, 2002); C. H. Danhof, 'The Tools and Implements of Agriculture', *Agricultural History* 46 (1972): 81–90; Leo Rogin, *The Introduction of Farm Machinery in its Relation to the Productivity of Labor in the Agriculture of the United States during the Nineteenth Century* (Berkeley, CA: University of California Press, 1931).

versions.<sup>52</sup> Gray's grandfather in Uddingston had entered his implements in the highly rated display of the Highland and Agricultural Society of Scotland in 1803; James' father obtained a prize medal at the Crystal Palace exhibition of 1851 and displayed 9 machines at the International Exhibition of 1862 in London. These competitions were reported with handsome lithographs in the most prestigious farm journals. Although we consider only one class of implements and draw on the records of a single manufacturer, the selling points resonated with farmers across the South Island and were reported to British and US competitors by their commercial agents.

The marketing ploys apparent from regional news coverage of A & P shows were of 3 types. First, the year's new and improved plough was touted for its combination of greater strength and lighter weight—the properties so often mentioned by judges at matches. The second virtue on offer was reliability. Since each farmer wanted to minimise downtime (and the number of trips to Ranfurly or Ashburton), Reid & Gray cultivated a reputation for prompt replacements for worn or damaged parts, and 'for a few pounds' the company would rebuild an implement and install the latest features. British manufacturers had created the image of the durable tool that looked the part: brand name and trademarks, a rugged, heavy-duty machine, traditional in style and highly finished (see Figure 3). Reid & Gray imported implements and parts from reputable suppliers and, consistent with the practice of other firms, they contracted to place their own name on the imported item: 'Tyzack's knives to be branded Reid & Gray No 13T'. On an order for manganese steel plough points they specified: 'We want our initials, R & G as well as the letter M cast in'. To Bamford & Sons of Uttoxeter they wrote: 'Will only place order if company removes its name from all parts.'<sup>53</sup> In 1912, to give prominence to the name and stylishness of their prizewinning ploughs in their annual catalogues Gray contracted for electrotype printing blocks with the London engraver P. Naumann.<sup>54</sup>

52 Joel Mokyr, *The Gifts of Athena* (Princeton, NJ: Princeton University Press, 2002), 51 and 34–7; Gwyn E. Jones, 'The Diffusion of Agricultural Innovations', *Journal of Agricultural Economics* 15 (1962): 387–409.

53 Reid & Gray archive, Order Book 1914–1915. MS-1165/003. Hocken Collections. They made a similar demand of Chicopee hillside ploughs (shipped 12 July 1912). To obtain the loyalty of its rural clients, the firm sought licences for other implements: Bamford's mowers, saw blades from Spear & Jackson, threshers, windmills, pumps, and Swedish separators, all with the Reid & Gray nameplate. The same practices are well documented in Winder, *American Reaper*, 37–63.

54 Peter W. Sinnema, *Dynamics of the Pictured Page: Representing the Nation in the Illustrated London News* (Brookfield, VA: Routledge, 1998).



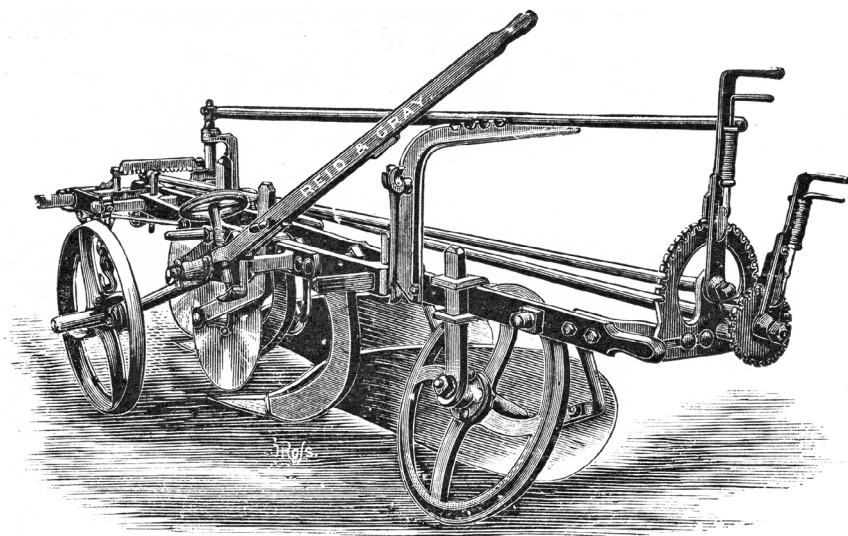


Figure 3: The Reid & Gray double-furrow plough. The 1901 catalogue featured the 'Champion' at £21, with circular coulters, 6 steel shares and Gray's patent steering gear: 'Simple, perfect, and easy to manipulate, it is just the plough that a ploughman who takes a pride in his work would like to handle.'

Source: Reid & Gray Limited 1901 catalogue. Hocken Collections Uare Taoka o Hākena MS-1164/045.

In contrast with the broad appeals of strength and reliability, the third advertising pitch was differentiated to assert a tailoring of the product to a particular market. From the first moment, Reid & Gray had framed their implements as right for New Zealand seasons and soils. In 1873, their 'colonial-made ploughs held their own' with the imported makes, and 5 years later they were still emphasising 'a strength suited for rough and new country'.<sup>55</sup> They reasserted the distinction into the 1920s, and indeed, Juan Homs, scouting for business opportunities for the US Department of Commerce at the end of the First World War, accepted the argument, reporting that New Zealand soils were 'not easy to plow'. New Zealand farmers, Homs was told, were willing to pay more for locally made implements, and the ploughs on sale were 'made to withstand very severe usage, with strength and simplicity, and no others in proportion to weight have so few parts'.<sup>56</sup>

At the turn of the century, competing manufacturers were employing this strategy for a wider array of implements. In Invercargill, James Macalister advertised his swamp plough as 'made specially for the requirements of Southland',<sup>57</sup> and Marshall's, a British firm long reputed for its steam engines, emphasised its 'great

55 *The Press*, 14 November 1873, supplement, 5; *Otago Witness*, 23 November 1878, 21.

56 Juan Homs, *Agricultural Implements and Machinery in Australia and New Zealand* (Washington, DC: Government Printing Office, 1919), 177 and 179.

57 *The Press*, 10 November 1899, 9.

solicitude in studying colonial requirements' for tolerance of inferior fuels.<sup>58</sup> A Canadian manufacturer offered a knife harrow heavier than for its domestic market, and Osborne's of Auburn, New York, redesigned its disc harrow with sand-proof bearings and a flexible head that would permit the gangs to rise independently over stumps and stones.<sup>59</sup>

Successful on frontier land, Reid & Gray at the same time proposed lighter models to work previously ploughed land already under lea or stubble. Bolt-on attachments adapted the implement for boring drains, and easy removal of the second share was advantageous for working a small team or a small field. The firm extended its offerings to suit any size of purse. In addition to the smaller start-up farms and the well-established estates able to undertake frequent upgrades of equipment, the company targeted a third clientele of increasing importance—the local contractor with a mobile outfit. By 1910, farmers such as Alec Davidson (Joseph's son) found it advantageous to hire an independent contractor for a few days a year. Such an outfit, with local clients, local workers, and a 10 hp steam engine, travelling within the radius of a county (15–25 km), could keep busy 7 to 9 months a year by ploughing in one season, harvesting and threshing in another.<sup>60</sup>

The large and small landholders polarised politics and continue to orient historical accounts, but their activities were often complementary. Many holders of small properties went contracting or cropping for several years to finance their own land purchases, and corporate owners, as they moved toward subdivision and speculative resale, contracted to such enterprises the first-ploughing and laying down in grass. On the Morton Mains estate in the winter of 1878–79—a decade after the initial venture with Gray's steam plough—the New Zealand and Australian Land Company was again breaking up land to bring into cultivation 8,000 acres more, and all the ploughing was performed by contract teams with draught horses hauling double-furrows purchased from Reid & Gray.<sup>61</sup>

To reach so diverse a market, Reid & Gray proposed implements of all sizes and for all local preferences: for 3 subregions, 3 models of its popular double-furrow. 'A plough that suits a Southland farmer would not be given yardroom by a Canterbury man, and vice versa'.<sup>62</sup> One size did not fit all; the implement had to be calibrated to local conditions, again and again redesigned and rebuilt.

58 *Otago Witness*, 3 December 1891, 16; 30 November 1899, 21; 5 December 1900, 16.

59 *Otago Witness*, 30 Nov 1904, 25; 29 November 1905, 26.

60 To power threshers and other barn equipment, Reid & Gray promoted Clayton & Shuttleworth steam engines made in Lincoln, England: 1 or 1½ hp for the small farm, 8 or 10 hp for a contractor. For examples of contract enterprise in several counties, see *Otago Witness*, 3 May 1911, 39. Martin, *The Forgotten Worker*, estimates the transition substantially reduced dependence on itinerant labour: 3f., 109, 136. On lifestyles in contract work, see Miles Fairburn, *Nearly Out of Heart & Home: The Puzzle of a Colonial Labourer's Diary* (Auckland: Auckland University Press, 1995), 74–91.

61 William Solter Davidson, *Notes Describing the Freehold Lands Offered for Sale by the New Zealand and Australian Land Company Limited* (Edinburgh: Muir and Paterson, 1880), 40 and 13–19.

62 *Otago Witness*, 23 November 1878, 21.

The incremental process involved many people at various stages of production. In each new situation, the need to test and tinker promoted talk along the production and marketing chain. In 1882, for instance, Reid & Gray adapted a double-furrow for planting potatoes and showed it off at Cave Valley (North Otago); the farmer who bought it made further alterations which Reid & Gray promptly introduced into its manufacture.<sup>63</sup> The same year, the foundry gave advice on preventing breakage of a connecting-rod via the 'Queries' column in the *Otago Witness* to a farmer in the Clutha Valley.<sup>64</sup> In July 1911, when Reid & Gray ploughs failed to take a single prize in a match held in Nelson Province, the local agent suggested the replacement of single-leaf with double-leaf springs. To the British engine manufacturer Burrell, the Dunedin manager wrote: 'We attach herewith copy of letter from our Ashburton manager re crank shafts and new main axle breaking. This district is in the centre of the Canterbury Plains and therefore no hills or rough country to negotiate. Can you give any cause for such breakages?'<sup>65</sup> Competitors of Reid & Gray were likewise providing feedback to their suppliers. In Christchurch, Andrews & Beaven, as agents for Blackstone, insisted that the British manufacturer reduce the weight of its portable engine to make it 'as handy as possible for getting about on the average New Zealand roads'.<sup>66</sup> Through close observation at trials, shows and matches, and person-to-person commentary, the farmers of southern New Zealand were making themselves heard.

## The edge and the twist

Progressive substitution of iron for wood, steel for iron, and the development of tough edges for ploughshares required a half-century of experimentation with a wide range of metals. The critical innovations emerged from interactions in the network of agents and suppliers displayed in Figure 4 from order books of the firm. In a network of this kind, any transaction may reinforce, redirect or extend the dynamic structure, and the company's agents were surveying a worldwide array of possibilities. The pattern was nevertheless remarkably stable. The structure is derived from what appear to be complete entries for the years 1911–24, but import notices for 1871–74 and letter books for 1878–1910 confirm loyalty to many of the same suppliers from the start.<sup>67</sup>

63 *Otago Witness*, 21 October 1882, 7.

64 *Otago Witness*, 25 March 1882, 17. This concerned a reaper made obsolete by Reid & Gray's new model.

65 Reid & Gray archive, Order for parts for 7 hp steam engine.

66 Andrews & Beaven, see *Progress*, 1 May 1908, 6; other competing foundries, P. & D. Duncan, *Oamaru Mail* 20 November 1879, 2; Haxton & Beattie, *Otago Witness*, 25 June 1881, 7; A. & T. Burt, *Otago Witness*, 26 April 1894, 35, and *Progress*, 1 February 1906, 10, and 1 November 1906, 10. Each occupied a distinctive manufacturing niche, acted as agent for a different array of imports, but depended on many of the same suppliers for the edge and the twist.

67 Among them Nettlefold for screws, Harper (Aberdeen) for keys and fence strainers, and Jackson & Turner (Glasgow) for spring steel. Order book for year beginning 20 March 1882. MS-1165/006. Hocken Collections.

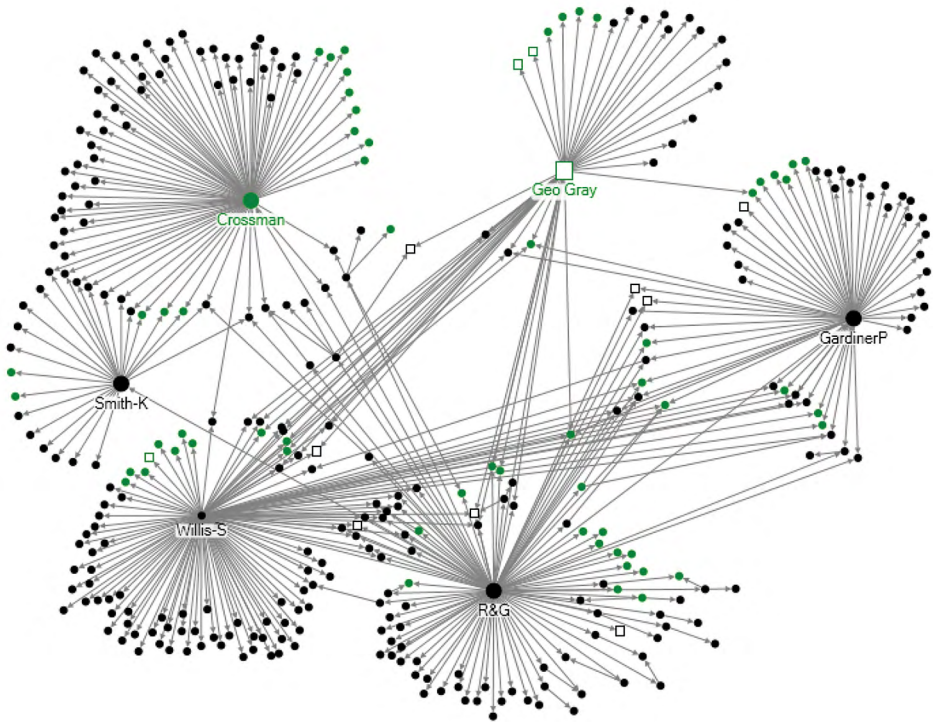


Figure 4: Reid & Gray addresses its supply network, 1911–14. Reid & Gray ordered directly from 30 firms and addressed 300 others through key agents. The open squares represent sites in Scotland. Shown in green are suppliers of edges and twists, most of them located in Sheffield.

Source: Reid & Gray Archive, Order books 1911 (last quarter) – 1914. Hocken Collections Uare Taoka o Hākena MS-1165/003. Created by the authors using NodeXL.

Table 3: Numbers of Reid & Gray orders by year and by geographical region.

	1912	1913	1914	1915	1916	1924	Sum (n)	Sum (%)
Australasia	1	1	3	7	1	8	21	1.7
England	127	125	154	133	50	151	740	60.3
Scotland	12	11	14	19	5	20	81	6.6
Europe	7	10	6	6	5	13	47	3.8
North America	35	43	45	38	25	39	225	18.3
Other	3	1		3	1	5	13	1.1
Unknown	17	21	16	19	8	20	101	8.2
<b>Total</b>	<b>202</b>	<b>212</b>	<b>238</b>	<b>225</b>	<b>95</b>	<b>256</b>	<b>1228</b>	<b>100.0</b>

Source: Reid & Gray Archive, Order books 1912–16 and 1924. Hocken Collections Uare Taoka o Hākena MS-1165/002–4.

Even during the First World War, the regional pattern of supply was maintained (Table 3). Correspondence indicates a wartime search for Canadian sources of steel, and for the set of tyres and inner tubes to suit Gray's own Crossley landau motor car: 'any make except German'. As late as 18 February 1916, letters to the London agent Patrick Gardiner anticipated a quick end to the war, but British suppliers were already caught up in the rising sense of urgency and conversion to a demanding and lucrative armaments industry,<sup>68</sup> and subsequent letters reflect further adjustments to a wartime 'stiffening of prices' and postwar inflation.

More important in terms of the intrusion of novelty into South Island farming were progressive shifts in the metallurgy. The technological changes can most easily be understood by distinguishing 3 types of purchases, each of which presented a distinct challenge to the company's business strategy: entire machines and engines, the supply of pig iron and bulk steel for castings, and—most demanding—critical parts made of high-quality, high-priced 'special steels'.

## Entire machines

When first established, Reid & Gray imported entire machines as well as equipment for their own workshop. We have found no details of the initial financing, but they equipped and re-equipped the foundry with the best, imported mainly from Britain or made by themselves: a British-made cupola furnace for melting iron, a screw-cutting lathe, planing and slotting machines, and an American-made tilt hammer.<sup>69</sup> The initial investments, the patents they advertised and James Gray's reliance on his older brother George as a purchasing agent resident near Glasgow all point to traditional practices of Scottish and English family firms whose face-to-face information networks were so effective in a trading world of custom design and purchase on credit.<sup>70</sup> Throughout the half-century, the kinship network underpinned the financial security of the firm and its geographic reach. This was the model initiated by the banks, land and mortgage companies, and the stock and station agencies whose networks Simon Ville has described as stretching between Great Britain and Australasia.<sup>71</sup> As brokers of wool and other farm products, the station agencies were also formidable competitors as importers of farm equipment, well positioned in the local sales network displayed in Figure 5.

68 Notably bayonet steel, and Vickers, producing Maxim guns.

69 The 1872 fire loss was estimated at £3,500 (*North Otago Times*, 22 October 1872, 2). For published accounts of the scale and equipment of the plant, see *Otago Witness*, 4 December 1875, 5; 3 August 1878, 3; 23 November 1878, 6; 18 May 1883, 6; 20 November 1878, 8; 25 January 1894, 18; *Otago Daily Times*, 9 January 1900, 12.

70 Robert J. Morris, *Men, Women and Property in England, 1780–1870: A Social and Economic History of Family Strategies Amongst the Leeds Middle Classes* (Cambridge: Cambridge University Press, 2005); Jim McAloon, 'Scots, Networks and the Colonial Economy: The Nineteenth-century Business relationships of Sanderson & Murray of Galashiels and Murray, Roberts & Co. of Dunedin', *Immigrants and Minorities* 29, no. 3 (2011): 243–63.

71 Simon Ville, *The Rural Entrepreneurs: A History of the Stock and Station Agent Industry* (Cambridge: Cambridge University Press, 2000); Simon Ville, 'Making Connections': Insights into Relationship Marketing from the Australian Stock and Station Industry', *Enterprise and Society* 10 (2009): 423–48.



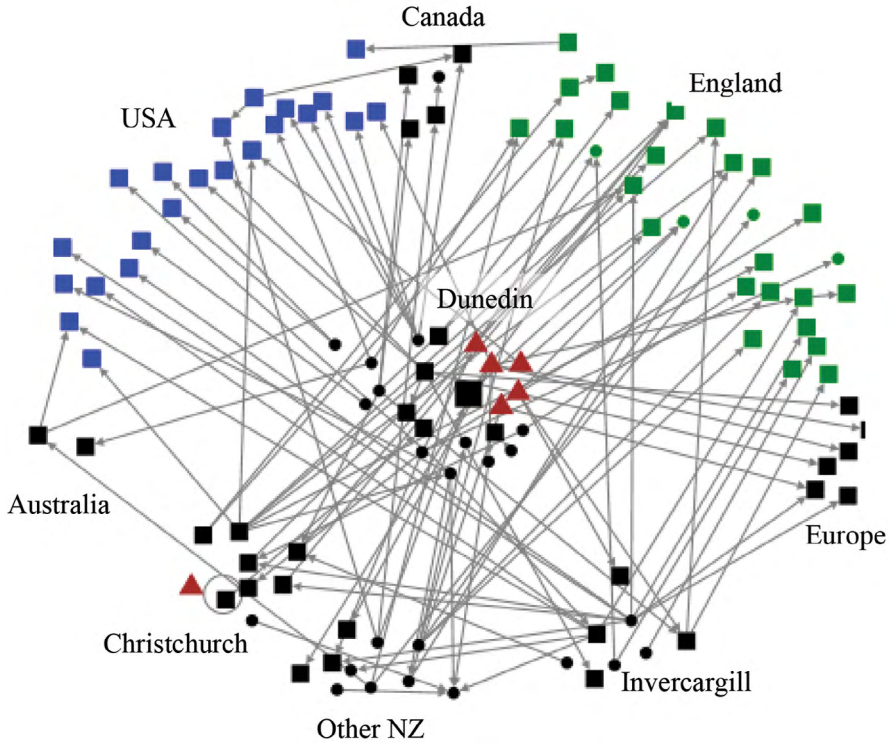


Figure 5: Network of firms competing with Reid & Gray in 1906. Shown are 112 relationships of agency authorised for import or representation of a manufacturer to landholders in the South Island for purchase of ploughs, reapers and other large machines. Red triangles identify the stock and station agencies, blue squares US manufacturers, green squares British manufacturers.

Sources: Advertisements and journalists' accounts of Agricultural & Pastoral Shows, from *Otago Witness*, *The Press* (Christchurch), and *Southland Times* (Invercargill).

Gardiner, an agent operating from London and Glasgow, brokered the purchases of Reid & Gray with the British engine manufacturers: Charles Burrell & Sons for steam traction engines, Clayton & Shuttleworth for threshing mills and Richard Hornsby & Sons for oil engines. In New York City, Crossman & Sielcken handled a wider array of transactions with select North American manufacturers of pumps, windmills and dairy equipment.

Throughout the history of the firm, Reid & Gray imported more (by value) than they manufactured; their own lines were carefully targeted, and important elements in the value added were selection, testing, the guarantee and service. Engines and farm implements could be imported from Britain and Victoria, Australia, free of duty, while the implement manufacturer in the colony was perennially threatened with a tariff (c. 15 per cent) on raw materials and parts. In July 1877, Reid & Gray mobilised a torchlight demonstration against the tariff by the 600 iron workers

of Dunedin.<sup>72</sup> About 1886 the firm abandoned the manufacture of the American-style reaper–binder they had patented and shown with pride in 1878.<sup>73</sup> The tariff issue resurfaced in 1898 and 1906.<sup>74</sup>

## Raw materials

The need to import basic materials set limits to the import substitution strategy, and rendered the firm vulnerable to shifts in the scale, scope and control of steel making in Scotland, England and the United States.<sup>75</sup> Steelmakers in the British Midlands and the United States were developing processes for high-volume continuous production of bulk steel. The well-known coke-fuelled processes initiated in Britain in the 1860s (Bessemer and Siemens–Martin open-hearth) yielded a material of great strength (primarily in compression and tension), but variable and relatively brittle. It required 15 years of experimentation to obtain a reliably uniform product that would replace wrought iron. Control of the dosage of carbon was critical to the response to subsequent operations of heating and cooling, rolling or drawing.<sup>76</sup> British and German techniques were adapted in the United States through moves by workers and entrepreneurs, purchases of patent rights and experimentation with a wider range of ores and fuels, so that by 1900 the economies of scale of taller furnaces operating at higher temperatures had cut the cost of bulk steel by half and fostered the emergence of the powerful ‘Big Steel’ monopoly in markets for rolled steel, wire and nails.<sup>77</sup>

72 *Otago Witness*, 21 July 1877, 1; *Thames Advertiser*, 6 August 1877, 3; *Otago Witness*, 11 August 1877, 5; *Otago Daily Times*, 27 August 1877, 2.

73 Early models in 1869 were ‘winning high encomium’ (*North Otago Times*, 26 February 1869, 2; 14 November 1871, 2); a reaper was heavily promoted in November 1874; the ‘extraordinary feat’ of matching the American combine was achieved with a reaper–binder, ‘every part of which was made in Dunedin’ (*Otago Daily Times*, 18 February 1878, 2; 1 March, 2; 27 August, 2). By 1881 they had sold 2,200 reapers, as well as 5,000 of the double-furrow ploughs. Reimposition of charges contributed to the firm’s abandonment of the manufacture of reapers in the mid-1880s, and subsequently of threshers; they became agents for Mercer in 1891 and for Deering in 1896. On the impact of the trust in Australasia, see *Progress*, 1 November 1905, 14; on the international context, see Winder, *The American Reaper*, 12.

74 The competing foundries were quick to collaborate on the tariff issue, wage policies and debt collection, but slow to negotiate trust agreements. The merger of McCormick and Deering stirred proposals for the amalgamation of local firms (*Lyttelton Times*, 7 February 1903, 7), and aggressive marketing by the North American harvester trust in 1905–6 coincided with the arbitration of moulders’ wages in Dunedin and Christchurch. On 23 September 1910, Booth MacDonald again proposed amalgamation to the 4 others; Reid & Gray rejected it (Reid & Gray correspondence. MS-1165/018. Hocken Collections).

75 Peter L. Payne, *Colvilles and the Scottish Steel Industry* (Oxford: Clarendon, 1979); T. S. Ashton, *Iron and Steel in the Industrial Revolution* (Manchester: Manchester University Press, 1924); Erickson, *British Industrialists*.

76 The qualities of steel are obtained from iron alloyed with 0.2 to 1.5 per cent carbon. For the lag in scientific understanding of what artisans were actually achieving, see C. S. Smith, ‘The Discovery of Carbon in Steel’, *Technology and Culture* 5 (1964): 149–75.

77 J. M. McFadden, ‘Monopoly in Barbed Wire: The Formation of the American Steel and Wire Company’, *Business History Review* 52 (1978): 465–89.





Figure 6: Reid & Gray plough seat, c. 1924. Castings such as this were made in Dunedin.

Source: Courtesy of Ozwrenches, 'New Zealand Showcase', [ozwrenches.com](http://ozwrenches.com).

Reid & Gray, from the outset, had imported pig iron, which they remelted in their own cupola furnace to produce iron castings in the shapes desired for a plough beam, mouldboard or plough seat, as shown in Figure 6.<sup>78</sup> For pig iron the firm gradually substituted bars of mild steel, which like pig iron had a very low carbon content (it is properly called iron) and was workable when cast.<sup>79</sup> Seeking always to keep 300 or 400 tons in stock, they favoured no single supplier, but relied on the month-to-month judgements of George Gray in Scotland and Willis, Sindall & Co., who specialised in the international iron trade, with headquarters in London and branch offices in New York City, Auckland, Melbourne and several Asian cities. Costs of shipping also fell by half over the period 1864–1914, but transport charges for material of such high unit weight encouraged recourse to the Tata smelter in Bengal from the moment it came into production in 1907.<sup>80</sup>

78 Reports of the scale of operation are fragmentary: in 1877, 350 tons of pig iron per year (*Otago Witness*, 23 November 1878, 6); in 1894, 100 tons of cast chilled shares per year (*Otago Witness*, 25 January 1895, 18); in 1905, 400 tons of pig iron, 400 of bar iron and 100 of 'standard iron' (the last referring to iron for casting fencing standards).

79 Reid & Gray's order books employ a variety of terms, all referring to iron suitable for casting: Bessemer pig, hæmatite pig and Garstberrie pig, bevil iron, mild steel bars, and rolled steel bars.

80 E. A. V. Angier, *Fifty Year Freights* (London: Fairplay, 1920). Reid & Gray imports from Bengal were handled by Briscoe, an iron merchant with agencies in London, Wolverhampton, Melbourne, Sydney and Dunedin. Tata is now the world's largest steel company. Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850–1940* (Oxford: Oxford University Press, 1988), 274–94.

## Blades and bearings

Less obvious, but critical to the efficiency of the plough and central to the business trajectory of Reid & Gray, were smaller-volume suppliers of the higher-grade special steels that combined exceptional hardness with malleability. Every cutting edge needed at least a sheath or welded edge of hard metal: shares, coulter and points for the ploughs; knives and teeth for harrows and other instruments of cultivation. Like the ploughshares and knives, wearing parts subject to shear stress were liable to break: springs, hinges, pinions, spokes for wheels, axles and axle boxes, wire rope and crankshaft chains. It is this set of parts—the cutting edge and the twist—that best reflect the impact of international advances in steel making on the landscape of enterprise in the South Island.

In the early 1870s, Reid & Gray could recover in Oamaru or Dunedin scrap iron with the desired low carbon content and good uniformity, such that it could be reworked for ploughshares. They welded worn-out saw blades, for example, originally of wrought iron, to a core of softer iron for a hard-edged, self-scouring ploughshare. Demand soon exceeded the local supply of scrap, and because there were no sources in Australasia, Reid & Gray, like the American arsenals during their civil war (1861–65), ordered the edge and the twist from the Sheffield manufacturers shown in Table 4.

Table 4: Sheffield suppliers to Reid & Gray, 1912–24, by types of goods.

Supplier	Principal items	Agent	Orders (n)
S. Osborne & Co.	Spring steel, highspeed drills, reamers	Gray, Willis S.	39
Tyzack & Turner	Knives, discs, nails, screws, springs	Willis Sindall	30
Ransom Sims & Jefferies	Engine parts, cast iron plough shares	P. Gardener	29
Tempered Steel Co.	Spiral tubes, springs, shares	Willis Sindall	26
Spear & Jackson (Etna)	Saw blades, coulters, discs, springs	direct	22
Ellin Footprint Works	Wrenches, hammers, spanners	P. Gardiner	10
Hadfields Steel Foundry	Manganese steel bars, shares & points	G. Gray	5
Wardsend Steel & Co.	Steel mouldboards & plough plates	Willis Sindall	5
W. Cooke & Co.	Spoke iron & chilled plough shares	G. Gray	4
G. T. Skelton	Steel moulders shovels	Willis Sindall	3
J. Evans & Sons	Forged spanners	direct	3
Bury & Co.	Steel beater bars & plough plates	P. Gardiner	2
Eagle & Globe Steel Co.	Bastard files & drawn steel bars	Willis Sindall	2
J. H. Andrew	Bars of iron, mild steel, spring steel,	G. Gray	2
B. K. Morton	High speed steel	P. Gardiner	1
Bung & Co.	Beater bars	P. Gardiner	1
J. Shaw Ltd	Steel wire rope	P. Gardener	1

Supplier	Principal items	Agent	Orders (n)
Mottramite	Steel punches	direct	1
<b>Total</b>			<b>186</b>

From its founding in 1868 through to 1924, Reid & Gray continued to rely on Sheffield suppliers for parts demanding cutting-edge and shear stress.

Source: Reid & Gray Archive, Order books, covering 1911 (fourth quarter), 1912–16 and 1924. Hocken Collections Uare Taoka o Hākena MS-1165/002–4.

Initially small and narrowly specialised, the Sheffield suppliers were still operating in the 1860s as an intricate regional network of furnace owners and highly skilled artisans, linked by marriage, apprenticeship and a culture of trade secrecy, chronic indebtedness and absentee Mondays.<sup>81</sup> To make small lots of steel in crucibles of clay or graphite, they imported low-carbon Swedish iron, and raised the carbon content by interlayering and fusing the iron bars with charcoal. Additional fastidious processes of remelting and remixing enhanced uniformity.<sup>82</sup> Here, too, new techniques were emerging. Since ‘most bulk steel was useless without tougher steel to machine it’, demand for the special steels increased in due proportion.<sup>83</sup> Tool steel commanded 10 times the price of bulk steel. This continued into the 1920s, and the unflagging demand stimulated efforts to shorten the time in the furnace, increase the size of the pot and the size of the charge, and design machines to manufacture the pots—1,000 a day at Hadfield’s large River Don works.<sup>84</sup>

The new blast furnaces that were making bulk steel cheaper and more uniform were re-engineered for the more elaborate steps required for manufacture of the higher-grade tool steels. Coke-fired furnaces and the regenerative chambers principle permitted yet higher temperatures and a more even heat over days or weeks, with less wear and breakage of the pots. The gas-fired furnace, by avoiding direct contact of the charge with the fuel, made possible tighter control of the carbon content. The successive substitutions of ores and fuels (in Scotland and the United States) compelled further rounds of experiment, resulting in greater control and acceleration of the process.

The select suppliers of Reid & Gray were participants in the stream of innovations. The critical processes for making high-quality tool steel still depended on the tacit know-how of their work force: the melter who at sight distinguished bright-red from cherry-red heat, the teemer who judged the readiness of the melt for pouring, and the pullers-out who, to face the heat, covered themselves with wet rags. As late

81 T. S. Ashton, *An Eighteenth-Century Industrialist: Peter Stubs of Warrington, 1756–1806* (New York: Barnes & Noble, 1961).

82 For the various recipes employed in Sheffield, see K. C. Barraclough, *Steelmaking before Bessemer*, vol. 1 *Blister Steel*; vol. 2 *Crucible Steel* (London: The Metals Society, 1984).

83 Geoffrey Tweedale, ‘Metallurgy and Technological Change: A Case Study of Sheffield Specialty Steel in America, 1830–1930’, *Technology and Culture* 27 (1986): 190.

84 Barraclough, *Steelmaking*, 2:39.

as 1918, some of the Sheffield pot makers trod the clay with their feet; the walls of moulds were coated with soot or local road dust; the melter stoppered the neck of the charging funnel with a ball of paper and ‘killed’ the process with a ‘pill’ of aluminium.<sup>85</sup>

From the farmer’s perspective as an implement user, the innovations that did most to ease the strain on draught horses and increase the rate at which the team covered the ground were roller and ball bearings with thrust or twist collars. Beginning in the 1890s, ball bearings were applied to bicycles and sewing machines as well as ploughs and engines, and were improved by ever more ingenious lubrication systems and housings.<sup>86</sup> Surging demand for farm implements in the United States coincided with breakthroughs in manufacture to obtain greater precision, reliability and acceleration of the production line.

Meanwhile, the largest firms in Sheffield were maintaining their strong position in tool steels by systematic experimentation with alloys. As early as 1884, Hadfield’s manganese steel was being advertised in Southland as being as ‘tough as the hardest iron, and yet capable of holding the finest edge’. This was the edge Reid & Gray wanted initialled ‘M’ on the plough points.<sup>87</sup> By the turn of the century Hadfield’s had created a research laboratory in metallurgy, and Frederick Taylor, remembered for his stopwatch control of workers at Bethlehem Steel in Pennsylvania, had begun his experiments to accelerate the cutting of accurate screw threads by machining at red heat and high speed. This was possible only with machine tools made from the new Sheffield alloys of steel with manganese, tungsten and antimony.<sup>88</sup>

How far could the Otago entrepreneur go toward tooling up for the local manufacture of blades and bearings? The Dunedin foundry of the 1870s was state of the art, with the best of British-made cutters, punches and lathes. In 1875, then employers of 70, the firm added an Oliver bolt-making machine with a skilled operator. In 1880, by then employers of 175, they installed reusable sand moulds for the production of chilled shares. Chilling—that is, the rapid cooling of hot iron in a carbon-rich mould—increased the carbon content in the surface layer, to give a harder, longer-wearing ‘steely’ edge. The factory grew in the 1890s to cover 4 times the area, with 4 times the steam power, the latest fast and rugged grindstones and a hydraulic machine for casting the chills in much larger batches, all of which raised the throughput and productivity of the labour force.<sup>89</sup>

85 Tweedale, ‘Metallurgy’, 196–7; Barraclough, *Steelmaking*, 2:22–4, 32, 46–50, 170–2.

86 These were among the parts on which duty was contested by the South Island foundries in 1906–8.

87 *Southland Times*, 20 May 1884, 2; 18 August 1884, 2.

88 Frederick W. Taylor, *The Art of Cutting Metals* (New York: American Association of Mechanical Engineers, 1907).

89 The firm maintained low employee turnover, and faster shaping, boring and planing machines kept employee numbers in check: 230 reported in the *Otago Daily Times*, 18 May 1883, 6; 200 in the *Otago Daily Times*, 9 January 1900, 12. On the chilled steel mouldboard in the American Midwest, see Meinig, ‘Colonization’, 207.

But this was neither a steel mill nor a machine-tool factory. Reid & Gray did not produce the special steels required to machine steel,<sup>90</sup> and on the eve of the First World War the Dunedin plant was outclassed by manufacturers in Britain and the United States; even locally it lay in the shadow of the government railway workshops at Addington, Christchurch.<sup>91</sup> The firm therefore continued to import ploughshares and points of manganese steel by the tens of thousands annually, for inspection, testing and reshipment to their many clients in Otago, Southland, Canterbury, Tasmania and New South Wales.<sup>92</sup> Unable to achieve in full the ambition of import substitution they had entertained in 1868, Reid & Gray was nonetheless a success: they managed to survive, to grow and to maintain for a century a solid reputation for quality.

Of peculiar significance was the role the firm played in technology transfer. Textbook definitions of entrepreneurship as decision-making in conditions of uncertainty imply a thirst for information. In the circulation of know-how between frontier and centre, between one sector and another, James Gray, buttressed by tradition of family enterprise, took full advantage of the new information technologies. He used post, telegraph, undersea cable and telephone to forward 'the talk' in both directions. Despite the rate of change and the social rank conveyed by cigar and motor car, Gray maintained his familiarity with the tacit culture of the steely edge, the cherry-red heat and the furrow 'clean and square'.

## Conclusion

The advance of horse and plough over the diverse landscapes of southern New Zealand was spurred on by market ambitions. In the 1870s Joseph Davidson walked behind his single-furrow plough; by 1880 he was seated on a treble-furrow, and in the 1890s his contractor son-in-law with a larger team and a steam traction engine served an entire neighbourhood. In fits and starts, Davidson's family and neighbours were advancing on a frontier of know-how, each in response to the challenges of a specific piece of land. Features initiated or readapted by local blacksmiths and foundries in Dunedin, Christchurch and Invercargill were adopted by implement manufacturers in Britain and North America. Adequate responses to demands on the frontier involved progressive application of the new metallurgy: the steel frame, standardised parts, techniques of chilling, high-precision bearings and, in the 15 years before the First World War, an array of steel alloys.

90 Geoffrey Tweedale, *Sheffield Steel and America: A Century of Commercial and Technological Interdependence, 1830–1930* (Cambridge: Cambridge University Press, 1987), xii; Sidney Pollard, *Three Centuries of Sheffield Steel: The Story of a Family Business* (Sheffield: privately published, 1954).

91 *Progress*, 1 October 1907, 444–6.

92 Reid & Gray archive, request of October 1915 for a trial shipment anticipating a guarantee of 20,000 shares yearly for 5 years. Hocken Collections.



The small size of the New Zealand market stymied local manufacture of the range of specialised tool steels for critical parts—the blades and bearings. This enabled the large operators based in Britain and North America to hold large shares of the Australasian market. Local entrepreneurs such as Reid & Gray, by selecting a manufacturing niche and grooming the image of reliability and response, maintained a competitive vigour, effective in nudging the British and North American implement makers to recognise the challenges of the landscape-specific.

The intrusion of novelty made the fancy ploughing of the local matches seem year by year more remote from the everyday realities of plain ploughing to sow grass seed. Yet the achievement in southern New Zealand of a landscape that met the demands of the world market depended on the intense circulation of information exemplified in the plodding routine that focused attention on the cutting edge.

By the end of the century, residents of the South Island were voicing concern over the implications of ‘creative destruction’: exhaustion of soils, diversion of trickling waters, invasions of rabbits and weeds, fragmentation of forest habitats of native birds, and elimination of wetland resources vital to the Māori economy. Yet the act of ploughing carried a powerful sense of entitlement,<sup>93</sup> and the annual agricultural & pastoral shows in each province continued to promote and celebrate the ‘great concourse of ploughs, harrows, harvesters, and everything that can break the skin of mother earth in any way’.<sup>94</sup>

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93 Episodes reported by South Island newspapers as ‘Maori ploughing’ expressed Māori claims against settler intrusion: *Otago Daily Times*, 28 May 1879, 3; *The Press*, 23 June 1879, 2; *Lyttelton Times*, 28 October 1879, 4; *Timaru Herald*, 3 August 1886, 2; 1 December 1897, 2.

94 ‘The Exhibition Show: Third Day’ [Canterbury A & P Show], *Otago Witness*, 14 November 1906, 20.

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