The contribution of human capital to agricultural growth in Germany, 1870–1939. Research strategy

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Abstract

This project description outlines the research strategy for assessing the effect of human capital on growth in the agricultural sector of Germany 1870–1939. First, the concept of useful knowledge (Mokyr 2002) is planned to be applied to curricula of agricultural winter schools in order to document diffusion of useful knowledge by these schools. The second part would deal with the quantification of the effect of agriculture specific human capital on growth in the agricultural sector. It is argued that human capital is essentially useful knowledge with a specific storage location: people. An econometric model based on a production function following Kopsidis and Hockmann (2010) is planned to be extended with a human capital variable derived from data on agricultural winter schools. Both parts of the proposed research focus on the agricultural winter school. In sum, this research could have the potential to contribute to the understanding of the fundamentals of economic growth in the agricultural sector. One major present limitation of this project description is that thus far known sources and data are not yet sufficient to conduct the proposed research. A second limitation is that it is questionable whether it will be possible to combine insights of both parts. The task would be to deduce weights from the curricula that are used for the refinement of the agriculture specific human capital variable.

Keywords: Useful knowledge, schooling, human capital, production function, growth, agriculture, curricula, agricultural school

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1 Agriculture and growth

Economists are fascinated with understanding the fundamentals of economic growth. If we knew why some grew rich and others did not, society would act accordingly in its political decisions, e.g. in development cooperation. Since the so-called residual debate (Metcalfe 2008: 215–6), knowledge and human capital have gained importance in explaining growth (Rosen 2008: 99; concept of useful knowledge: Mokyr 2002; endogenous growth theory: Romer 1986; unified growth theory: Galor 2005, and Galor 2008). Crafts (2011) documents the discussion on the role of knowledge vs. factor prices for economic growth.

Agriculture is of particular interest in growth analysis. The reasons are practical relevance of the agricultural sector, historical growth experiences, and theoretical arguments. At the beginning of economic development, agriculture is important for growth, because it has a high share in both labour force and GDP (Mellor 2008: 100; Dennison and Simpson 2010: 148). Permanent increases in agricultural output are therefore of macroeconomic relevance. In Germany, for example, 49.5% of the labour force were employed in agriculture in 1875 (Broadberry 1997: 252, table 4). The share of agriculture in output in 1850/54 was 45.2% (Pfister 2011: 8, based on Hoffmann 1965). In the developing economies of today similar high shares are reported, e.g. for the labour force in China or India (Huffman and Orazem 2007: 2293, 2295). Most countries jump-started economic growth in agriculture according to Huffman and Orazem (2007: 2299–301).

Four theoretical arguments deal with the transmission of growth in agriculture to the economy. (i) Productivity gains make Smithian growth possible (Crafts 1985 in: Dennison and Simpson 2010: 148). If technical change occurs, the migration of labour from the agricultural to the non-agricultural sector keeps a closed economy in equilibrium (Huffman and Orazem 2007: 2285). (ii) Farm households consume non-farm goods which leads to non-agricultural rural employment effects (Mellor 2008: 102–3). (iii) Food prices matter. The (a) level of food prices has a strong impact on real wages at low income levels (Engel's law; Mellor 2008: 102). Additionally, with reference to Sen (1981), it can be argued that lower food prices reduce the vulnerability to death by famine. In addition to this, decreasing (b) volatility of food prices reduces the risk of death by famine. This is likely to enhance human capital investments (Pfister and Fertig 2010: 54–6). (iv) Nutrition affects physiological capital, i.e. the initial health stock and its changes over time (Fogel 2004: 645–7). Thus, better availability of food improves nutrition, which results in higher labour productivity and a higher number of available labour units (Fogel 2004: 651–4; Huffman and Orazem 2007: 2303–5). Furthermore, the improvement of nutrition affects human capital investments in the economy positively (ibid.).

In the case of Germany, Grant (2009) finds a labour productivity growth of 1.5% per annum for 1880–1909.[1] The main forces for increasing productivity 1870–1913 expressed

[1]From 1800–1850, agricultural production grew 77% and labour productivity in agriculture almost 30%

in yields were improved nutrient supply and plant breeding (Grant 2009: 184). The role of increased nutrient supply also applies to the period 1913–38 (Grant 2009: 197). This result is deduced from total factor productivity (TFP) analyses (two different methods; Grant 2009: 190–2), and additional regression analyses in earlier work focusing on sugar beet, farm size and market access (Grant 2002: 22–33). Grant (2009: 191–2) underlines that overall growth in TFP was high.

The problem which is planned to be analysed is the insufficiently explained growth of the agricultural sector in Germany. Explaining the residual would be based on two arguments that explore the role of agricultural winter schools. The first argument is that agricultural winter schools diffuse useful knowledge to producers. To the the best of my knowledge, the literature on the emergence of agricultural science in Germany (e.g. Uekötter 2010; Klemm 1992) might be interpreted as documenting advances in agriculture specific knowledge. Mokyr also deals with scientific progress in agriculture, however, the author credits less importance to it relative to the Industrial Enlightenment for the British case (see e.g. Mokyr 2002: 19, footnote 24; 72; 93–4; 109; 179–80, footnote 16; Mokyr 2009). Huffman and Orazem (2007: 2283, 2293–4) put emphasis on the importance of positive agricultural technology shocks for growth, in particular on those resulting from advances in agricultural sciences. Agricultural schools and particularly agricultural winter schools might epitomize an important channel for knowledge diffusion.

The second argument focuses agricultural winter schools in their role of increasing agriculture specific human capital. Human capital in agriculture has not been considered as an explanation for the increase in output and labour productivity in agriculture in Germany, although it is of particular theoretical relevance compared to other sectors. Technical change plays a major role in increasing productivity in agriculture, which leads to high demand for human capital (Mellor 2008: 104).

This research project would first aim at exploring the role of agricultural schools in diffusing agriculture specific useful knowledge to agricultural production in Germany 1870–1939. Based on this, the second aim would be to quantify the effect of agriculture specific human capital on growth in the agricultural sector in selected regions in Germany for the period 1870–1939. The purpose of this paper is to receive valuable criticism on the proposed research strategy from participants of the Rural History Conference 2013.

The remainder of the paper is structured as follows. Section 2 introduces the proposed method to ascertain what knowledge agricultural winter schools diffused. This is followed by the outline of how the second aim of quantifying the effect of agriculture specific human capital on growth is planned to be met. Each of these two sections contains a literature review, a description of the underlying theoretical arguments, thus far known data and

(Pfister 2011: 13). Kopsidis and Hockmann (2010) provide regional evidence for this period (cf. Kopsidis 1996: 492). One explanation focuses on market integration (Kopsidis 1998; Kopsidis and Hockmann 2010, Pfister, Uebele, and Albers 2011). Kopsidis doubts the relevance of institutions, namely the liberalization of serfdom (*Bauernbefreiung*) and trade liberalization (ibid.).

sources, and the empirical approach. The fourth section is an outlook on combining both arguments, and on possible international comparisons. The last section discusses major limitations and concludes.

2 Useful knowledge and its diffusion by agricultural schools in Germany

"Only an increase in useful knowledge can permanently remove the ceiling on prosperity growth (Mokyr 2002: 285)."

Research question: What was the role of agricultural winter schools in diffusing useful knowledge to agricultural producers in Germany?

2.1 Literature review

Mokyr (2009: 171) explores whether an Agricultural Enlightenment contributed to the development of the British economy until 1850, comparable to an Industrial Enlightenment.[2] Overall, the importance of the Agricultural Enlightenment in Britain during the period 1750–1830 is limited (Mokyr 2009: 184–91). Most significant advances in useful knowledge with regard to science were made in the 19th century, in particular 1840–80 Mokyr (2009: 187, 194).

Mokyr (2002) documents several important innovations that account for a change in agriculture specific useful knowledge: the identification of nitrogen and the law of the minimum (1830), the beginning of systematic experimentation (1840), and the understanding of nitrogen fixing bacteria (1880s) (Mokyr 2002: 93–4; 19, 72; 93).[3] According to Mokyr (2008: 218), "[...] until 19th century organic chemistry widened the epistemic base, basic distinctions between nitrates, phosphorus and potassium were not made [...]." This entailed better fertilizer application and improved yields (ibid.).

Some of the innovations which Mokyr (2002) names took place in Germany. An additional example for advances in agricultural sciences is the emergence of phytopathology in the middle of the nineteenth century (Klemm 1992: 181–2). Contributions on the emergence of agricultural sciences in Germany include monographs by Klemm (1992) and more recently Uekötter (2010). Grant (2003: 59–66) notes that new knowledge is a reason for East-Elbian superiority in growth. Germany played a key role in expanding the knowledge on agricultural chemistry in the 19th century, and developments in the U.S. regarding the education of

[2] In an earlier draft of the abstract to this paper I have referred to Mokyr (2002), who to the best of my knowledge does not apply the term Agricultural Enlightenment, however, I have unfortunately missed that Mokyr (2009) uses it and apologize for not having noticed this (cf. `http://www.ruralhistory2013.org/panels/RuralHistory2013_Panel_10.1.pdf`; last access August 7, 2013).

[3] The Haber-Bosch process (1909; Mokyr 2002: 109) can rather be considered as providing new inputs to the production process, not new knowledge applied by agricultural producers who are focused here. Grant (2009: 192, 197) provides information on the relevance of a first plant using the Haber-Bosch process.

agricultural scientists, for example, were inspired by Germany (Huffman and Orazem 2007: 2295 and there cited literature). According to Johnson (2000), advances in the science of agriculture contributed to early economic development (Huffman and Orazem 2007: 2293–4). Although the introduced list is probably far from complete at the current, incomplete stage of studying all relevant literature, the advances in knowledge are evident for the 19th and beginning 20th century. Thus, the role of its diffusion to production deserves a closer look.

To the best of my knowledge, the role of agricultural winter schools in diffusing agriculture specific useful knowledge in Germany has not been analysed applying the framework of useful knowledge. Mokyr (2002: 102) exemplifies that useful knowledge during the Industrial Enlightenment was also accessed via schools, which introduced technical subjects in their curricula. Another example is the knowledge on germ theory which can be found in handbooks for teachers of girls' schools (Mokyr 2002: 194, 208). It might be that in this notion new useful knowledge on agriculture became part of the curricula of agricultural winter schools in Germany. Agricultural schools were hosting field experiments (Uekötter 2010: 86–7). Systematic experimentation was one ingredient to expand useful knowledge on fertilizing (Mokyr 2002: 202). According to Uekötter (2010: 104), however, the importance of agricultural schools was at best limited due to the low quality of knowledge taught in agricultural schools. In essence, agricultural schools failed to diffuse the revolution of agricultural knowledge (ibid.).

According to the analysis of curricula of agricultural schools by Exner (2000), a considerable part was still devoted to general education in the 1920s (Uekötter 2010: 104). Only since Nazi-Germany, fertilizing and agricultural engineering became part of the curriculum, since 1945 firm management (Exner 2000: 69–71; cited according to Uekötter 2010: 104). After the Second World War also physics and chemistry became part of curricula (Exner 2000: 71). These analyses refer to the region Westphalia (Exner 2000: 70). Furthermore, the author provides one example of a school in Bühl (near Stuttgart, Southern Germany), which was founded as winter school in 1866. The school offered 20 lessons per week of agriculture specific education, which made up 55.6% of 36 lessons in 1868 (35 lessons per week in Bavarian schools; Exner 2000: 71–2 and there cited literature). In 1959/60, the percentage of lessons devoted to agriculture specific topics was ca. 90%, while 39 lessons were given in total (more detailed information in there provided table; ibid.). Additionally, Exner (2000: 72–3) provides information on the content curricula for girls since the 1930s.

In short, the literature shows an increase in agriculture specific useful knowledge during the 19th and early 20th century. Agricultural schools, however, play no active role in diffusing science to farmers at the current state of research. It seems that the current state of research underestimates the role of agricultural winter schools, however.

2.2 Sources and methodology

2.2.1 Theoretical base: Mokyr's useful knowledge

Mokyr (2002) understands knowledge as useful knowledge. He defines two types of knowledge: propositional knowledge (the epistemic base) and prescriptive knowledge (techniques) (Mokyr 2002: 1–27). Mokyr (2002: 3) excludes knowledge on social phenomena in his definition of useful knowledge, although for example in the case of economics there are admittedly some grey areas (see also Mokyr 2008: 217). Growth is understood as a result of broadening the propositional knowledge, overcoming simple acceptance of the fact that some techniques work (Mokyr 2002: 2–4, 26). With regard to human capital, Mokyr (2002: 291–2) argues that the knowledge of an average worker might not be a crucial determinant of growth, because a small elite who mattered knew and the education system taught them how to access new knowledge. Whether counting the total number of school years helps to explain growth is questionable according to this argument (ibid.).

2.2.2 Sources

Curricula of agricultural schools should be available at least through literature (Strauch 1903). Thus far, regional coverage is unknown. Strauch (1903: 67–9) observed that curricula were very different between regions. He analysed almost 200 curricula of agricultural winter schools of different regions (including foreign countries) at different points of time (Strauch 1903: 69).[4] The result of their analysis is a table which presents covered areas of knowledge and a range of lessons that can be attributed to them. His analysis then focuses on explaining the differences in the range of lessons, and on the question of what is the right amount of lessons per knowledge area (Strauch 1903: 70–1). Table 1 presents the result table with added English translations.

In a following part of his work, Strauch (1903) presents more detailed contents of curricula of a sub-sample of 10 anonymised winter schools from the sample introduced above (Strauch 1903: 392) . This includes detailed description of what was taught in physics, chemistry, and applied agricultural sciences: cultivation of soil and plant production, animal breeding, and firm management (Strauch 1903: 390–2, 405–8, 424–9). This material would allow for example to show that differences in plant nutrients were made (nitrogen, phosphorus, potassium; Strauch 1903: 408) or that fertilizing was part of the curricula (Strauch 1903: 424).

Thus far it is unknown, whether the by Strauch analysed sample of curricula still exists as archival source, which would be preferable to the material published in Strauch (1903) for the proposed analyses due to the contained richer information.

[4] "Um klar und deutlich die Verschiedenheit in den Lehrplänen und der Lehrstoffverteilung erkennen zu können, haben wir gegen 200 Unterrichtspläne älterer und neuerer Winterschulen des In- und Auslandes mit einander verglichen [...] (Strauch 1903: 69)."

Table 1: Summary table of the analysis of curricula by Strauch (1903: 70)

Translation		First course number of lessons*	Second course number of lessons*
Subjects	Lehrfächer	Unterkursus Stundenzahl	Oberkursus Stundenzahl
Calculus	Rechnen	2–4	2–4
German language	Deutsche Sprache	2–8	
Writing (emphasis on beautiful)	Schönschreiben	2	
Physics	Physik	1–3	1–2
Anatomy of plants	Pflanzenanatomie	1–2	
Fertilizing	Düngerlehre	2–3	1–2
Soil science and cultivation of land	Bodenkunde und Ackerbaulehre	2–5	
Chemistry	Chemie	2–6	2–4
Animal breeding	Tierzucht	2–8	
Firm management	Betriebslehre	1–3	2–5
Horticultural sciences	Obst- und Gartenbau	1–2	
Special plant production	Spezieller Pflanzenbau		3–8
General and special animal breeding	Allgemeine und spezielle Tierzucht		3–5
Writing referring to business, German	Geschäftsaufsätze, Deutsche Sprache		1–6
Accounting	Buchführung		1–3
Legal issues	Gesetzeskunde		1–3

Source: Table by Strauch (1903: 70). English translations added. Sample size of analysed curricula of agricultural winter schools: “almost” 200 (Strauch 1903: 69). * Refers to one week.

2.2.3 Approach

It is planned to show that agricultural schools diffuse *propositional knowledge* (Ω), and *prescriptive knowledge* (λ, Mokyr 2002). This requires the analysis of the content of the curricula of these schools, in order to permit an assessment of the quality of the knowledge base which was available to farmers and which might have resulted in agricultural growth. Furthermore, it would be interesting to assess how much of the available useful knowledge was adapted in these schools. To answer this question, the curricula could be combined with the findings of Mokyr (2002), Klemm (1992) and Uekötter (2010) on the evolution of agricultural sciences.

A potential shortcoming is that this type of source shows what should have been taught and not what actually was learned. However, the weight of the argument depends on the question of who provided these documents. Strauch (1903: 68–71) observed the differences in the curricula, and also argued that this reflects the fact that no central institution was responsible for these winter schools. The heterogeneity of curricula while no central institution was responsible might indicate that the curricula were in fact close to reality of teaching, because they might have been more uniform otherwise. However, in the end, this cannot be known with certainty.

The main purpose of this qualitative analysis is to outweigh the weakness of the production function approach if simple schooling variables are considered, namely its inability to account for the quality of diffused knowledge.

3 Agriculture specific human capital and growth in Germany

"[...] the role of schooling levels in raising long run growth rates has strong theoretical appeal [...] that awaits a more definite empirical test (Huffman and Orazem 2007: 2310)."

Research question: What is the contribution of agriculture specific human capital to agricultural growth relative to technical change, nutrition, and urban demand in Germany 1870–1939?

3.1 Literature review

To the best of my knowledge no research exists on agriculture specific human capital formation in Germany 1870–1939. According to Lains and Pinilla (2009: 16) the analysis by Grant (2009) also addresses human capital, however, I was not able to confirm this. In earlier work, Grant (2003) analyses (based on Grant 2002) why East-Elbian agriculture was growing rapidly. He names knowledge diffusion as one reason among many but does not provide a detailed analysis or statistical evidence for this point (Grant 2003: 59, 66).[5]

Exploiting the less labour intensive winter time for schooling was the base for school attendance for many farmers' sons compared to full year courses and thus, winter schools were crucial among agricultural schools (Uekötter 2010: 103). Whereas in 1880 1,320 pupils were educated in agricultural winter schools (*landwirtschaftliche Winterschule*), the number increased to 19,900 in 1920 on the territory of Western Germany (Hudde 1965: 105). This development demonstrates a increase in people reached by agriculture specific knowledge. Additionally, schools which focused on education of young women (*Haushaltungsschulen*) existed at least at the end of the nineteenth century (Hudde 1965: 106–9). Particularly for dairy production and animal husbandry, this phenomenon might play a role for productivity increases. Generally, schooling exhibited a geographical heterogeneity: relatively more pupils

[5] "British observers were impressed by German agricultural education, and by the system of research institutes and experimental farms which demonstrated the new techniques to local farmers (Grant 2003: 59)."

attended the agricultural schools in the west compared to the east, and in the north western compared to southern regions (Uekötter 2010: 100;Hudde 1965: 118).

Agricultural academies (Schmidt 2006; Hudde 1965: 91–2) or agricultural unions (*landwirtschaftliche Vereine*) (Pelzer 2000, Pelzer 2002, Pelzer 2004) seem to be less important. The reasons are that the unions aimed at knowledge diffusion via reading literature, which can be shown to be not particularly successful (Pelzer 2004: 42, 50–2), that the students of the agricultural academies were part of a social elite, and that their tuition fees were high (Schmidt 2006: 121; see also Frielinghaus 2006: 92). The proposed elite story seems very plausible, which is an obstacle to explaining broad growth dynamics resting on human capital. A very low number of agricultural advisers, 100 *Wanderlehrer* in Prussia in 1894 (Uekötter 2010: 74–5 and there cited literature), might indicate that agricultural extension by them played a, as Uekötter (2010: 75) puts it, "symbolic", role prior the Second World War.

Uekötter (2010: 32–3) describes the communication in the agrarian knowledge society of the 19th and 20th century as asymmetric: academia with solid experimentally proven but specific knowledge on the one hand, farmers with practical broad knowledge but without scientific and often without agricultural specific education on the other. According to Uekötter (2010: 34), agricultural consultants (and their literature) were the link between these two groups. Uekötter (2010: 99–104) also reviews the role of agricultural schools in diffusing knowledge. Contemporaries of 1920 already argued that education was important for success for farmers (Uekötter 2010: 99). This optimistic view, however, was also doubted by others (Uekötter 2010: 100). Furthermore, until 1920 59% of pupils missed the second term in agricultural schools (Uekötter 2010: 100). In sum, Uekötter (2010: 104) argues in line with the pessimistic view that the importance of the agricultural schools was at best limited due to low numbers of pupils and, as introduced above, the low quality of knowledge taught in agricultural schools.

Admittedly, the thus far presented view does not seem to support the relevance of schooling for growth. However, even if indeed only a small fraction was educated in schools this is no sufficient proof for the unimportance of schools in knowledge diffusion. As referred to above, Mokyr (2002: 291–2) argues that the knowledge of an average worker might not be a crucial determinant of growth. The small educated fraction of farmers could have been responsible for a large fraction of output, depending on the farm size structure. E.g. in his analyses of Prussian yields at county level for selected years (1878, 1883, 1897, 1900) Grant (2002: 26–33) distinguishes between farm size of less than 20 hectares and more than 100 hectares, indicating a wide range of this variable which constitutes a weight on the effect of agriculture specific education on aggregate output.[6] Moreover, further theoretical arguments might give credence to the positive effect of schooling on output and growth.

[6] For 1960/1, there is a positive correlation of farm size and share of schooled farmers (Uekötter 2010: 109).

3.2 Data and methodology

3.2.1 Theoretical base: knowledge, human capital and production functions

"Human capital is the stock of skills and productive knowledge embodied in people (Rosen 2008: 98)." According to Mokyr (2008: 217), technology does not include "the manipulation of regularities in human behaviour by firm management", which is debatable. Compared with the definition of human capital introduced above, it seems that the most fundamental difference between both is the storage location. This can take different forms for technology (Mokyr 2002: 7–12), but is precisely defined for human capital: people. Thus, human capital would be a storage specific subset of useful knowledge, i.e. technology. This might lead to human capital as an explanation of the regional heterogeneity of growth. To illustrate, whereas it is difficult to ascertain who knew about latest innovations judging by the date of public availability, it is comparably simple to count people who were educated.

Schooling is one important channel to acquire human capital. The quantification of its effect on output draws on the production function as theoretical framework. This is a microeconomic concept, however, growth models such as the Solow model and its variants have their roots in the production function (Snyder and Nicholson 2012: 273, 672–3; cf. Huffman and Orazem 2007: 2309; Romer 1990: S80–1).[7] Furthermore, Huffman and Orazem (2007: 2310) state that "the linkage between macroeconomic and microeconomic estimates of the impact of schooling on labour productivity is open to further research." Production functions are suitable for addressing technical efficiency effects of human capital whereas profit functions additionally acknowledge possible allocative efficiency effects (Huffman 2001: 359–60; Huffman and Orazem 2007: 2333). Additionally, schooling might have a positive effect on investment decisions and thus, technology adoption, which is working through a higher capacity to acquire and process information (Huffman and Orazem 2007: 2332).

In what follows, methodological problems in quantifying the effect of human capital on output are discussed. "The production function approach only implicitly allows recognition of technology's fundamental nature [...] that it is [...] knowledge (Mokyr 2008: 217)." Thus, production function estimation might be a limited approach due to the problem of quantifying knowledge with the help of metric scaled variables. A fundamental question is whether human capital is treated as factor of production or affects the elasticities of other inputs (Miller and Upadhyay 2000: 403, 407). Further problems of incorporating human capital in empirical models include potential endogeneity (cf. Huffman and Orazem 2007: 2307) and the so called ability bias (Rosen 2008: 103–4). In addition to this, positive human capital effects could be biased upwards. This might result from omitting positive effects of improvements in nutritional status. Better nutrition raises labour productivity directly, increases the investment in human capital (more allocatable time per year; more demand

[7] Additionally, the empirical testing of macroeconomic models (Mincerian earning functions) including human capital variables shows that results are sensitive to inclusion of e.g. physical non-human capital (Huffman and Orazem 2007: 2305, 2309–10).

for schooling with rising income from better nutrition) and enhances its returns (schooling outcomes might improve directly and through better physical and mental development of young children; Huffman and Orazem 2007: 2303–5, 2320–1). Empirical evidence for such a bias in low- and middle-income countries 1961–99 shows a small decline of the effect of education (here: literacy rate) and loss of statistical significance, if instrumental variables for nutritional availability are added (Huffman and Orazem 2007: 2324–6).[8]

3.2.2 Data

Potential source of production data is Grant's work and its underlying sources, preferable in a revised version at lower levels of aggregation and extended time period (if possible), however, focused on particularly relevant commodities such as cereals (Grant 2009; Grant 2002).[9] The inputs land, labour, capital, and material inputs (fertilizer) are available at least at national level and partly disaggregated (ibid.). Other potential data sources are past research on Westphalia (cross-sectional data for 1880; Kopsidis and Hockmann 2010). Data on heights are available e.g. for the region Bavaria until the 1880s (Baten and Murray 2000). Data on schooling thus far exist as national aggregate for selected years 1880–1920 in Hudde (1965: 105).[10] More disaggregated data is available for Prussia in 1892 from Strauch (1893: 290–301).[11] Exner (2000: 66–7) provides some numbers of agricultural schools for the region Westphalia 1930/1, 1938/9 and later.

In what follows, the data on winter schools are described more detailed, which to the best of my knowledge has not been analysed thus far. Strauch (1893: 289–91) provides a short descriptive data analysis of a sample of 86 winter schools in Prussia in 1892.[12] With very few exceptions the courses last 2 winters, mainly starting in October and November (ibid.). An amount of 6–8 lessons per week can be considered as not meeting the requirement of a winter school: Strauch (1893: 291) argues that "only 6–8 lessons" are between the winter school and the *Fortbildungsschulen* (schools providing further training).[13] Most winter schools were

[8]Model based on Mincerian earning function analysing aggregated data; results are reported in table 1: see regressions 5 and 7 (Huffman and Orazem 2007: 2324–6). Huffman and Orazem (2007: 2327) conclude that the modest effect of education is more important than nutritional status. They admit that much of this result might be due to poor data for nutrition. Particularly regression 7 questions this conclusion, because both have equally high marginal impact on growth in this model. The effects of better nutrition and thus, increased physiological capital might be even stronger for earlier periods, because there was a strong convergence to better health during the 20th century in some countries, which was mainly due to better diets (quantity and diversity) (Fogel 2004: 649–50).

[9]It seems that the data sets are not publicly available.

[10]Where Hudde acquired this information is unclear.

[11]The Ifo Prussian Economic History database contains one variable, i.e. the total number of vocational schools for 1864, which include next to the type *Ackerbauschule* other types of non-agricultural schools, however (iPEHD 2013; Becker et al. 2012).

[12]Strauch is editor of this journal. The author of the article is not explicitly given.

[13]Winter schools had up to 630 hours of agriculture specific education covering two semesters (Strauch 1903: 27). See also table 1 above.

subsidized, and according to Strauch (1893: 291) the differences in the amount of subsidies were considerable.

The exploratory data analysis of one cross-section for 1892 draws on the same sample and calculates some basic descriptive statistics like Strauch but works at lower level of aggregation (*Regierungsbezirk*) compared to his analysis and extracts more variables from the data set. These include total amount of educated pupils since foundation of the school, which shows the accumulated educated pupils from the schools of the district. Furthermore, variables which might be used to assess the quality of the school are included: number of teachers, pupils per teacher, experiment fields, doctoral degree and profession of the director of the school). Descriptive results are in table 2.[14]

The data additionally contain information on tuition fees. Figure 1 shows a plot of the empirical cumulative distribution function of tuition fees, payable for the first semester. In all schools (5 cases excluded as no data are available) pupils had to pay. This shows that pupils who were enrolled in these schools invested not only their opportunity costs but also tuition fees in agriculture specific education. Most payable tuition fees were about 20 to 30 *Mark*.

[14]The software R was used for this analysis (R Development Core Team 2013).

Table 2: Descriptive statistics winter schools 1892

Row	Regierungsbezirk	schools	pupils	pupils acc.*	pupils per school	teachers	pupils per teacher	experiment field**	agricultural teacher***	PhD***
1	Aachen	2	48	363	24	11	4.36	1	0	0
2	Arnsberg	6	336	709	56	43	7.81	4	0.5	0
3	Breslau	1	108	1565	108	16	6.75	1	1	0
4	Danzig	2	45	212	22.5	19	2.37	1	0	1
5	Düsseldorf	5	179	599	35.8	23	7.78	3	0	0
6	Erfurt	2	86	617	43	15	5.73	0	1	0
7	Frankfurt a.O.	1	33	64	33	9	3.67	0	0	1
8	Gumbinnen	2	78	1020	39	20	3.9	0	0	0.5
9	Hannover	3	139	133	46.33	17	8.18	0	0	0.33
10	Hildesheim	2	110	90	55	18	6.11	0	0	0.5
11	Kassel	5	132	283	26.4	32	4.12	2	0.2	0.6
12	Koblenz	5	132	441	26.4	23	5.74	1	0	0.2
13	Köln	4	97	394	24.25	18	5.39	2	0	0.25
14	Königsberg	3	100	245	33.33	21	4.76	0	0.33	0
15	Liegnitz	1	75	424	75	12	6.25	0	0	1
16	Lüneburg	2	99	175	49.5	15	6.6	0	0	0
17	Magdeburg	2	115	591	57.5	18	6.39	1	0.5	1
18	Marienwerder	1	31	188	31	9	3.44	0	0	0
19	Merseburg	2	125	1079	62.5	22	5.68	0	0	0.5
20	Minden	2	60	124	30	15	4	2	0.5	0
21	Münster	4	232	239	58	22	10.55	1	0	0
22	Oppeln	2	154	590	77	18	8.56	0	1	0
23	Osnabrück	2	45	0	22.5	9	5	0	0	0.5
24	Posen	1	49	10	49	16	3.06	1	1	0
25	Potsdam	1	13	12	13	12	1.08	0	0	1
26	Schleswig	6	106	230	17.67	18	5.89	1	0.5	0.33
27	Sigmaringen	1	19	180	19	5	3.8	1	0	0
28	Stade	2	54	22	27	12	4.5	0	0.5	0
29	Stettin	1	38	69	38	13	2.92	0	0	0
30	Trier	5	126	688	25.2	23	5.48	2	0	0.4
31	Wiesbaden	4	124	516	31	22	5.64	0	0	0

Source: own calculation based on data from Strauch (1893: 290–301). Sample size: 82. Four schools (Two in Schlewsig, one in Lüneburg and one in Brügge in Westphalia) were excluded due to missing observations for all variables. * Accumulated educated pupils since foundatation of school; ** schools with experiment field or garden; *** refers to share of directors of schools with this profession.

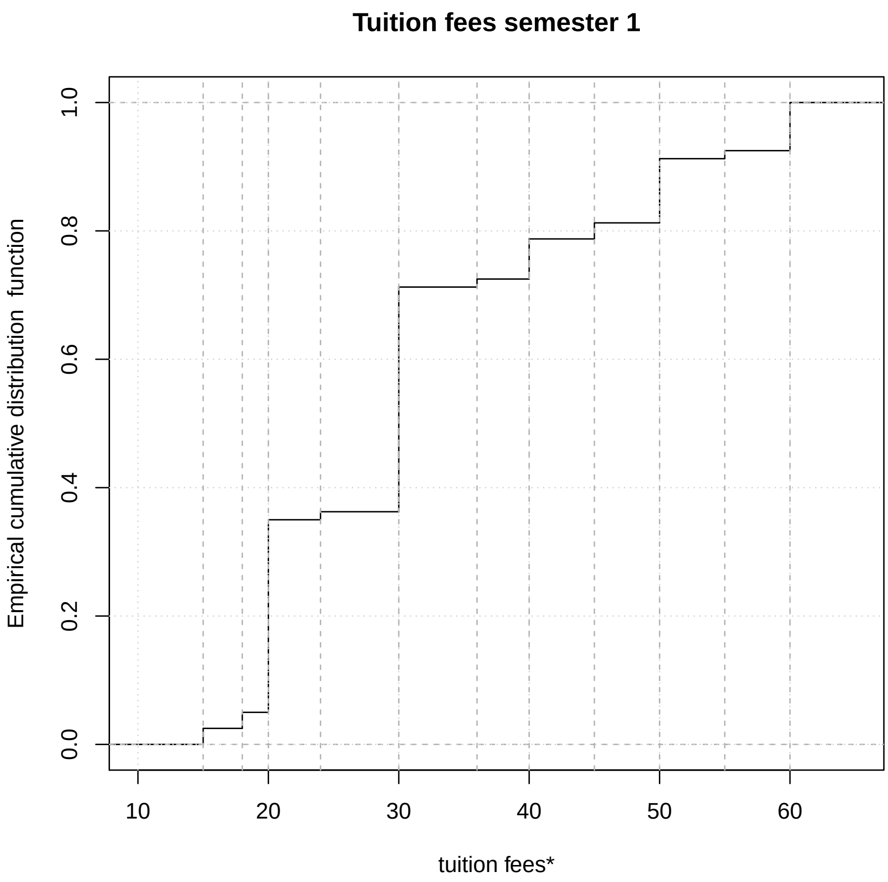

Figure 1: Source: own calculation based on data from Strauch (1893: 290–301). * Tuition fees in *Mark*. One case of 82 is excluded, because the tuition fee contains the fee for accommodation.

Tuition fees were the same for all semesters in most cases (table 3).[15] However, in roughly a quarter of schools tuition fees were lower for the second term, indicating that there might have existed decreasing marginal returns to agriculture specific human capital at the micro-level.

Table 3: Amount of tuition fees and semester (rounded to 2 digits)

	Share
Tuition fees lower in semester 2	0.24
Tuition fees equal in both semesters	0.75
Tuition fees higher in semester 2	0.01

Source: own calculation. Data from Strauch (1893: 290–301).

[15]Strauch provided the information on both tuition fees in one column. In case of two tuition fees he gave a first amount of money as tuition fee and than adding "and" plus a second amount of money. This second amount is interpreted as the tuition fee for the second semester.

A future aim is to add the time series perspective to this cross-sectional information. Data provided by Hudde (1965) is available at very low frequency and high aggregation, which are plotted in figures 2–4. Unfortunately, it is thus far unknown which data sources Hudde (1965) consulted. The figures show that there was a trend to more agricultural winter schools educating more pupils.[16]

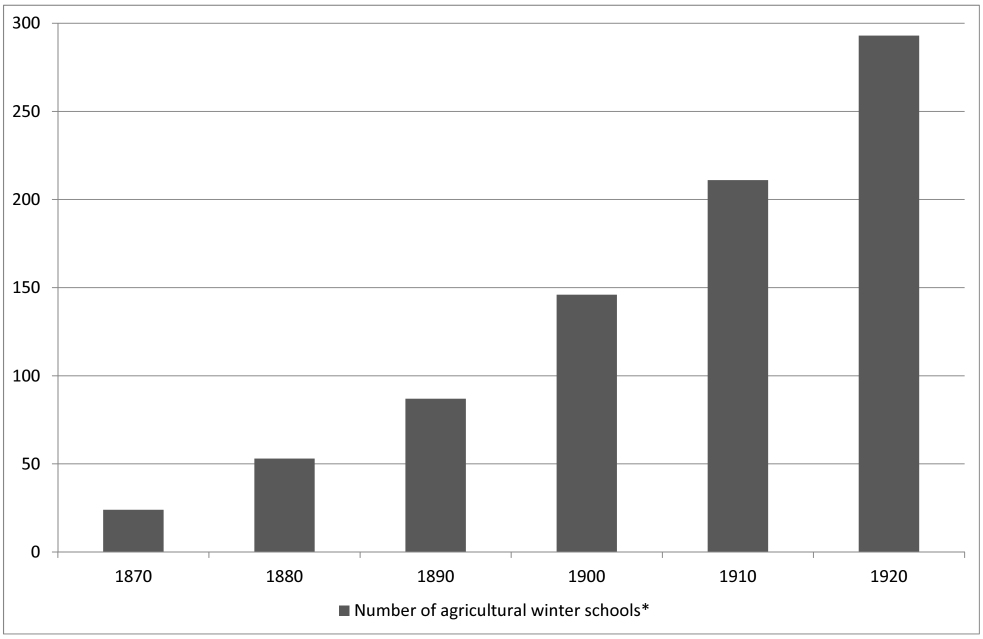

Figure 2: Number of agricultural winter schools. * Refers to the territory of the Federal Republic of Germany (West-Germany). Source: own figure based on data from Hudde (1965: 105).

[16]Although this is speculative, the development of increasing investments in agriculture specific human capital might contribute to the decline in fertility. Germany exhibited a decline in crude birth rates of 37% 1875–1920 (Galor 2008: 109).

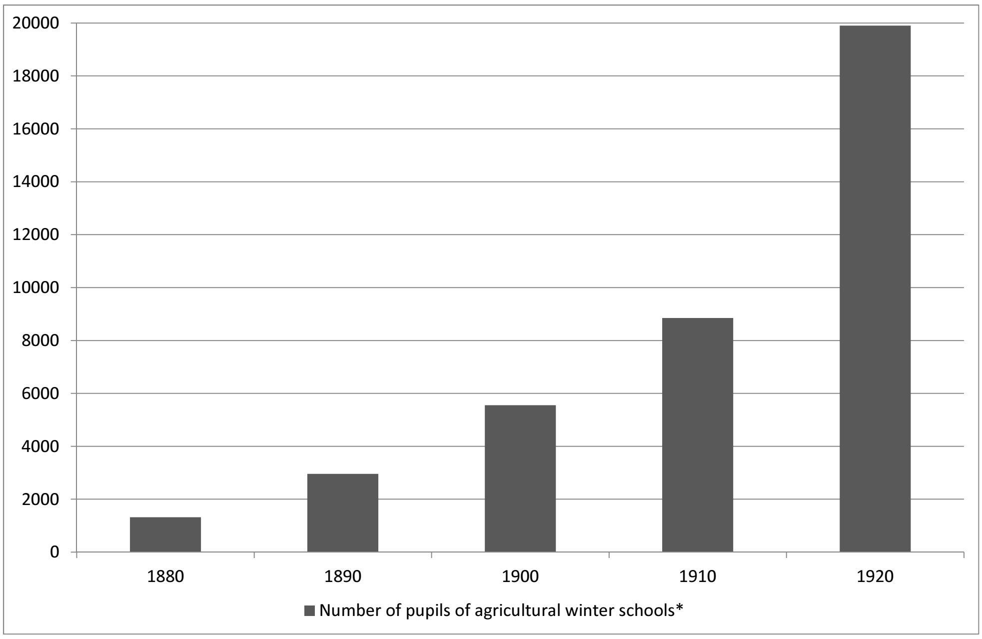

Figure 3: Number of pupils in winter schools. * Refers to the territory of the Federal Republic of Germany (West-Germany). Source: own figure based on data from Hudde (1965: 105).

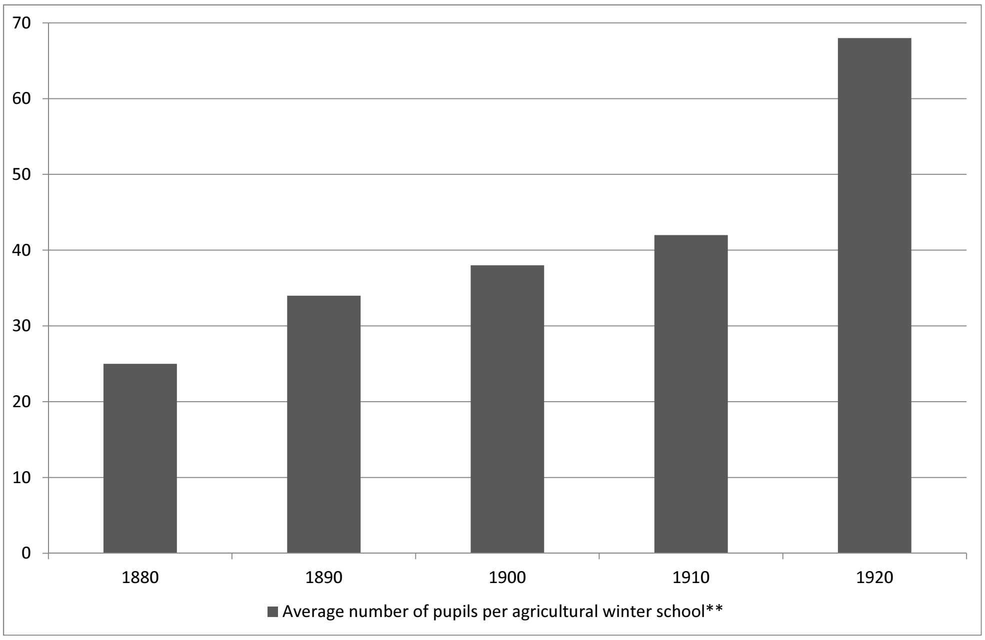

Figure 4: Average number of pupils per school. ** Refers to the territory of Imperial Germany. Source: own figure according to data from Hudde (1965: 105).

3.2.3 Empirical approach

The contribution by Kopsidis and Hockmann (2010) serves as model study of an empirical production function and is extended with variables for human and physiological capital. Nutritional status and thus physiological capital might be best approximated by height in the historical context (Fogel 2004: 645–7). The problem of quantifying knowledge is addressed by refining the human capital variable, e.g. number of pupils per county. Huffman (2001: 365) states that empirically, the technical efficiency effects seem to be small compared to allocative efficiency effects. Admittedly, the extension to a profit function to assess allocative effects would be preferable but depends on data availability (out- and input prices). Testing the robustness of the effect of human capital vs. demand-induced growth could draw on variables quantifying the distance to urban markets (Kopsidis and Wolf 2012).

4 Outlook

4.1 Quality adjusted human capital

This section briefly explores the potential of combining both introduced fields of research. These lines are very preliminary and it should be stressed that relevant literature such as Wößmann (2002) has not been consulted yet. In case differences between the useful knowledge existed, which agricultural winter schools diffused at different points in time, an equally weighted number of pupils as human capital variable cannot reflect this development. This first refers to the amount of lessons devoted to agriculture specific knowledge, and second to the quality of the content of lessons.

As the analysis by Exner (2000) introduced above illustrates, the amount of lessons devoted to agriculture specific knowledge was lower in a winter school in 1868 compared to 1959. If the curricula could be used to deduce weights based on the amount of lessons devoted to agriculture specific knowledge, a more appropriate scaled variable of schooling would be the result. This also applies to variations across space, which existed according to the analyses by Strauch (table 1).

The quality of lessons, however, would hardly be assessed by this procedure. As table 2 shows, schools differed by pupil to teacher ratios, or by characteristics such as running experimental fields. This provides potential for explaining further regional differences, because the achievements in learning might have been quite different between these schools. In addition to this, not all useful knowledge was available at the beginning of agricultural winter school education. If new useful knowledge is added to the curricula, comparable to the problem of adding new commodities to a consumer basket, advances in quality are not visible in the human capital variable.

Applying any procedure to adjust for these differences would be based on the belief that quantifying human capital can help in a valuable fashion to incorporate knowledge into the production function framework, however, that quality of knowledge matters.

4.2 International comparisons and trade

It would be interesting to compare Germany or regions of Germany to other countries. Olmstead and Rhode (2009: 28) argue that the question of closed vs. open economy makes a difference for (i) the growth dynamics in the agricultural sector and (ii) the effect on growth of the economy (based on insights of a neoclassical trade model with two sectors). Accordingly, Huffman and Orazem (2007: 2284–6) derive from a two-sector model that trade is a crucial determinant of growth in the agricultural sector, because in the open-economy case technical change in agriculture can raise agricultural relative to non-agricultural incomes. Moreover, free trade might have a positive effect not only *per se*. Trade leads to specialisation and hence, higher demand for human capital (Miller and Upadhyay 2000: 409–10). The positive role of trade might be limited, however. Developing economies often lack the resources to buy food in the world market and thus, raising labour productivity in agriculture is essential for economic development (Huffman and Orazem 2007: 2296).

Since 1878, Germany imposed high tariffs on imports of cereals (Grant 2009: 180–2). Denmark, for example, followed a free trade policy instead (Henriksen 2009: 127). Furthermore, Denmark and Germany start in different groups of productivity in 1870 but are both part of the group of very productive countries in 1910 (Zanden 1991: 219–20, 230). It seems valuable to conduct international comparisons of the effect of agricultural schooling on growth in the considered period with regard to the trade regime.[17] Henriksen and O'Rourke (2005: 549) have tested whether the amount of pupils in agricultural schools can explain the decline in seasonality of milk production in Denmark. The relationship proved to be not statistically significant (ibid.). However, they aimed at assessing the impact of schooling on the volatility of production rather than on production.

[17]Available international country studies in agricultural development for the considered period hide the diversity of regional developments by national aggregates (Olmstead and Rhode 2009: 39–40). Thus, this limitation should be overcome by analysing as disaggregated data as possible for selected regions within considered countries.

5 Conclusion

This paper has outlined a research strategy on assessing the role of agricultural winter schools in diffusing useful knowledge, and on the quantification of the effect of agriculture specific human capital on growth of the agricultural sector in Germany for the period 1870–1939. Both arguments aim at exploring the effect of knowledge on growth. The first argument puts emphasis on the relevance of the quality of knowledge available to producers, the second argument instead on the quantity of knowledge. Both arguments meet at the agricultural winter school. What did enrolled pupils learn? How many pupils were educated for how long? The outlook on quality adjusted human capital discusses major problems in combining both arguments. The outlook on possible international comparisons puts emphasis on the theoretical relevance of the trade regime. Possibly, Denmark could be compared to Germany.

With regard to the limitations of this proposal, the following points are noted. Thus far provided sources and data are promising but are still a very thin base for the proposed analyses. In particular it is questionable, whether more cross-sectional sources on quality and quantity of schooling can be obtained in order to allow comparisons over time. At the current stage it must be concluded that sources on curricula and data are not sufficient yet to conduct the proposed research. With regard to the quantification of the effect of agriculture specific human capital on growth, one major challenge is to collect data on all theoretically relevant variables in order to achieve robust results.

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