

RESEARCH ARTICLE

# Manufacturing agricultural working knowledge: the scientific study of agricultural work in industrial Europe, 1920s–60s

Juri Auderset

Archives of Rural History, Bern and Department of Contemporary History, University of Fribourg, Switzerland  
Email: [juri.auderset@agrarchiv.ch](mailto:juri.auderset@agrarchiv.ch)

## Abstract

After the First World War, agricultural work became a subject of intense interdisciplinary scientific inquiry. The shortage of agricultural labour, the nutritional and agricultural crises and the increasing significance of the movement for the rationalisation of work contributed to the creation of new scientific institutions that focused on the study and improvement of agricultural work. This contribution sketches the emergence and development of the science of agricultural work in Europe from the 1920s to the 1960s and explores the intellectual controversies sparked by the attempts to shape farm work along the model of industrial manufacturing. The frictions and tensions between industrial ideals and agricultural idiosyncrasies not only led to a new scientific treatment of agricultural work, but also created a field of contestation between different conceptual approaches to perceiving, analysing and transforming agricultural work in the age of industrial capitalism.

## Introduction

In his book *Socialism and Agriculture*, Eduard David remarked in 1903 that the preoccupation with work in industrial and agricultural contexts requires strict scrutiny that needs to account for the divergent conditions of industrial and agricultural production.<sup>1</sup> Work in agriculture, David suggested, is always directed to the ‘evolution of living beings’ in an ‘organic process’, whereas work in manufacturing was shaped by a ‘mechanical processing of dead things’. These divergent conditions of production imposed a set of different spatial and temporal logics on the labouring process in agriculture and industry. While the steam engine and the consumption of mineral resources in industrial manufacturing enabled a spatially fixed and temporally continuous fabrication, the reliance on living animals and plants in agriculture defied such a transformation and re-arrangement of the production process to a considerable degree.<sup>2</sup> The industrial ideal of a ‘continual flow’ in the production process and the organisation of work in a ‘continuing chain of mechanic operations’ were almost impossible in agriculture because of the seasonal cycles and vegetative rhythms that are inherent to the biotic resources used in farming.

Working the soil, animals and plants was thus bound to the cyclical rhythms of seasonality, regeneration and reproduction. In agriculture, David argued, nature dictates the beginning and the end of the labouring process, not the whistle of the overseer or the siren of the factory. Contrary to industrial manufacturing in which the individual steps of production could be independently organised and re-arranged according to the linear time-regime of the factory, farm work was embedded in various metabolic flows that encumbered a similar modularisation and standardisation of the production process. While the simultaneous division and specialisation of labour in industrial manufacturing was perceived as a key to its increasing productivity,

in agriculture only the merging of different ‘cultures of plants and animals’ and the adjustment of their respective production rhythms on the same farm could enable a more or less continuous working process that nonetheless remained subject to seasonal variation.<sup>3</sup>

Moreover, the labour process in agriculture was bound to the spatial extent of the land. Contrary to industrial manufacturing where the means of production and the workforce were spatially centralised and sheltered from weather and climate changes, agricultural work took place in varying and widely dispersed sites, many of which were much more subject to uncontrollable and unpredictable weather and climatic influences than the factory. When it came to working the land, caring for animals and growing plants, David urged, the industrially inspired ideas of the rationalisation of work frequently ran up against the complexities of agriculture and organic resistances. As feverishly as the farmer may toil, as incessantly as he rushes and throngs – the ‘organic growth cannot be accelerated at will’: the grain will not grow faster, the cherries will not ripen quicker and the calf will not develop more promptly in the womb of the cow. ‘The conservatism of living nature’, David concluded his comparative observations on agricultural and industrial work, ‘imposes a tenacious and growing resistance against the propulsive efforts of man’.<sup>4</sup>

Thirty years later, in 1931, the Russian agricultural economist Morduch Tcherkinsky introduced his study on *L’Organisation scientifique du travail agricole en Europe* with a reappraisal of David’s reflections on the peculiar nature of agricultural work and quoted extensively from the latter’s work. However, Tcherkinsky’s treatment of agricultural work also displayed a clear shift in emphasis. While David had stressed the intangible and elusive nature of agricultural work and thus regarded the attempts to rationalise farm work along the industrial model as a more or less vainly enterprise, Tcherkinsky was decisively more optimistic regarding that point. In his view, the science of agricultural work that had emerged shortly after the First World War was destined to overcome the peculiarities of agricultural work and thus to align farm work with the industrial visions of rationalised and efficient labour that contemporaries usually associated with scientific management and ‘Taylorism’. In 1911, the North American engineer Frederick W. Taylor had published *The Principles of Scientific Management* in which he presented his ideas designed to increase the efficiency of factory production by analysing jobs through time and motion studies, eliminating unnecessary motions, subdividing, standardising and routinising all tasks and performances along the line of production.<sup>5</sup>

The obsessive search for the most efficient and productive solution not only spread across the Atlantic Ocean and triggered attempts to rationalise factory work in European plants,<sup>6</sup> but it soon captured the imagination of agricultural economists and engineers who tried to apply Taylorism to farm work. When Tcherkinsky summarised his account of these ventures, he conceded that the ‘natural difficulties inherent in agriculture impose certain limits to the application of Taylorism to the farming business’. ‘However’, he went on, ‘they will not impede its application entirely.’<sup>7</sup> Tcherkinsky’s optimism clearly stemmed from the emergence, the institutionalisation and the wide-ranging research activities of a science of agricultural work that had occurred between David’s treatment of agricultural work at the turn of the century and his own in the early 1930s.

In what follows, I will explore this contested transition in the conceptualisation of agricultural work by sketching some of the intellectual controversies that surrounded the establishment and the development of a science of agricultural work in Europe from the 1920s to the 1960s. As I will argue, the frictions and tensions between industrial ideals and agricultural idiosyncrasies that shaped in varying degrees both David’s and Tcherkinsky’s view, not only led to a new scientific treatment of agricultural work, but also created a field of contestation between different conceptual approaches to perceiving, analysing and transforming agricultural work in the age of industrial capitalism. This article proposes a re-evaluation of our understanding of the industrialisation of agriculture by examining how the attempts to apply industrially inspired methods of ‘work rationalisation’ to farming repeatedly ran up against the peculiarities of agricultural production.

It further considers how these very failures not only generated insights into the complexities and the contingency of farm work, but also fuelled the determination to overcome the idiosyncrasies of agricultural work.

The article is structured as follows: The first section discusses the crisis-ridden contexts in which the scientific study of agricultural work emerged after the First World War. The following section then sketches the transition from the early discussions of Taylorism in agriculture to a more sophisticated scientific occupation with farm work during the 1920s. Section three elaborates on some of the key problems that researchers in the field of farm labour studies encountered when trying to cope with the complexities of agricultural work in the interwar years. Finally, the fourth section briefly discusses how the ideas of farm work research lingered on into the postwar era and why they, at the same time, displayed substantial changes due to the dramatic transformation of European agriculture in the 1950s and 1960s.

### The emergence of the scientific study of agricultural work in the interwar years

By the time of Tcherkinsky's overview in *L'Organisation scientifique du travail agricole en Europe* in 1931, agricultural work had become a subject of intense interdisciplinary scientific inquiry for about a decade. To be sure, agricultural labour was not a completely disregarded issue before the First World War. In fact, it was a crucial concept in nineteenth-century agricultural economics and by the late nineteenth and early twentieth centuries the 'rural labour question' intrigued many social scientists, Max Weber being only the most renowned among them, and ranked high on the agenda of social politics and reform movements.<sup>8</sup> However, in this context, early social scientists and agricultural economists alike treated agricultural work and agricultural labour almost exclusively in terms of money and numbers. Georg Derlitzki, one of the pioneers of the German science of agricultural work, remarked aptly in 1927, that the issue of work in late nineteenth- and early twentieth century-agricultural discourse was either reduced to concerns over the 'rural exodus' and shortages in the agricultural work force or it was flattened down to 'wage questions'.<sup>9</sup>

While these concerns on the 'rural exodus' and the economics of wage labour lingered into the interwar period,<sup>10</sup> the decades after the First World War also witnessed a shift towards a more thoroughgoing examination of agricultural work practices, technologies and working bodies. Beyond calculating work force numbers and wages, several early protagonists of a science of agricultural work called for an orchestrated attempt to study and improve farm work in order to 'rise the efficiency of the human motor', as Derlitzki put it.<sup>11</sup> Against the backdrop of the severe food shortages and experiences of hunger that had haunted European societies during the First World War and its aftermath, the systematic scientific investigation of farm work and its improvement were perceived as a crucial means to tackle the multiple challenges European agriculture faced in the interwar years: Meeting the expectations of food security of the growing non-agricultural, urban-industrial population by increasing agricultural labour productivity, coping with the pressing rural labour shortages and raising the living standards and the social welfare of the destitute family farms and rural working classes.<sup>12</sup>

Thus, the recent experiences of decreased agricultural production in the war-ravaged areas of Europe, the lingering menace of food scarcity, the shortages of agricultural labour, the global agricultural crisis of the 1920s and the increasing significance of the movement for the rationalisation of work all contributed to the creation of new scientific institutions that focused on the study of agricultural work. This preoccupation with the scientific improvement of agricultural working techniques was an integral part of broader attempts to turn the rural world into an experimental ground for practices driven by the 'scientisation of the social' in the age of 'industrialism' and 'high modernity'.<sup>13</sup> The question of how to make agricultural work more productive in order to cope with the challenges of food production and food supply in the interwar years eventually induced a European-wide proliferation of institutions dealing with the scientific study of farm work. Whereas the early promoters of a new science of agricultural work had still bemoaned the long

lasting negligence of the agricultural sciences towards practical labour problems in the early 1920s,<sup>14</sup> the expert for agricultural work at the International Management Institute in Geneva, Frédéric-Etienne Tapernoux, detected in 1929 already a ‘wave of enthusiasm’ surrounding the new discipline.<sup>15</sup> In the same vein, Tcherkinsky eventually drew in 1931 the picture of a European-wide network of scientific institutions, experiment stations and university institutes that directed their intellectual and financial energies substantially to the study of agricultural work.<sup>16</sup>

The ‘scientific study of the labouring man in agriculture’ imagined the body and the soul of working people on farms as a site in which diverse threads of agronomic studies and social sciences interlaced and created a new field of scientific investigation that had the practical purpose of ‘rationalising farm labour’.<sup>17</sup> According to its promoters, the science of agricultural work thus offered a new way of synthesising the various subdisciplines of the agricultural sciences by focusing on diverse aspects related to the work performances on the farm. This endeavour covered a wide range of scientific interests that required interdisciplinary mediation and unification.

Work physiologists like Géza Farkas in Budapest and Edgar Atzler at the Kaiser-Wilhelm-Institute for Work Physiology in Berlin began to measure the energy input and output of agricultural labourers, going to the fields with a respiratory apparatus during harvest when they expected an extraordinary workload and an unusual ‘exposure of the muscle activities’ of the ‘human motor’.<sup>18</sup> Psychologists and advocates of ‘psychotechnics’ such as Kurt Lewin in Germany and Walter Dunlop from the Agricultural Division of the National Institute of Industrial Psychology in Britain promoted the ‘rationalisation of the farming enterprise by the instruments of applied psychology’. According to their views, the necessity to reform agricultural working practices and to select the most capable farm labourers turned the farms into a laboratory of ‘industrial psychology’.<sup>19</sup> Agricultural economists such as Ernst Laur in Switzerland, Wilhelm Seedorf in Göttingen and Georg Derlitzki in Pommritz, Saxony, all reflected with varying enthusiasm on the prospects of applying Taylorism and scientific management to agricultural work and conducted time and motion studies on farms in order to detect the most efficient and productive way of doing farm labour.<sup>20</sup>

As the ‘gendering of the agricultural work force’ accelerated in the interwar years,<sup>21</sup> farmwomen and their work increasingly became a target of the rationalisation campaign. This led not only to the institutionalisation of what Dorothea Derlitzki called the ‘work science of the farm household’, but also to an examination of the repercussions of physically demanding field work on female bodies and of the prospects of what the Swiss farmwoman Augusta Gillabert-Randin termed ‘la rationalisation du travail de la paysanne’.<sup>22</sup> The imperative of avoiding unnecessary labour also induced a reappraisal of farm architecture and arrangements of farm buildings. These endeavours amounted in the mind of the Canadian scholar and agricultural expert at the International Labour Organisation (ILO) Walter Alexander Riddell to a ‘science of construction’ that minutely ‘considers how unnecessary movement, unnecessary lifting, unnecessary expenditure of power may be eliminated’ and thus represented ‘a sort of motion study of the inanimate’.<sup>23</sup> With the zeal of ethnographers, graduate students in agricultural sciences at the Swiss Institute of Technology in Zurich set out in the 1930s and 1940s to study the labouring processes in the peasant economy, painstakingly registering the working techniques, the working time and the organisation of labour in family farms in the Swiss midlands.<sup>24</sup> Other scholars drew on the tradition of Etienne Marey’s chronofotography and Frank Gilbreth’s cinematographic methods in their attempts to capture, represent and analyse the movements of agricultural labourers and to detect the most rational and the less fatiguing way of hoeing or hay making.<sup>25</sup>

At the same time, animal physiologists and agricultural scientists such as Nathan Zuntz, Henry Armsby and Hans Wenger began to study the working capabilities, the power and skills of farm animals. They imagined the animal bodies as ‘machines’, ‘motors’ and ‘transformers of energy’, measured their draught power with dynamometers and analysed their manifold functions as a living source of power and labour in the rural economy.<sup>26</sup> Meanwhile, agricultural engineers such

as the Swiss Konrad von Meyenburg, the Frenchman Max Ringelmann, and the Belgian Alexandre Lonay developed their ideas on 'agricultural moticulture', trying to engineer adequate motorised technology that would suit the peculiar circumstances of agriculture and envisioning a future agriculture liberated from the necessity of physical toil and drudgery.<sup>27</sup>

Moreover, by the second half of the 1920s, these geographically widely spread attempts in researching agricultural work were increasingly tied together as international organisations developed an interest in the science of agricultural work, created forums for transnational exchanges and thus acted, in the words of Kiran Klaus Patel, as 'clearinghouses of global expertise'.<sup>28</sup> While first tentative attempts so discuss the problems of farm work and their scientific investigations had been made on sections of the International Congresses of Agriculture and of the International Management Congresses in the early 1920s, the second half of the decade witnessed an increasing preoccupation with these issues in transnational discourse communities. In 1926, Seedorf used the pages of the *International Review of Agriculture*, the journal of the International Institute of Agriculture in Rome, to call for an international collaboration of scholars in the field of farm labour research.<sup>29</sup> In the following year, in 1927, the International Management Congress in Rome hosted an intense and contested discussion on the prospects of the science of agricultural work<sup>30</sup> and the International Labour Organisation decided to start a cooperation with the International Institute of Agriculture and the International Management Institute on the further investigation of scientific management in agriculture.<sup>31</sup>

In short, by the late 1920s a European-wide web of scientific institutions and initiatives dedicated to the study of agricultural work was firmly in place, linking scholars across national boundaries and releasing an extensive stream of studies on the physiology, psychology and practical aspects of agricultural work, as well as on the treatment, education and feeding of working animals and the prospects of replacing the workforce of humans and animals by motorised technology. The newly proclaimed science of agricultural work was the most visible sign of an almost obsessive preoccupation with work in agriculture that left its mark on the interwar years.

### From 'Taylorisation' to the science of agricultural work

In the eyes of the early promoters of a science of agricultural work in Europe, the agricultural sciences had so far overwhelmingly focused on plant improvement, animal breeding, animal husbandry, animal nutrition, agricultural chemistry, mechanical engineering and farm management, but almost completely neglected agricultural work as a subject of scientific study. 'Apparently it was believed that by the invention and introduction of farm machinery enough had been done in this field', sneered Wilhelm Seedorf.<sup>32</sup> And Georg Derlitzki remarked that it was completely incomprehensible why uncountable institutions and researchers had been occupied with increasing the efficiency of steam engines and combustion-engines, while they woefully neglected the efficiency of the 'most valuable motor': 'the human motor'.<sup>33</sup> At the same time, the emergence of Taylorism in America and the various strands of the industrial work sciences in Europe led to the perception that the study and the practical improvement of labour on the farms lacked far behind the advances that had turned the industrial factory into a symbol of progress as well as of rational, efficient and modern work.<sup>34</sup> 'It seemed to me', reported Seedorf retrospectively to an audience at the Second International Conference of Agricultural Economists in Ithaca, New York in 1930, 'that Taylor's theories and that of his followers could be applied to advantage in devising ways and means for increasing the efficiency of farm labour'.<sup>35</sup>

Indeed, the application of Taylorism and the 'Taylor-system', as the contemporaries usually called it, to agriculture was much on the mind of agronomists and agricultural economists in the late 1910s and the early 1920s. As early as 1916, the eminent Swiss agricultural economist Ernst Laur introduced Taylor's ideas on scientific management to agricultural circles in Switzerland. While Laur somewhat sceptically pondered that agricultural labour can hardly be 'organised like in a factory', he nevertheless saw Taylor's writings as an important inspiration

for farmers and agricultural reformers to ‘render numerous tasks more productive’.<sup>36</sup> Others displayed less hesitancy in this regard. Nothing less than a ‘Taylorisation of agriculture’ and a ‘Taylorist reform of the working processes of men, animals and machines’ was on the mind of the German Gustav Winter.<sup>37</sup> In France, Charles Brillaud de Laujardière, the director of the *Syndicat central des Agriculteurs de France* asked in an article entitled *Taylorism in Agriculture* in 1920: ‘Why not adapt to that great factory that is our earth, a method that has proved to be excellent in the workshop?’<sup>38</sup>

However, the early enthusiasm for Taylor and the high-flying expectations associated with the application of his methods to agriculture soon began to vanish. A semantic indication of this fading vision of a Taylor-inspired transformation of agricultural work may be seen in a remarkable conceptual drift. The frequent reference to Taylor’s scientific management and the inflationary use of the words ‘Taylorism’ and ‘Taylor-system’ were pushed to the margins of the discourse on agricultural work by the late 1920s and early 1930s. They were successively replaced by the concepts of ‘*Landarbeitslehre*’ or ‘*Landarbeitswissenschaft*’ – science of farm labour or science of agricultural work – that became the common denominators for the rising numbers of scholars who wrestled with the analysis and improvement of agricultural work.

This semantic shift indicates a more profound change in the scientific conceptualisation of agricultural work in the mid-1920s. Mirroring the class bias and the dichotomous labour relations of the industrial realm and despite Taylor’s own evocations that both workers and managers benefited from his system, his methods actually placed the interests of management and owners in the forefront.<sup>39</sup> It comes as no surprise that it fell on fertile ground chiefly among the large-scale landowners and agrarian capitalists who relied heavily on hired wage labour and tried to ensure labour discipline and higher productivity. In contrast, the science of agricultural work intended to transform agricultural labour in the interest of the whole working population in agriculture. It not only promised to ease the physically demanding work of farm labourers, but it explicitly claimed to be of relevance also for smallholders and peasant family farms, where the division between managing and working the farm was extremely porous, as especially Derlitzki and Laur, but also the Swiss socialist agronomist Franz Schmidt, never ceased to emphasise.<sup>40</sup>

Moreover, as the debate on Taylorism and agriculture evolved in the early 1920s, a growing number of sceptical voices joined the discussion and emphasised the specific working conditions in agriculture that seemed in many ways at odds with the rationalisation schemes borrowed from the industrial shop floor and from Taylor’s writings. ‘According to the idiosyncrasy of agriculture, the paths to proceed will of necessity be different from industrial labour research’, proclaimed Derlitzki in 1927. ‘One just has to become aware of the dependencies of agricultural work from climate, weather, season, type of soil, the rapidly changing condition of the soil, the crops, the quickly changing places of work, etc. to avow that the industrial experiences will be of little help in those regards.’<sup>41</sup> Derlitzki came to these conclusions against the background of countless experiments he conducted with his collaborators on the experimental farm affiliated to the Experimental Station for the Study of Agricultural Work in Pommritz, Saxony, which soon enjoyed international reputation for its innovative research. During the 1920s and early 1930s, Pommritz became a frequently visited site for scholars interested in agricultural work, attracting such renowned guests as Ernst Laur and his pupil Frédéric-Etienne Tapernoux, the American physiologist Samuel Brody or the head of the Agricultural Service of the International Labour Organisation Louise Howard.<sup>42</sup>

In Pommritz, Derlitzki and his collaborators studied a wide array of questions regarding agricultural work, stretching from the management of labour on farms, across the investigation of the layouts of farms and farm buildings to physiological and psychological experiments and time and motion studies. One of the thorniest issues regarding the organisation of farm labour was to cope with the diverse and uneven rhythms of the workload across the seasons. Contrary to the experiences in the factories, specialisation in agriculture reinforced the seasonal variation of the burden of work, whereas mixed farming provided more opportunities to arrange for a more balanced

distribution of tasks along the time-line. Thus, in the light of his experimental research, Derlitzki called for a reappraisal of crop rotation schemes, a more skilful coordination of early and late varieties in plant production and a synchronisation of the vegetative rhythms in plant production with working rhythms in livestock farming in order to better cope with nature's constraints and the seasonal fluctuations of agricultural work. For instance, management decisions regarding cropping and plant production required the anticipation of workflow and the planning of narrowly timed tasks such as soil preparation, planting, weeding, fertilising and harvesting. Derlitzki was convinced that a more thoroughgoing reflection on the multilayered temporal structure of agricultural work as well as a systematic record keeping would allow a steadier workflow in agriculture despite the extraordinary variability of tasks and the unavoidable ups and downs of the workload that came with the seasonality of agricultural production.<sup>43</sup>

Besides such reflections on managing labour on farms and coordinating the temporal heterogeneity inherent to agricultural work, Derlitzki also made use of stopwatches, photography and film cameras to compare how different agricultural labourers conducted the same tasks, to analyse the motions of their bodies and their handling of tools and to find out the most efficient way of the work performance. For instance, Derlitzki examined different ways of harvesting grains and compared the different techniques of gathering up the sheaf and binding it in its own straw. After having systematically compared the different working techniques by time and motion studies, the most efficient way was determined and taught to a female farm worker who was generally considered very receptive and clever. After a day's training she managed to reduce the time for this operation from forty to thirty seconds and a similar acceleration of work was found among her co-workers emulating her technique.<sup>44</sup>

Furthermore, by tests inspired by psychotechnics, Derlitzki tried to determine the optimal size of fields and the most efficient way of organising the labouring process. As his experiments had shown, labourers often felt discouraged when the size of the fields were stretched out too long because it induced a feeling of endless toil and thus negatively affected the motivation, accelerated fatigue and impaired the quality of work. But if the fields were too small, Derlitzki observed, the idling cycles and thus the time wasted for unproductive work were multiplied because of the increased frequency of the turning of machines or draught animals. Against the backdrop of these observations, he advocated a differentiated approach that favoured relatively small fields for tasks relying heavily on manual labour and larger fields for tasks involving draught animals and machinery.<sup>45</sup>

The Experimental Station in Pommritz also put work physiology in agriculture on its research agenda. Inspired by the research that the French and German physiologists Jules Amar and Edgar Atzler had begun in the 1910s,<sup>46</sup> Derlitzki's close collaborator Werner Huxdorff began to use respiratory apparatuses to measure the workings of the energy metabolism of agricultural labourers.<sup>47</sup> While these methods developed on the industrial shop floor and in the laboratories of work physiologists proved to be valuable for stationary and repetitive tasks, Derlitzki also clearly saw the limits of applying them to agriculture. Agriculture had not only relatively few repetitive and stationary tasks or large operations that could be broken down into small and specialised tasks; furthermore, the close observations of the specific circumstances and performances of agricultural work also showed that farm work remained an object of various, random and sometimes uncontrollable influences that turned the quest for standardised schemes into an elusive enterprise and questioned the validity of the results obtained by physiological experiments. For those interested in applying the methods of Taylorism and industrial work physiology to agriculture, a number of obstacles stood in the way, Derlitzki urged:

The working conditions in industry are much more invariant than in agriculture, where we have to face permanently changing working conditions and resistances even in one and the same task. Think of the hoeing of beets, for instance: how differently this task must be handled depending on whether the hoeing takes place on heavy, crusted and rocky soil or on light

ground, whether it takes place on a damp or a weedy piece of the acre; it even depends on the kind of weeds, furthermore on the size of the plants, on the exposure to sun light, etc., etc. Every moment the working conditions can be different and therefore require a different handling of the hoe.<sup>48</sup>

Interestingly, the most scrutinising observation of working techniques that emerged from the application of Taylorist methods to agriculture did not always lead to the detection of ‘the one best way’; rather, it induced an awareness of the complexities of agricultural work and of the various and random influences acting upon the working process in farming. As Derlitzki’s reflections indicate, the distinctive challenges of improving agricultural work made it difficult, if not outright impossible, to simply transfer the industrial model wholesale to farming.

### Struggling with the complexities of agricultural work

The confidence in transforming agricultural work along the model of industrial scientific management eroded further as work scientists increasingly became aware of the social complexity and the heterogeneity of labour relations in rural contexts.<sup>49</sup> Thus, one of the crucial challenges that the work sciences in agriculture faced was what Louise Howard called in her 1935 survey *Labour in Agriculture* the ‘almost bewildering’ variety of working practices, techniques and schemes of work organisation, labour relations and labour contracts in agriculture.<sup>50</sup> Ranging from peasant agricultural labour that relied almost exclusively on family labour instead of hired hands, to large-scale landowners that depended heavily on wage labour, encompassing permanent, seasonal and day labourers, tenants, domestic servants, child labour and working animals – the labouring agents in agriculture and their relationships displayed an almost inconceivable variety and heterogeneity, even though the various labour regimes in agriculture also displayed certain regional patterns that influenced the research of work scientists in agriculture.<sup>51</sup>

In general, the large commercial estate farms relying strongly on wage labour and displaying a more specialised structure of production in Eastern Prussia, Poland or Hungary were seen as more inclined to apply scientific management successfully to their enterprises. The ‘idea of scientific management will always be most applicable on large-scale farms’, Louise Howard argued, because the wage-centred labour relations, the hierarchies between management and labourers as well as the control of the working process came closer to the conditions of industrial manufacturing.<sup>52</sup> However, as some contemporaries compared the different regimes of agricultural labour in European agriculture, took notice of the astonishing resilience of family farming and assessed the impact of the science of agricultural work, they also saw the potential, if not the necessity, to adapt the methods of scientific management and work rationalisation to family farms.<sup>53</sup> As the Swiss agricultural economist Ernst Laur put it in 1927:

In the utilisation of the workforce, the peasant has thus far proved to be significantly superior compared to the large farm. By the new ways of scientific management and the improvement of working methods the danger is evoked that the large farms will get more efficient and push the family holdings to the margins. . . . That imposes on us the duty to study this problem with regard to the conditions of family farming.<sup>54</sup>

And indeed, the late 1920s and early 1930s witnessed a proliferation of initiatives in Switzerland, France and south-western Germany to investigate the organisation and practices of work on small- and medium-sized family farms shaped by mixed production systems and family labour.<sup>55</sup>

As the work scientists further examined the regionally different regimes of agricultural labour they increasingly became aware that not only the labour relations, the size of the farms and the degree of market- or subsistence orientation impacted the outcome of their suggestions to



rationalise agricultural work. Moreover, they detected that the conceptualisations of work in rural contexts changed markedly. Whether labour was oriented towards subsistence, wages or profits; whether toil was embedded in mixed farming systems, in the specialised production of cash crops or in the overlapping spheres in between; whether work was linked to morals, religion, virtue and education or whether it was subordinated to capitalism's claims for commodification, efficiency, calculation and profitability; whether labour was placed in the conceptual framework of alienation and exploitation or whether it was seen as a means for cultural uplift and the acquisition of skill and knowledge about nature – the perception and valuation of agricultural work changed not only in time, but it also varied across the farming population. In the world of rural society, then, labour seemed to be omnipresent; it was a crucial vehicle for crafting social and cultural identities and in remained somewhat elusive at the very same time.

Even more troublesome in the eyes of agro-industrial improvers was the fact that this intangible world of rural labour virtually blew up the epistemic categorisations that usually defined labour relations in industrial capitalist societies. It is not accidentally, that Howard used the metaphor of a 'social kaleidoscope of agricultural labour' when she attempted to come to terms with the stupendous variations, heterogeneities and ambiguities of labour relations in agriculture.<sup>56</sup> And equally multifarious were the working techniques, the tools and machines used in farm labour. When Wilhelm Seedorf first became interested in studying agricultural labour in 1919 he was astonished by the 'extraordinary different types of agricultural implements in the various regions in Germany' and declared in the fashion of a Taylor-follower the search for the 'factually and objectively best' design of implements a crucial goal of the science of agricultural work.<sup>57</sup>

Others were less surprised when facing such diversity of working methods and implements. The varying conditions of the soil, climate and topography led to a cultural adaptation of the working techniques and tools to these natural circumstances, declared an anonymous writer who was obviously quite familiar with the world of rural labour, in one of the leading agricultural journals in Switzerland. The proclamation of 'rational implements and working methods' that are declared in Taylorist rhetoric as the 'one best way' were destined to face 'almost unsurmountable difficulties' among peasant communities, he maintained. Moreover, the one-sided emphasis on efficiency and productivity that permeated the agenda of most researchers in the field of the work sciences rendered them at least partially ignorant towards the cultural and religious values that many peasant communities linked to their everyday work. However, this author did not perceive the reluctance on the part of farmers with contempt. Quite to the contrary, he took it as a fortunate sign, that 'agricultural work can obviously not be judged solely from a capitalist standpoint as they tend to do it in the factory'.<sup>58</sup>

As the scholars dedicated to the study of agricultural work began to recognise the variable and dynamic factors that left their marks on the world of rural labour, the scope of interests that they claimed to cover increasingly extended. Thus, the gradual abandonment of the vocabulary of Taylorism indicates a threefold departure. Firstly, it reflects the shift to a more encompassing interest in the complexities of agricultural labour beyond the narrow search for increasing productivity, efficiency and maximum output of the labour force along the industrial model. Secondly, the science of agricultural work began to consider the variable and dynamic conditions of farm work in a broader perspective. It aimed at the physiological and psychological rationalisation of the labouring bodies of the farm population at large, targeting the elimination of fatigue, overwork and wasteful movements in agricultural labour, while at the same time enhancing the 'efficiency of the human motor', as Derlitzki put it.<sup>59</sup> And thirdly, it displays the emergence of a phenomenon that I would call a comparative epistemology of work. As forcefully as the industrial paradigm of rational and efficient labour endured in the mind of the protagonists of the science of agricultural work and as receptive as they remained for the progressive imagery of industrial productivism, they increasingly became aware that the proof of scientifically legitimated knowledge on agricultural work and the realistic prospects of its improvement had to be found on the farm itself, in the fields, in the yards, in the barns, and in the farm kitchens. The obvious divergences

between the work performed on the shop floor and the working of the land – divergences that the attempts to shape the farm along the model of the factory paradoxically highlighted – demanded a redefinition of their respective scientific conceptualisations. Thus, the persistent differences between agricultural and industrial work constituted an epistemic stumbling block to the extension of industrially inspired rationalisation schemes, while they, at the same time, geared future research to the goal of overcoming the very resistances that agricultural production continued to display in the face of the transforming forces of industrial capitalism.

An instructive example for this contested trajectory may be seen in the inventor of agricultural machinery and protagonist of a science of agricultural work Konrad von Meyenburg.<sup>60</sup> Meyenburg was in many regards a likely candidate to detect and scrutinise the commonalities and differences between agricultural and industrial work. Trained as an engineer, he began to develop agricultural machinery and soil tilling machines, visited Frederick W. Taylor in America on a regular basis in the 1890s and wandered, as he once put it himself, ‘from the realm of industrial work science to the realm of agricultural work science’.<sup>61</sup> In the course of this trajectory, Meyenburg increasingly became aware of the specific logics of agricultural work and they seemed to be at odds with the assumptions that governed the thinking in industrial work science in decisive ways.

Researchers of industrial labour, Meyenburg observed in 1927, usually faced a standardised and uniform mass production process, based on a far-reaching division of labour and centred on machines. The labour process followed a ‘clockwork-like’ regularity, that allowed for a steady and precise registration of ‘all fixed operations through which the material flows’ and that, therefore, ‘could be observed, filmed, and discussed thousands of times’, as Taylor and Gilbreth have effectively shown. The work scientists dealing with agricultural labour, in contrast, usually faced a production process that was not as specialised, repetitious, spatially fixed and machine-paced. Agricultural work was shaped by spatial dispersion and vegetative and seasonal temporal rhythms that defied such a factory-like standardisation, concentration and linearity to a certain degree and that, according to Meyenburg, posed serious challenges for the work scientists.

Labouring people in agriculture, he maintained, ‘pitch with implements, tools and motors into gigantic masses of biotic material, rapidly changing their tasks, . . . handling earth, plants and animals that continually change either their places, their conditions or their resistances to the labouring hand of man’.<sup>62</sup> From these specific conditions of the agricultural production process and its embeddedness in nature emerged a remarkable variety of working practices, as Meyenburg pointed out in a rather staccato-like fashion: Farmers were ‘cultivating, fertilising, sowing, hoeing, manuring, weeding, cutting, binding, collecting, loading, discharging, threshing, selecting, proceeding, mucking out, hilling up, racking up. They must get feed, feed, milk and clean livestock, assist the birth of calves, they must butter, make cheese, and they have to know fairly well a lot of good and bad plants and animals.’ This remarkable multitude of working practices and skills, he argued, displayed a world of labour that was not only much more complicated and confusing than simplified and monotonous industrial labour, but also much harder to grasp in a precise manner for the work scientist. In a rather resigning tone he declared that the inextricably ‘intertwined and unmeasurable flows of energy and matter that circulate between pasture, field, dunghill, household, stable, yard, pantry, kitchen, men, and animals’ defied to be captured in numbers, time units and money, just as the ‘condition and capacity of the farmer’s body and mind’ do.<sup>63</sup>

### The transformation of agricultural work studies in the postwar era

Meyenburg’s sceptical remarks, however, did not impede his colleagues, nor himself, from the further investigation of agricultural work. Perhaps it was the very diversity and complexity of agricultural work emphasised by Meyenburg, that made researchers in the field of farm labour studies so keen to further organise and rationalise agricultural work so as to align labour on the farms with

the industrial model of the factory. Interestingly, the many drawbacks and difficulties that farm labour research encountered in its attempts to apply schemes borrowed from industrial manufacturing to farming and to make agricultural work more productive did not lead to an abandonment of this kind of scientific investigation. In fact, there is a trajectory that links the formative years of farm labour research in the interwar period with the reconstruction of agriculture in post-war Europe after 1945. The postwar years witnessed several endeavours to rebuild an institutional network in the scientific study of agricultural work and to strengthen the transnational intellectual exchange that had been shattered during the Second World War. For instance, the eighth International Management Congress in Stockholm hosted a discussion on the prospects of applying scientific management to agriculture in July 1947, and two months later, on the occasion of the sixth International Conference of Agricultural Economists in Dartington Hall, England, several papers were dedicated to work simplification and scientific management in agriculture.<sup>64</sup> Taking up this regained dynamism in the discipline of farm labour studies, leading European researchers founded the Centre international pour l'organisation scientifique du travail en agriculture (CIOSTA) in 1950, which provided with its annual conference an important platform for intellectual exchanges among farm work scientists.<sup>65</sup>

However, in the transformative context of what has been called the 'third agricultural revolution' the perspectives of farm labour research displayed remarkable shifts.<sup>66</sup> As changes in agricultural technology, the broadened access to mineral resources, the increasing substitution of working animals by motors, the use of fertilisers and pesticides and the rise of capital intensiveness had brought a level of uniformity and standardisation to farming that was without historical precedent, the perception of work and the research agenda in the scientific study of farm labour altered dramatically.<sup>67</sup> In particular, the 1950s witnessed an epistemic shift away from an intellectual occupation with the logics of living resources that was at the centre of agricultural work studies in the interwar years, towards a 'voice of decontextualised rationality' that saw in farming little more than the management of a business unit detached from its embeddedness in specific ecological, social and cultural contexts.<sup>68</sup> This epistemic shift also stemmed from rapid technological changes, which led more than one observer of agriculture to perceive the mid-1950s as a 'turning point' in the history of farm work.<sup>69</sup> As motorisation advanced in this decade and multi-purpose and more versatile tractors and agricultural machinery entered the farm gates, the improvement of human labour was increasingly seen as an obsolete venture; instead of changing agricultural working methods, the gaze of industrially minded work scientists and agricultural economists was now centred on shifting labour from human and animal bodies to motorised machines altogether.

'Farming has come to be looked at as if it were a factory', Sir Albert Howard wrote on the threshold of this transition.<sup>70</sup> Along with this change in perspective went a shift of interest among researchers in the field of farm labour studies. Many of the initiatives to establish a science of agricultural work that had emerged in the interwar years and regained traction for some years in the early postwar period either eroded by the late 1960s or shifted their attention from studying human and animal farm work to engineering agricultural technology and fostering the motorisation of agricultural production.<sup>71</sup>

## Conclusions

The science of agricultural work emerged from the convergence of two developments that had their roots in the last decades of the nineteenth century, but began to fuse only in the interwar years against the backdrop of the experiences of food scarcity and labour shortages caused by the First World War. First, the second half of the nineteenth century witnessed the appearance of a scientific discourse that subjected the working body, its movements and rhythms to a most detailed investigation. This process of a scientisation of work had its origins in the laboratories

of physiologists and found its first practical arena on the shop floors of the factories, yet the expansion of industrial logics in agricultural production contributed to a wide diffusion of this scientific discourse on work in agricultural circles. Hence, the metaphor of the ‘human motor’ with its imagination of the body as ‘a site of energy conservation and conversion’ that had unleashed a remarkable explanatory power and had so thoroughly transformed the world of industrial labour<sup>72</sup> began to frequently appear in agricultural literature. Agricultural scientists, physiologists and work scientists used the metaphor of the ‘human motor’ to describe and analyse the working capacities of the labouring population on farms or, in the slight metonymic variation of the ‘animal motor’, to capture the working performance of animals in agriculture.<sup>73</sup>

Closely related to this process was, secondly, the emergence and unfolding of an ‘industrial ideal’ that increasingly came to define what ‘efficient’, ‘rational’, and ‘modern’ work should look like and that acquired a hegemonic status by the late nineteenth and early twentieth centuries.<sup>74</sup> From this hegemony of an industrial paradigm resulted not only a constant making of comparisons between industrial and agricultural work, but also, and maybe even more importantly, a continuing pressure on agricultural work to become more industrial-like. ‘The use made of human labour in agriculture is often, measured by modern standards, ineffective, careless and wasteful’, concluded a study by the Agricultural Service of the International Labour Organisation,<sup>75</sup> and Wilhelm Seedorf drew the consequences out of this frequently uttered observation: ‘The outward form of farm labour must, as far as possible, be made similar to industrial work.’<sup>76</sup>

The convergence of those two dynamics that – for the sake of simplicity and in awareness of their fractured character – might be called the scientisation of work and the industrialisation of agriculture set the stage for the establishment, the institutionalisation and the temporary flowering of a science of agricultural work from the interwar years to the 1960s. However, the knowledge production on agricultural work that poured out of these scholarly endeavours and their application to practical farming also highlighted the tensions, contradictions and frictions inherent in these developments and unfolding between them. As a consequence, the insights into the idiosyncrasies of agricultural work seemed to disrupt some of the expectations that had emerged from studying labour in the industrial workplace. As much as the industrially inspired quest of efficiency and the visions of productive labour captured the mind of many agricultural scientists, economists and engineers, their attempts to shape work on the farms along the model of the factory frequently ran up against the peculiar logics of agricultural production, as Eduard David had already cautioned at the turn of the century. These experiences with the elusive and highly contingent nature of agricultural work was a rich source for frustrations, yet, and maybe more importantly, the confrontation with the peculiarities of agricultural work also induced many of them to rethink, adapt and revise their ideas. Only by changing and adapting industrially inspired methods to the idiosyncrasies of agricultural production, rather than simply accepting them as they dropped out from the shop floor, could actual improvements in farm work be hoped for.

By the late 1960s, however, the interest in the scientific investigation of farm work had slowly eroded. As labour was replaced by capital and living resources by mineral ones, and as the versatile, multipurpose oil-fuelled tractor revolutionised agricultural work in Europe’s fields, the cultivation of soil, plants and animals was substantially, albeit never entirely, transformed into an activity of converting mineral resources into food for human consumption.<sup>77</sup> Hence, in order to integrate agriculture into the patterns of capitalist industrialisation on the verge of its ‘great acceleration’,<sup>78</sup> it had to be seen as if it were similar to industrial manufacturing. This required abstraction from agriculture’s material biotic conditions, from its embeddedness in diverse ecological and socio-cultural systems and, therefore, from the idiosyncrasies of agricultural work that, by and large, ceased to be an object of scientific research.

**Acknowledgements.** Support from the Swiss National Science Foundation for the research project ‘Semantics of Agricultural and Industrial Work: Knowledge, Metaphors of Production and the Transformation of Work in the 19th and 20th Centuries’ (Grant No. 100011\_169566) is gratefully acknowledged. I would like to thank my colleagues at the Archives of Rural History in Bern, Peter Moser and Hans-Ulrich Schiedt, as well as the two anonymous reviewers of *Rural History* for their valuable comments on earlier drafts of this article.

## Notes

- 1 Eduard David, *Sozialismus und Landwirtschaft* (1903, Leipzig, 1922), p. 45. All translations from German and French sources are the author’s. For a broader discussion of the debate on the ‘agrarian question’ shaped by Eduard David and Karl Kautsky, see also Juri Auderset, ‘Agrarfrage und Industriekapitalismus: Reflexionen über eine marxistische Debatte’, *Schweizerische Zeitschrift für Geschichte*, 76 (2017), 293–315.
- 2 Juri Auderset and Peter Moser, *Die Agrarfrage in der Industriegesellschaft. Wissenskulturen, Machtverhältnisse und natürliche Ressourcen in der agrarisch-industriellen Wissensgesellschaft (1850–1950)* (Wien 2018); David Goodman, Bernardo Sory and John Wilkinson, *From Farming to Biotechnology: A Theory of Agro-Industrial Development* (London, 1987), pp. 6–14; Tim Ingold, *The Perception of the Environment: Essays in Livelihood, Dwelling and Skill* (London, 2000), p. 81.
- 3 David, *Sozialismus und Landwirtschaft*, p. 47.
- 4 *Ibid.*, p. 51.
- 5 Frederick Winslow Taylor, *The Principles of Scientific Management* (New York, 1911); Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (Cambridge, 2005).
- 6 Mary Nolan, *Visions of Modernity: American Business and the Modernization of Germany* (New York and Oxford, 1994); Victoria de Grazia, *Irresistible Empire: America’s Advance through 20th-Century Europe* (Cambridge and London 2005).
- 7 Institut International d’Agriculture, *L’organisation scientifique du travail agricole en Europe* (Rome, 1931), pp. 13–14.
- 8 Max Weber, ‘Die Erhebung des Vereins für Sozialpolitik über die Lage der Landarbeiter’, in *Max Weber Gesamtausgabe*, vol. 4/1 (Tübingen 1993), pp. 120–53; Gerhard Schildt, ‘Die Landarbeiter im 19. Jahrhundert – eine unvollendete Klasse’, *Archiv für Sozialgeschichte*, 36 (1996), 1–26.
- 9 Georg Derlitzki, ‘Die Landarbeitsforschung, dargestellt an den Arbeiten der Versuchsanstalt für Landarbeitslehre Pommritz’, in G. Derlitzki, ed., *Berichte über Landarbeit* (Stuttgart, 1927), p. 12.
- 10 See, for example, Edouard Lynch, ‘Interwar France and the rural exodus: the national myth in peril’, *Rural History*, 21 (2010), 165–76.
- 11 Georg Derlitzki, ‘Die Bedeutung der Landarbeitsforschung in Deutschland’, in *Atti del III Congresso Internazionale di Organizzazione Scientifica del Lavoro, Parte II: Memorie*, vol. 1 (Rome, 1927), p. 136. On the history of the metaphor of the human motor, see Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (Berkeley and Los Angeles, CA, 1992).
- 12 Kiran Klaus Patel, ‘The Green Heart of Governance: Rural Europe during the Interwar Years in Global Perspective’, in Liesbeth van de Grift and Amalia Ribí-Forclaz, eds, *Governing the Rural in Interwar Europe* (London and New York, 2018), pp. 1–23; Paul Brassley, Yves Segers, Leen van Molle, eds, *War, Agriculture and Food: Rural Europe from the 1930s to the 1950s* (New York and London, 2012); Giovanni Federico, *Feeding the World: An Economic History of Agriculture, 1800–2000* (Princeton, NJ, 2005), pp. 191–6; Frank Trentmann, ‘Coping with Shortage: The Problem of Food Security and Global Visions of Coordination, c. 1890–1950’, in Frank Trentmann and Flemming Just, eds, *Food and Conflict in Europe in the Age of the Two World Wars* (Basingstoke, 2006), pp. 13–48.
- 13 Ulrich Herbert, ‘Europe in high modernity: reflections on a theory of the 20th century’, *Journal of Modern European History*, 5 (2007), 19; Lutz Raphael, ‘Embedding the Human and Social Sciences in Western Societies, 1880–1980: Reflections on Trends and Methods of Current Research’, in Kerstin Brückweh et al., eds, *Engineering Society: The Role of the Human and Social Sciences in Modern Societies, 1880–1980* (Basingstoke and New York, 2012), pp. 41–57.
- 14 Wilhelm Seedorf, ‘Die Vervollkommnung der Landarbeit und die bessere Ausbildung der Landarbeiter unter Berücksichtigung des Taylor-Systems’, *Jahrbuch der Deutschen Landwirtschafts-Gesellschaft*, 34 (1919), 471.
- 15 Frédéric Etienne Tapernoux, ‘L’Organisation scientifique du travail agricole: Rapport présenté au XIV Congrès International d’Agriculture à Bucarest’, *Actes. XIVe Congrès international d’agriculture, Bucarest, 7, 8 et 10 juin 1929* (Bucarest, 1930–32), vol. 2, p. 379.
- 16 Institut International d’Agriculture, *L’organisation scientifique du travail agricole en Europe*, pp. 5–8, 22–34.
- 17 Georg Derlitzki, *Die Versuchsanstalt für Landarbeitslehre Pommritz i.S.* (Bautzen, 1931), p. 5.
- 18 Géza Farkas et al., ‘Über den Energieumsatz beim Ernten’, *Arbeitsphysiologie*, 1 (1929), 466–79; Edgar Atzler, ‘Arbeitsphysiologie und Landwirtschaft’, in Derlitzki, ed., *Berichte über Landarbeit*, pp. 91–104.
- 19 Kurt Lewin, ‘Die Rationalisierung des landwirtschaftlichen Betriebs mit den Mitteln der angewandten Psychologie’, *Zeitschrift für angewandte Psychologie*, 15 (1919), p. 400; Walter Ronald Dunlop, ‘Industrial Psychology and Agriculture’, in C. Myers, ed., *Industrial Psychology* (1929, London, 1943), pp. 231–44.

- 20 Ernst Laur, *Die landwirtschaftliche Arbeiterfrage in der Schweiz: Vierter Teil: Vorschläge zur Lösung des Problems* (Brugg, 1916), p. 171; Seedorf, 'Die Vervollkommnung der Landarbeit'; Georg Derlitzki, *Das Taylorsystem und seine Anwendung auf die Landwirtschaft: Schriften der Ökonomischen Gesellschaft* (Leipzig, 1921).
- 21 Elizabeth B. Jones, 'The gendering of the postwar agricultural labor shortage in Saxony, 1918–1925', *Central European History*, 32 (1999), 311–29; Elizabeth B. Jones, *Gender and Rural Modernity: Farm Women and the Politics of Labor in Germany, 1871–1933* (Farnham, 2009), pp. 127–59.
- 22 Dorothea Derlitzki, *Arbeitersparnis im Landhaushalt: Eine zusammenfassende Darstellung der 'Arbeitslehre im Haushalt' unter Berücksichtigung der hausaltswissenschaftlichen und hauswirtschaftlichen Bestrebungen der Jetztzeit für Landfrauen, wirtschaftliche Frauenschulen, Haushaltungsschulen, usw.* (Berlin, 1926); W. Pidgajetzky, 'Problem der Rationalisierung der Frauen-Arbeit auf den Zuckerrüben-Feldern', in *Atti del III Congresso Internazionale di Organizzazione Scientifica del Lavoro, Parte II: Memorie* (Roma, 1927), vol. 1, pp. 415–20; Augusta Gillibert-Randin, 'La section féminine au XVème Congrès international d'agriculture', in Peter Moser and Marthe Gosteli, eds, *Une paysanne entre ferme, marché et associations: Textes d'Augusta Gillibert-Randin, 1918–1940* (Baden, 2005), p. 257.
- 23 Walter A. Riddell, 'The influence of machinery on agricultural conditions in North America', *International Labour Review*, 13 (1926), p. 321.
- 24 Walter Studer, *Untersuchungen über Arbeitswirtschaft und Arbeitstechnik in bernischen Bauernbetrieben* (Zürich, 1946).
- 25 Vladislav Brdlik, 'L'organisation scientifique du travail agricole', in *Atti del III Congresso Internazionale di Organizzazione Scientifica del Lavoro, Parte II, Memorie* (Roma, 1927), vol. 2, pp. 869–92. On Marey, see Rabinbach, *The Human Motor*, pp. 84–119. On the Gilbreths, see Frank and Lilian Gilbreth, *Die Magie des Bewegungsstudiums: Photographie und Film im Dienst der Psychotechnik und der Wissenschaftlichen Betriebsführung*, ed. by Bernd Stiegler (München, 2012).
- 26 Nathan Zuntz et al., *Untersuchungen über den Stoffwechsel des Pferdes bei Ruhe und Arbeit* (Berlin, 1898); Henry Prentiss Armsby and Robert C. Moulton, *The Animal as a Converter of Matter and Energy: A Study of the Role of Live Stock in Food Production* (New York, 1925); Samuel Brody and Richard Cunningham, *Comparison between Efficiency of Horse, Man, and Motor, with Special Reference to Size and Monetary Economy* (Columbia, 1936), p. 5; Hans Wenger, *Untersuchungen über die Arbeitsleitung von Schweizer Rindern* (Bern, 1939). See on this issue, E. J. T. Collins, 'The Farm Horse Economy of England and Wales in the Early Tractor Age 1900–40', in F. M. L. Thompson, ed., *Horses in European Economic History: A Preliminary Canter* (Reading 1983), pp. 73–100; Ann Norton Greene, *Horses at Work: Harnessing Power in Industrial America* (Cambridge and London 2008), pp. 200–43; Juri Auderset and Hans-Ulrich Schiedt, 'Arbeitstiere: Aspekte animalischer Traktion in der Moderne', *Traverse* (2021).
- 27 Konrad von Meyenburg, 'Prinzipien bei der Prüfung von Maschinen der Motorkultur', *Mitteilungen des Verbandes landwirtschaftlicher Maschinen-Prüfungs-Anstalten*, 3 (1909), pp. 77–86; Max Ringelmann, 'Recherches sur les moteurs animés: Travail de l'homme', *Annales de l'Institut national agronomique*, 7 (1913), pp. 1–40; Alexandre Lonay, 'Les principes fondamentaux de l'organisation scientifique du travail en agriculture', *Mémoires du congrès international de l'organisation scientifique du travail* (Bruxelles, 1925), pp. 311–16. See on this issue, Juri Auderset and Peter Moser, 'Mechanisation and Motorisation: Natural Resources, Knowledge, Politics and Technology in 19/20th Centuries Agriculture', in Martiin, Pan-Montojo, Brassley, eds, *Agriculture in Capitalist Europe, 1945–1960*, pp. 145–64.
- 28 Kiran Klaus Patel, *The New Deal: A Global History* (Princeton, NJ, 2016), p. 39. On the role of international organisations in the history of twentieth-century agriculture, see the contributions in *Agricultural History Review*, 65 (2017). On other fields of transnational cooperation in the interwar years, see Cornelia Knab and Amalia Ribí-Forclaz, 'Transnational co-operation in food, agriculture, environment and health in historical perspective', *Contemporary European History*, 20 (2011), 247–55.
- 29 Wilhelm Seedorf, 'Die Landarbeitswissenschaft: Ihre Entwicklung in Deutschland, ihre internationale Bedeutung', *Internationale Agrikulturwissenschaftliche Rundschau*, 2 (1926), 792–806.
- 30 *Atti del III Congresso Internazionale di Organizzazione Scientifica del Lavoro*, 2 vols (Rome, 1927). See also Jennifer Karns Alexander, 'Rationalization comes to Rome: Expertise in Labour Management at the Third International Congress, 1927', in Joris Vandendriessche et al., eds, *Scientists' Expertise as Performance: Between State and Society, 1860–1960* (New York, 2015), pp. 147–60.
- 31 ILO Archives, AG 803/1/3, Mixed Advisory Agricultural Committee, third session January 1927: new questions laid before the ILO, pp. 8–10.
- 32 *Proceedings of the Fifth International Conference of Agricultural Economists held at MacDonald College, Canada, 21 August to 28 August 1938* (London, 1939), p. 217.
- 33 Derlitzki, 'Die Bedeutung der Landarbeitsforschung in Deutschland', p. 136, 139.
- 34 Joshua B. Freeman, *Behemoth: A History of the Factory and the Making of the Modern World* (New York and London, 2018).
- 35 Wilhelm Seedorf, 'Methods and Results of Research Work on the Efficiency of Human Labor on German Farms', *Proceedings of the Second International Conference of Agricultural Economists* (Menasha, 1930), p. 952.
- 36 Laur, *Die landwirtschaftliche Arbeiterfrage in der Schweiz*, p. 171.
- 37 Gustav Winter, *Der Taylorismus: Handbuch der wissenschaftlichen Betriebs- und Arbeitsweise für die Arbeitenden aller Klassen, Stände und Berufe* (Leipzig, 1920), pp. 153–5.
- 38 Charles Brillaud de Laujardière, 'Le Taylorisme en Agriculture', *La vie agricole et rurale* (1920), 74–5.

- 39 Harry Braverman, *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century* (New York, 1974).
- 40 Derlitzki, 'Die Bedeutung der Landarbeitsforschung in Deutschland', p. 139; Ernst Laur, *Einführung in die Wirtschaftslehre des Landbaus unter besonderer Berücksichtigung der Landarbeitslehre* (Berlin, 1930), p. 54; Franz Schmidt, 'Rationalisierung in der Landwirtschaft', *Gewerkschaftliche Rundschau*, 20 (1928), 359.
- 41 Derlitzki, 'Die Bedeutung der Landarbeitsforschung in Deutschland', p. 136.
- 42 *Mitteilungen des schweizerischen Bauernsekretariates Nr. 89: Dreissigster Jahresbericht des leitenden Ausschusses des schweizerischen Bauernverbandes und des schweizerischen Bauernsekretariates 1927* (Brugg 1928), p. 54; Frédéric Etienne Tapernoux, 'Organisation du travail agricole', *Bulletin de la Classe d'Agriculture de la Société des arts de Genève*, Cinquième série, No. 3 (1930), 2; Samuel Brody, *Bioenergetics and Growth, with Special Reference to the Efficiency Complex in Domestic Animals* (New York 1945), pp. 898–9; [Louise Howard], 'The science of farm labour: scientific management and German agriculture', *International Labour Review*, 15 (1927), 379–413.
- 43 Derlitzki, 'Die Landarbeitsforschung, dargestellt an den Arbeiten der Versuchsanstalt für Landarbeitslehre Pommritz', p. 14.
- 44 Georg Derlitzki, Weber, 'Abraffen, Einlegen und Binden bei der Ernte', *Deutsche Landwirtschaftliche Presse* 1924, p. 297.
- 45 Derlitzki, 'Die Landarbeitsforschung, dargestellt an den Arbeiten der Versuchsanstalt für Landarbeitslehre Pommritz', p. 16.
- 46 Jules Amar, *Le moteur humain et les bases scientifiques du travail professionnel* (Paris, 1914); Edgar Atzler, ed., *Körper und Arbeit: Handbuch der Arbeitsphysiologie* (Leipzig, 1927).
- 47 Werner Huxdorff, 'Ergebnisse und Aufgaben von arbeitsphysiologischen Untersuchungen in der Landarbeitsforschung', *Fortschritte der Landwirtschaft*, 5 (1930), 290–4.
- 48 Georg Derlitzki, *Das Taylorsystem und seine Anwendung auf die Landwirtschaft*, Schriften der Ökonomischen Gesellschaft (Leipzig, 1921), p. 8.
- 49 See also Josef Ehmer and Michael Mitterauer, 'Zur Einführung: Familienstruktur und Arbeitsorganisation in ländlichen Gesellschaften', in Josef Ehmer and Michael Mitterauer, eds, *Familienstruktur und Arbeitsorganisation in ländlichen Gesellschaften* (Vienna, 1986), pp. 7–30; Erich Landsteiner and Ernst Langthaler, eds, *Agrosystems and Labour Relations in European Rural Societies (Middle Ages–Twentieth Century)* (Turnhout, 2010); Rita Garstenauer, Erich Landsteiner, Ernst Langthaler, eds, *Land-Arbeit: Arbeitsbeziehungen in ländlichen Gesellschaften Europas (17. bis 20. Jahrhundert)* (Innsbruck, 2010); Nicola Verdon, *Working the Land: A History of the Farmworker in England from 1850 to the Present Day* (London, 2017).
- 50 Louise Ernestine Howard, *Labour in Agriculture: An International Survey* (London, 1935), p. 19. On this issue, see Amalia Ribí Forclaz, 'A new target for international social reform: The International Labour Organisation and working and living conditions in agriculture in the interwar years', *Journal of Contemporary European History*, 20 (2011), 307–29.
- 51 See also David B. Grigg, 'The agricultural regions of the world: review and reflections', *Economic Geography*, 45 (1969), 95–132; David B. Grigg, *The Agricultural Systems of the World: An Evolutionary Approach* (London and New York, 1974); Erich Landsteiner and Ernst Langthaler, 'Agrosystems and Labour Relations', in Landsteiner and Langthaler, eds, *Agrosystems and Labour Relations in European Rural Societies*, p. 22.
- 52 [Howard], 'The science of farm labour', p. 380.
- 53 Niek Koning, *The Failure of Agrarian Capitalism: Agrarian Politics in the United Kingdom, Germany, the Netherlands and the USA, 1846–1919* (London, 1994), pp. 14–15.
- 54 *Schweizerische Landwirtschaftliche Monatshefte*, 5 (1927), 155.
- 55 Adolf Münzinger, *Der Arbeitsertrag der bäuerlichen Familienwirtschaft* (Berlin, 1929); Oskar Howald, 'Untersuchungen über die Verwendung und Verteilung der Arbeitszeit in schweizerischen Bauernbetrieben', *Landwirtschaftliches Jahrbuch der Schweiz* (Bern, 1933), pp. 1161–220; Michel Augé-Laribé, 'L'organisation scientifique de la production agricole en France', *Atti del III Congresso Internazionale di Organizzazione Scientifica del Lavoro*, parte 2: Memorie, vol. 2 (Roma, 1927), pp. 776–85.
- 56 Howard, *Labour in Agriculture*, p. 63.
- 57 Seedorf, 'Die Vervollkommnung der Landarbeit', p. 472.
- 58 'Betrachtungen über die Rationalisierung der Landwirtschaft', *Schweizerische landwirtschaftliche Zeitschrift*, 60 (1932), 844.
- 59 Derlitzki, 'Die Bedeutung der Landarbeitsforschung in Deutschland', p. 139.
- 60 See also Auderset and Moser, *Die Agrarfrage in der Industriegesellschaft*, pp. 96–102.
- 61 Konrad von Meyenburg, 'Vortrag an der Jahrestagung des Schweizerischen Werkbundes in Bern, 9. September 1928', *Archivbestand Konrad von Meyenburg (AfA Nr. 764)*, Archives of Rural History, Bern.
- 62 Konrad von Meyenburg, 'Grundsätzliches zur Kritik der Rentabilitätsberechnungen des Schweizer Bauernsekretariates', *Zeitschrift für schweizerische Statistik und Volkswirtschaft*, 63 (1927), 446.
- 63 Konrad von Meyenburg, 'Grundsätzliches zur Kritik der Rentabilitätsberechnungen des Schweizer Bauernsekretariates: Erwiderung auf die Replik von Dr. O. Howald', *Zeitschrift für schweizerische Statistik und Volkswirtschaft*, 64 (1928), 117.
- 64 Daniel M. Braum, 'Progress in Scientific Farm Management', *Eighth International Management Congress, Stockholm 1947: Papers Submitted to the Sectional Meetings* (Stockholm, 1947), vol. 1, pp. 319–29; Lowell S. Hardin, 'Work Simplification in Agriculture', *Proceedings of the Sixth International Conference of Agricultural Economists* (London, 1948), pp. 384–401; S.

- Schmidt, 'The Application of Scientific Management to Agriculture', *Proceedings of the Sixth International Conference of Agricultural Economists* (London, 1948), pp. 367–75.
- 65 Oskar Howald, 'Zur Förderung der Landarbeitstechnik', *Agrarpolitische Revue*, 7 (1950/51), 519–28.
- 66 Paul Bairoch, 'Les trois révolutions agricoles du monde développé: rendements et productivité de 1800 à 1985', *Annales E.S.C.*, 44 (1989), 317–53.
- 67 Christian Pfister, 'The "1950s Syndrome" and the Transition from a Slow-Going to a Rapid Loss of Global Sustainability', in Frank Uekötter, ed., *The Turning Points of Environmental History* (Pittsburgh, PA, 2010), pp. 90–118; Peter Moser, 'Zugriff auf die Lithosphäre: Gestaltungspotenziale unterschiedlicher Energiegrundlagen in der agrarisch-industriellen Wissensgesellschaft', *Traverse*, 3 (2013), 37–48; Céline Pessis, Sezin Topçu, Christophe Bonneuil, eds, *Une autre histoire des 'Trente Glorieuses': Modernisation, contestations et pollutions dans la France d'après-guerre* (Paris, 2013).
- 68 Jack Kloppenburg Jr, 'Social Theory and the De/Reconstruction of Agricultural Science: Local Knowledge for an Alternative Agriculture', in George Henderson and Marvin Waterstone, eds, *Geographic Thought: A Praxis Perspective* (London and New York, 2009), p. 248.
- 69 Hermann Priebe, *Landarbeit Heute und Morgen: Grundfragen und praktische Hilfen* (Hamburg, 1953), p. 15; Franz Zihlmann, 'Geschichtliche Entwicklung, Methoden und Probleme der modernen Arbeitswissenschaft unter spezieller Berücksichtigung der Landarbeitswissenschaft', *Schweizerische Landwirtschaftliche Monatshefte*, 36 (1958), 11.
- 70 Sir Albert Howard, *Mein Landwirtschaftliches Testament* (Berlin and Frankfurt 1948), p. 194.
- 71 Auderset and Moser, 'Mechanisation and Motorisation', pp. 156–8.
- 72 Rabinbach, *The Human Motor*, p. 2.
- 73 See, for instance, David, *Sozialismus und Landwirtschaft*, p. 157; Henry Prentiss Armsby, *The Computations of Rations for Farm Animals by the Use of Energy Values* (Washington, DC, 1909), p. 9.
- 74 Deborah Fitzgerald, *Every Farm a Factory: The Industrial Ideal in American Agriculture* (New Haven, CT and London 2003).
- 75 Anon., 'Labour efficiency investigations in English farming', *International Labour Review*, 21 (1930), 707.
- 76 *Proceedings of the Fifth International Conference of Agricultural Economists*, p. 219.
- 77 Peter Moser and Tony Varley, 'The State and Agricultural Modernisation in the Nineteenth and Twentieth Centuries in Europe', in Peter Moser and Tony Varley, eds, *Integration through Subordination: The Politics of Agricultural Modernisation in Industrial Europe* (Turnhout, 2013), pp. 20–1.
- 78 Christophe Bonneuil and Jean-Baptiste Fressoz, *The Shock of the Anthropocene: The Earth, History and Us* (London and New York, 2017), p. 51.