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**Human Capital Investment in a Late-Developing
Economy: Evidence from Württemberg, c. 1600 – c. 1900**

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Abstract

Modern growth models view human capital, particularly education, as central to economic growth. But historical evidence has proved elusive. This paper investigates human capital levels in Württemberg, a late-developing German economy, between 1610 and 1899. Württemberg achieved higher and more universal literacy than any other European economy before 1800. A multivariate analysis reveals that this exceptional level of human capital in Württemberg was largely decoupled from economic variables from a very early date. Literacy declined significantly with individuals' age, suggesting that education was irrelevant to economic life. The Württemberg human capital miracle was unrelated to economic growth or human development indicators, casting doubt on theories that ascribe education a central role in economic growth.

JEL Classifications: N33; E24; J24; O15

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1. Introduction

Human capital investment, particularly in the form of education, is widely regarded as central to economic growth. Modern versions of neoclassical growth models routinely view education as preventing diminishing returns to physical capital. Endogenous growth models view education as accelerating the adoption of innovative techniques. Unified growth theory stresses the role of education in increasing the time costs of having children and motivating parents to substitute child quality for quantity, thereby reducing fertility, slowing population growth, and increasing capital per worker.

Economic growth, as is now widely recognized, has its roots far back in history. So if these theories are correct, then we should observe a close relationship between education and growth in historical developing economies. Did education and economic performance significantly influence one another during the long-term economic growth which took place in European societies in the centuries before and during industrialization?

Economic historians have devoted much research to this question, but have yet to provide a definitive answer. Certainly, the literature has established incontrovertibly that education and incomes increased in most European economies between c. 1500 and c. 1900. But no study has yet shown that this increasing education was an investment that *caused* economic growth, rather than a form of consumption that *resulted* from that growth. Cross-country comparisons show little association between literacy or school attendance on the one hand and economic performance on the other, let alone a clear causal link running from human capital investment to economic growth. Book production was more strongly associated

internationally with economic performance, but this may reflect demand for books by consumers whose incomes were rising rather than a set of human capital investments that encouraged economic performance. Within-country analyses in European history have also failed to provide definitive evidence of a clear causal association between education and economic outcomes. No study of the economic history of the Netherlands has been able to demonstrate that its educational attainment was cause rather than consequence of the Dutch Golden Age. Analyses of English industrialization provide little support for the view that education played an important role in the Industrial Revolution. Studies of the French demographic transition have not been able to establish that the earliest fertility decline in Europe was caused by a shift from quantity to quality of children induced by distinctively high levels of education.

Hitherto, most of the contributions to the human capital literature from the perspective of economic history have understandably focussed on the high-performing economies of the north Atlantic seaboard – the Netherlands in the seventeenth century, England in the eighteenth and nineteenth – in the quest to show that these economic and demographic success stories can be traced back to human capital investment. Most studies have also operated at a relatively high level of aggregation, analyzing data on the level of administrative districts, countries, or even entire continents, comparing Europe with Asia or the Islamic world.

This paper uses a different approach: we focus on a late-developing economy and we use micro-level data. We analyze a detailed documentary corpus for Germany covering almost three centuries, spanning the period before and during industrialization. German-speaking central Europe is an excellent laboratory for testing theories of economic growth since it was not a fortunate exception like the

Netherlands in the seventeenth century or England in the eighteenth, but rather a more typical “catch-up” industrializer. We exploit a rich database of thousands of marriage inventories, linked to family reconstitutions, for two contrasting communities in the south German territory of Württemberg between 1610 and 1899.¹ More than half our observations are for females, shedding light on the human capital of women, whose human capital investment decisions play a central role in modern theories of economic growth but whose experience is often obscured in developing economies. Our micro-level analysis of these data makes it possible to trace the development of literacy over time in a late-developing European economy at the level of individuals, where human capital investment decision are actually made.

2. The Micro-Study

This study analyzes individual human capital in two communities of the German territory of Württemberg between 1610 and 1899. Württemberg was a “German territory of the second rank” – neither a gigantic composite state such as Brandenburg-Prussia nor one of the German micro-dominions belonging to Free Imperial Cities, independent nobles, or religious houses. From 1496 to 1806, it was a sovereign duchy of the Holy Roman Empire of the German Nation. After the abolition of the Old Empire in 1806, Württemberg became a kingdom, and in 1815 one of the 39 members of the newly established German Confederation. In 1871, the kingdom of Württemberg became a state of the newly united Imperial Germany, which it remained until the end of the First World War.²

¹ For further detail on the sources and methods used to create this database, see Ogilvie, K pker and Maegraith 2009; Ogilvie 2010; Guinnane and Ogilvie 2014; K pker, Maegraith and Ogilvie 2015.

² Vann 1984, 36; Ogilvie, K pker and Maegraith 2009, 48-55.

The territory of Württemberg, although *de jure* subject to the institutions of the wider German empire, operated *de facto* as a sovereign state during most of the period under analysis in this paper. In theory, it was subject to a measure of oversight from the institutions of the Old Empire until 1806 and by the government of a united Germany after 1871, but in practice the government of Württemberg enjoyed far-reaching political autonomy vis-à-vis these imperial authorities. Internally, by contrast, the princely administration in Stuttgart (the capital) was not strong enough to govern the country without the cooperation of the powerful Württemberg parliamentary estates, manned by the representatives of the 40-60 administrative districts. Each district (*Amt*) was administered by the district town (*Amtsstadt*), which also elected the two parliamentary representatives from among its own citizens. One of the two communities under analysis here, the small town of Wildberg, was the capital of its own administrative district until 1807; the other community we analyze, the village of Auingen, was located two kilometres from its own district town of Münsingen. Each Württemberg district had a resident ducal bureaucrat (the *Amtmann*) who governed and administered the district, but was only able to do so in close cooperation with local institutions, notably the communities, the guilds, and the church.³

In Württemberg, towns and villages alike had powerful community councils which operated simultaneously as decision-making bodies, civil courts, regulatory courts, and administrative offices. The court and council in the district town was the first instance of appeal beyond the courts and councils of the villages of the district, and it also had far-reaching regulatory and administrative responsibilities for a wide

³ Schaab 1974, 191, 193, 235-7, and passim; Fulbrook 1983; Vann 1984, 149-61 and passim; Wilson 1995, 52-3, 57-9, 281, and passim; Mertens 1995, 142-7 and passim; Amend et al. 2007; Baumann et al. 2005; Hippel 1992, 481; Ogilvie 1999; Ogilvie, Kùpker and Maegraith 2009, 48-55.

range of issues internal to the district.⁴ The matters regulated by community courts and councils included educational provision, although for the most part community institutions acted to reinforce the mandates of the church (on school education) and the guilds (on vocational education).⁵

Württemberg resembled many other societies in central Europe in having a pervasive network of occupational guilds. As in many parts of southern and central Germany, Austria, Switzerland, Bohemia, Italy and Iberia, guilds in Württemberg regulated rural as well as urban occupations and existed not just in traditional crafts but also in export-oriented proto-industries, retailing, commerce, a wide array of other service-sector activities, and even primary-sector occupations such as those of shepherds, fishermen, and boatmen. All Württemberg guilds administered mandatory apprenticeships which operated as the main system of vocational education, although a key characteristic of guild apprenticeships in Württemberg, as in most European societies, is that they completely excluded females.⁶ As the Württemberg jurist Johann Friderich Christoph Weisser put it in 1780, “Anyone who wants to learn a craft has to possess particular qualities, which are necessary because without them no one can be accepted as an apprentice and registered with a guild. Among these qualities is ... masculine sex, since no female may properly practise a craft, even if she understands it just as well as a male person”.⁷

⁴ For more detail on the communal and district courts of Württemberg, see Grube 1954; Grube 1960; Ogilvie 1986, 282-4.

⁵ Ogilvie 1986; Ogilvie 1997; Ogilvie 1999; Ogilvie, Kúpker and Maegraith 2009, 55-71.

⁶ Hoffmann 1905, 10-11, and passim; Raiser 1978, 5-6, 151-3, 159-61, and passim; Hippel 1992, 572-3; Schaab 2000, 461, 507-8, 551 and passim; Ogilvie 1997, esp. ch. 3; Ogilvie 2003, 96-9; Ogilvie 2004a; Ogilvie, Kúpker and Maegraith 2009, 72-82.

⁷ Weisser 1780, 99-100: “Von einem Jeden, der ein Handwerk erlernen will, werden gewisse Eigenschaften erfordert, welche insgesamt dergestalten notwendig sind, daß ohne sie keiner zum Lehrjungen angenommen, und bei der Zunft eingeschrieben wird. Unter diese Eigenschaften gehört ... Das männliche Geschlecht; denn ordentlicher Weise darf kein Weibsbild ein Handwerk treiben, ob sie es gleich eben so gut, als eine Mansperson, verstünde”.

School education in Württemberg was operated by the established Lutheran church, which appointed the teaching personnel, laid down the curriculum, and monitored school attendance on the local level. Although the basis for the Lutheran educational system in Württemberg was laid down in the “Great Church and School Ordinance” (*Große Kirchen- und Schulordnung*) of 1559, and many schools were established in the second half of the sixteenth century, implementation was initially spotty and schooling was predominantly experienced by a minority of children from better-off families in urban centres. It was not until c. 1640 that the princely government and the Lutheran church in alliance erected the legislative and administrative structures necessary for the establishment and manning of a primary school in every community, including villages, and for the enforcement of school attendance for children between the ages of 7 and 14.

This enterprise was greatly assisted from the early 1640s onwards by the establishment of a network of powerful community-level moral and regulatory courts (*Kirchenkonvente*). Each of these local church courts was manned by the pastor and a subset of the community court, and held regular sittings at which these local householders monitored and regulated pedagogical matters, the performance of schoolmasters, and the compliance of pupils and their parents, among many other aspects of inhabitants’ everyday behaviour.⁸ The minutes of these local church courts reveal that from the second half of the seventeenth century onwards, Württemberg communities increasingly sought to compel all children between the ages of 7 and 14 to attend school. In Wildberg by the 1670s and in Auingen by the 1690s, the community church court minutes record prosecutions of parents who failed to send

⁸ For a detailed analysis of how one early modern Württemberg community church court monitored and regulated the upbringing and education of children and youths, see Ogilvie 1986.

their children to school, admonitions of negligent schoolmasters, and lists of poor children whose school fees were to be paid from community funds.⁹

A notable characteristic of the Württemberg school system, which distinguished it from the guild apprenticeship system, was that it not only permitted but positively encouraged human capital investment by females as well as males.¹⁰ In the context of our analysis in this paper, which uses signatures to measure human capital, it is particularly important to note that the skills that Württemberg schools were supposed to impart to both females and males included not just religion and reading but also the ability to write. This was explicitly stated in the national school ordinances of 1730 and 1782, which declared that learning to write

is not only of utility in civil life, but also serves the best interests of the soul ... it is not to be neglected, but rather all children, of both female and male gender, are to be held to it. For one must not allow any action to be taken based on the fact that simple people sometimes say that their girls do not need anything; this excuse is totally unjustified. For there are always cases and times when people speak quite differently and wish they had not neglected this.¹¹

⁹ Königliches statistisch-topographisches Bureau 1862, 81-2, 151, 256, 258, 265; Landesarchivdirektion Baden-Württemberg 1997, vol. II, 60; Ogilvie 2003, 80-96; Ogilvie, Küpker and Maegraith 2009, 102-13.

¹⁰ Schad 2002, 74-5; Ogilvie 2003, 80-96.

¹¹ "Erneuerte Ordnung vor die Teutsche Schulen" (1782, footnotes give passages which differ in 1730), in Reyscher 1828ff, Vol. 11, part 1, 36-69, here 59: "Da aber auch das schreiben nicht nur zum Nutzen im Bürgerlichen Leben, sondern auch zum Besten der Seelen dienet ... ist solches allerdings nicht zu verabsäumen, sondern die Kinder allesamt sowohl Weiblich als Männlichen Geschlechts darzu anzuhalten. Dann man muß denen einfältigen Leuten nichts daraus gehen lassen, wann sie zuweilen sagen, ihre Mägdlein haben nichts vonnöthen, dieser Vorwand ist allerdings ungegründet. Dann es fallen immer Fälle vor, und kommen immer solche Zeiten, da man ganz anderst spricht und wünschet, man hätt es nicht versaumet."

Arithmetic, too, was supposed to be taught to both girls and boys, on the grounds that it is “a quite necessary thing in common civil life, without which a house-father or house-mother, especially when they are crafts-people, cannot come to rights”.¹²

Local records from the communities under analysis here reflect the view that “catechists” (children between the ages of 7 and 14), whether male or female, were to be compelled to attend school and to learn the same skills. Thus in 1769 the Wildberg church court ordered the *Subprovisor* (the schoolmaster in charge of the mixed class of the junior pupils) to “teach the beginners in the ABC and the last ones in spelling, of both genders”.¹³ In 1776, the Wildberg church court ordered that “in the German school, reckoning shall be taught for 1 hour every afternoon to all children aged 12 to 14 years, both male and female”.¹⁴ Church visitation reports are rife with complaints about the negligence of both teachers and pupils, but the school attendance figures in these reports suggest that by the second half of the seventeenth century nearly 40 per cent of Wildberg “catechists” were attending school, rising to 73 per cent in the first half of the eighteenth century and virtually 100 per cent in the second half; by the early eighteenth century in Wildberg, there was little difference in school attendance between boys and girls.¹⁵

As already mentioned, Germany was a late-developing economy by western European standards. Macroeconomic estimates before 1800 have many recognized weaknesses, but the series compiled by Angus Maddison is widely used as a basis for

¹² “Erneuerte Ordnung vor die Teutsche Schulen” (1782, footnotes give passages which differ in 1730), in Reyscher 1828ff, Vol. 11, part 1, 36-69, here 61: “so ist es darum eine in dem gemeinen Burgerlichen Leben allerdings nöthige Sache, ohne welche nicht wohl ein Hausvatter oder Hausmutter, sonderlich nach dem die professionen seynd, zurecht kommen kan”.

¹³ Pfarrarchiv Wildberg [henceforth PAW] KKP [henceforth Kirchenkonventprotokolle] Vol. VI, fol. 194v-195r, 2.6.1769: “welcher die Anfänglinge im A. b: C: auch die leztern im buchstabiren sowohl männlich, als weiblichen Geschlechts unterrichten solte”.

¹⁴ PAW KKP Vol. VI, fol. 313r-313v, 15.11.1776: “in der teutschen Schuele ... alle Nachmittag 1 Stund lang das Rechnen dociert und zu diesem ... die Kinder und Scholaren von 12-14 Jahr sowohl männ- als weibl.n geschlechts ... gezogen werden sollen”.

¹⁵ Ogilvie 2003, 85-9 with Tables 3.1 and 3.2.

comparisons across societies.¹⁶ Table 1 shows the Maddison estimates of per capita GDP for Germany compared to other western European societies for six benchmark years between 1600 and 1900, the period covered by our analysis. The Maddison figures suggest that per capita GDP in Germany was below the average for the twelve large western European countries for the entire three hundred years. In 1600, per capital GDP in Germany was lower than that of seven of the twelve large western European countries, surpassing only Finland, Norway, Sweden, and Switzerland. In 1700, German per capita GDP was lower than that of six of the twelve, surpassing the same four countries, and occupying equal place with France. Even as late as 1870, Germany's per capita GDP was lower than that of seven of the twelve large western European economies, surpassing only Finland, Italy, Norway, and Sweden. It was not until 1900 that Germany rose even to the rank of sixth among the twelve large western European countries by per capita GDP. Recent unpublished revisions to German per capita GDP estimates from an ongoing research project by Ulrich Pfister suggest a somewhat more optimistic picture that places Germany closer to the Maddison estimate of the average for western Europe.¹⁷ But revisions to the Maddison figures are also generating more optimistic estimates for other western European societies. Thus revisions by Jutta Bolt and Jan Luiten van Zanden suggest higher per capita GDP for the Netherlands, too, which would increase its lead over Germany, especially before 1820.¹⁸ Future research, it is to be hoped, will improve our macroeconomic estimates for all European economies. Current research suggests that Germany enjoyed low – or at best average – per capita GDP by western European standards from 1600 until relatively late in the nineteenth century.

¹⁶ See the data and documentation available online at <http://www.ggd.net/maddison/maddison-project/home.htm>.

¹⁷ Although see for instance Pfister 2011; Pfister, Riedel and Uebele 2012.

¹⁸ Bolt and Van Zanden 2013.

Table 1:
Per Capita GDP in Germany Compared to Other Western European Economies,
1600-1900 (in \$1990)

	1600	1700	1820	1850	1870	1900
Large Western European Countries						
Austria	837	993	1,218	1,650	1,863	2,882
Belgium	976	1,144	1,319	1,847	2,692	3,731
Denmark	875	1,039	1,274	1,767	2,003	3,017
Finland	538	638	781	911	1,140	1,668
France	841	910	1,135	1,597	1,876	2,876
Germany (Maddison Estimate)	791	910	1,077	1,428	1,839	2,985
Germany (Pfister Baseline Estimate)	957	1,113	> 1169	1,692	–	–
Italy	1,100	1,100	1,117	1,350	1,499	1,785
Netherlands	1,381	2,130	1,838	2,371	2,757	3,424
Norway	665	722	801	956	1,360	1,877
Sweden	700	750	819	1,019	1,359	2,209
Switzerland	750	890	1,090	1,488	2,102	3,833
United Kingdom	974	1,250	1,706	2,330	3,190	4,492
Total 12 Large Western European Countries	906	1,028	1,234	1,652	2,080	3,067
Small Western European Countries						
Ireland	615	715	877	–	1,775	–
Greece	483	530	641	816	880	1,351
Portugal	740	819	923	923	975	1,302
Spain	853	853	1,008	1,079	1,207	1,786
14 Other Small Western European Countries	698	789	956	1,273	1,602	2,361
Total 30 Western European Countries	888	993	1,194	1,567	1,953	2,885

Source:

Angus Maddison, Statistics on World Population, GDP and Per Capita GDP, 1-2008 AD (Horizontal file, copyright Angus Maddison, University of Groningen) [http://www.ggdc.net/maddison/Historical_Statistics/horizontal-file_02-2010.xls]. Pfister 2011, p. 15 (Table 4).

Württemberg, in turn, was on the poor and slow-growing end of the spectrum for Germany. Its economy was characterized by low per capita incomes, poor agricultural productivity, stagnation in crafts and proto-industries, a small and non-dynamic commercial sector, and late and hesitant factory industrialization.¹⁹

Comparative GDP figures are not available for the various German states before the nineteenth century, but Table 2 presents estimates for 1849, the earliest available date.²⁰ Unfortunately, these figures are not directly comparable to those in Table 1 as the units are Marks rather than 1990\$. However, they show that Württemberg was

¹⁹ Ott 1971, 16-17; Langewiesche 1974, ch. 4; Hippel 1977, vol. I, 66, 130; Kazmaier 1978, 39-40, 43, 45, 48; Naujoks 1982, 173; Hippel 1992, 482-4, 502-4, 514-33, 623-4, 641-700; Fellmeth 1998, 27-39; Schaab 2000, 539-45; Ogilvie, K pker and Maegraith 2009, 175-7, 184-208.

²⁰ Ziblatt 2006, p. 36, Table 3.1; for a more detailed breakdown according to Regierungsbezirk, see Frank 1993, Appendix 8, p. xxx.

poorer than average even by German standards, with a lower per capita GDP than 15 of the 24 German states shown in Table 1. The small group of eight states which were even poorer than Württemberg consisted mainly of eastern territories which had been subject for centuries to serfdom (Posen, Pomerania, Mecklenburg) and of other poor southern territories (Baden, Bavaria). Württemberg's economic performance was even surpassed by that of Schleswig-Holstein and Silesia which had previously been subject to serfdom. As late as 1913, average per capita income in Württemberg was only 88 per cent of the average for Germany as a whole.²¹ The society whose human capital we examine in this paper, therefore, lay distinctly on the low-performing end of the relatively low-performing economies of German-speaking central Europe.

Table 2:
Per Capita GDP in Württemberg Compared to Other German States, 1849

German State	GDP per capita (Reichsmark)
Posen	384.3
Bavaria	385.0
Hohenzollern	392.8
Oldenburg	455.8
Pommern	457.7
Hannover	463.7
Mecklenburg	473.6
Baden	485.7
Württemberg	489.2
Kassel	496.4
Silesia	497.6
Westfalen	517.2
Schleswig-Holstein	532.8
Darmstadt	539.2
Saxony-Weimar	552.5
Saxony-Coburg	552.5
Thüringen states	552.5
Prussian Saxony	584.2
Nassau	603.9
Rheinland	620.8
Saxony	670.6
Brandenburg (Berlin)	679.8
Bremen	750.0
Hamburg	800.0

Source:

Ziblatt 2006, p. 36, Table 3.1.

²¹ Mann 2006, 216.

The two communities we analyze were, by the standards of Württemberg, not centres of economic dynamism. Wildberg was a very small town located in the forested valley of the Nagold River, in the hilly northern zone of the Württemberg Black Forest (*Württembergische Schwarzwald*). Throughout the three centuries under analysis, its population fluctuated between about 1,000 and about 1,600 inhabitants.²² An export-oriented worsted proto-industry arose in Wildberg the 1580s, flourished until the 1630s, but then stagnated in the grip of entrenched guilds of merchant-dyers and weavers until its final collapse in the 1790s.²³ Full-time farming was rare, but about 70 per cent of Wildberg households relied partly on their own land in 1600, falling to about 50 per cent by 1700 and to 20 per cent by 1800, and then rising again to about 30 per cent by 1870. Wildberg was therefore what one might call an agrotown, in which nearly all households had a non-agricultural occupation (mostly a guilded craft or proto-industry) but many also engaged in agricultural by-employments. A few tiny manufactories sought to establish themselves in the surrounding region in the course of the nineteenth century, but none flourished, and Wildberg continued to experience long-term economic stagnation up to 1900.²⁴

Auingen was a small village located on a hilly plateau in south-eastern Württemberg, the Swabian Jura (*Schwäbische Alb*), which was known for its infertile soil and harsh climate. With a population of 350 around 1600, Auingen expanded to 435 inhabitants by 1634, but was hard hit by the Imperial invasion of that year, collapsed to only 30 inhabitants in 1642, and was totally deserted between 1645 and 1647. Even after the end of the Thirty Years War, Auingen recovered only very slowly, taking until 1760 to regain the population of 350 it had recorded in 1600; as

²² Ogilvie, Kúpker and Maegraith 2009, 3-11.

²³ Troeltsch 1897; Ogilvie 1997; Ogilvie 2004a.

²⁴ Ogilvie, Kúpker and Maegraith 2009, 228-42

late as 1850, Auingen had fewer than 600 inhabitants, rising to 863 by 1900.²⁵

Auingen had the legal status of a village, and although it was not exclusively agricultural, about one-third of its households were full-time farmers, while another one-quarter were agricultural day-labourers. After c. 1750, the village saw the growth of export-oriented proto-industrial linen-weaving, which at its height employed about one-quarter of the village households, but which declined after c. 1850. In the final decades of the nineteenth century a few mechanized industries arose in the region, and by the late 1890s some Auingen villagers were employed in a nearby cement plant.²⁶

In summary, the two settlements from which our data are drawn were characteristic of the small communities of fewer than 2,000 inhabitants in which a majority of the German population lived until well into the nineteenth century.²⁷ The economic structure of these two settlements was also fairly typical for Germany, in being based primarily on part-time agriculture, local crafts, and low-tech proto-industry, with a small service sector and very late and minor involvement in mechanized production. These localities therefore provide a good laboratory for investigating human capital in a context of late and slow economic development in both town and countryside.

3. The Data Sources

Pre-modern education can be analysed using a variety of different indicators, each measuring different aspects of human capital investment. School attendance figures, typically collected during periodic church inspections, registered inputs into

²⁵ Ogilvie, K pker and Maegraith 2009, 3-11.

²⁶ Ogilvie, K pker and Maegraith 2009, 228-42.

²⁷ Twarog 1997, 288-9 (Table 8.2).

the educational process.²⁸ School or church examination results, such as those collected by the religious authorities in eighteenth-century Sweden, measured outputs, at least in so far as these were registered by the skills tested by the examinations.²⁹ Book ownership registered the possession of material objects which could be fully consumed only by individuals with a certain level of human capital.³⁰ Age-heaping in censuses or other age-related documents registered the degree to which an individual (or the person who reported or recorded that individual's age) was aware of precise numbers rather than merely rounding them to the nearest multiple of five or ten.³¹ Communicant registers recording religious status – “infant”, “catechist”, “communicant” – alongside the name of each inhabitant registered passage through certain stages in a religious education.³² Occasionally, a particularly conscientious official of the church or the state drew up a community census which recorded the educational status of the inhabitants, according to categories such as schooling, apprenticeship, or the ability to say the catechism, read, or write.³³

Perhaps the most widely used educational indicator in historical studies of human capital, however, consists of signatures on documents, registering the possession of at least a minimal ability not merely to read but to write. Pre-modern administrative mechanisms generated a number of different documents to which people in particular European societies were formally expected to sign their names or

²⁸ See, for instance, the analysis in Ogilvie 2003, 85-9, using Württemberg church visitation reports.

²⁹ Early modern Sweden generated sources which can be used for such analyses; see Johansson 1973; Johansson 1977; Lindmark 2004; Graff et al. 2009.

³⁰ See the cross-country analyses within pre-industrial Europe undertaken in Baten and Van Zanden 2008; Buringh and Van Zanden 2009.

³¹ See the many studies of pre-industrial European numeracy using this approach pioneered by Jörg Baten, including Baten, Crayen and Manzel 2008; Hippe and Baten 2012; and Baten and Szołtysek 2014. For comparative figures for different pre-modern European countries using this approach, see A'Hearn, Baten and Crayen 2009. For a comprehensive recent survey, see Tollnek and Baten 2016 (forthcoming).

³² See the application of this approach to Württemberg communicant registers in Ogilvie 1986, 312-9; Ogilvie 2003, 89-95.

³³ For analyses of such censuses, see for the small Württemberg town of Beutelsbach, Baumann 2013, 10-5; for the Swiss village of Müllheim in 1723 in Löffler-Herzog 1935, here esp. 4.

make their marks: marriage registers, marriage contracts, marriage inventories, wills, property transfers, debt certificates, witness statements, and legal judgements, among many others. These mechanisms created a large number of documentary sources recording signatures, which in turn must be tested for representativeness relative to the underlying population.³⁴ As discussed below, signatures are not perfect indicators of human capital investment, but they have a number of advantages which encourage us to use them in this paper.

The documentary sources from which we derive our data consist of inventories of personal possessions, which Württemberg national law required district-level state clerks, assisted by communal officials called “inventory-makers” (*Inventierer*), to draw up for both brides and grooms at marriage. Württemberg had a partible inheritance system in which each spouse retained separate ownership rights over property brought into marriage, and daughters inherited equally with sons. To facilitate administration of this system, from 1551 onwards the Württemberg state mandated “contingent inheritance inventories” (*Eventualteilungen*), drawn up for a couple when one spouse died, at which inheritance shares were recorded but not actually allocated among heirs; and “actual inheritance inventories” (*Realteilungen*), drawn up for widowed (and a few never-married) persons, at which inheritance shares were actually distributed. From 1610 onwards the state also mandated inventories at marriage and remarriage (*Beibringungsinventare*), which recorded the possessions of bride and groom separately. Inventories were sometimes also “decreed” to address special circumstances such as marital conflict, desertion, crime, or indebtedness.³⁵

³⁴ For the application of this approach to pre-modern France, see Houdaille 1977; Houdaille 1988; Fouret and Ozouf 1977. For Denmark, see Munck 2004. For Württemberg see Schad 2002. For Spain, see Rodriguez and Bennisar 1978. For England, see Cressy 1980. For Scotland, see Houston 1982; Houston 1985. For a survey of the approach, see Houston 1983; Houston 1991; Houston 2011.

³⁵ Borscheid 1979; Borscheid 1980, 89-93; Quarthal 1989, 350; Quarthal 1995; Mannheims 1991, 28-35, 49; Maisch 1992, 21-7; Schad 2002, 65, 67, 70, 74-94; Küpker, Maegraith and Ogilvie 2015.

This legal regime was implemented in such a thorough way that Württemberg marriage and death inventories are recognized as occupying an extraordinary position among all surviving inventories in pre-modern Europe: they were drawn up in extraordinarily large numbers, they covered a very high percentage of inhabitants, and they were mandatory for persons from all social and economic backgrounds, making them unusually representative of the entire society.³⁶ A person or couple was not legally obliged to be inventoried at marriage if they possessed a special legal status, agreed legally to marital community of property, got the district court's approval, or drew up a private inventory – although such people could be inventoried, since these rules were just treated as guidelines. Administrative breakdown, corruption, and bureaucratic negligence could also prevent comprehensive inventorying in particular periods and places. Nonetheless, the law mandating compulsory inventorying applied to all social strata, rich or poor, solvent or indebted, craftsman, merchant, farmer or day-labourer – in the words of the legislation of 1780, “of whatever social order someone might be, that person is subject to this most wise ordinance”.³⁷ Furthermore, the legislation explicitly envisaged that inventories would be used to deal with inheritance claims by private persons, repayment claims by creditors, tax demands and compliance with sumptuary regulations by the state, and applications for welfare support by the local community. Local records confirm that inventories were indeed used for these purposes. These multiple uses created strong incentives for individual citizens, community tax officials, and state authorities to ensure that inventories be drawn up systematically and comprehensively.³⁸

Consequently, a substantial and growing proportion of marriages in early modern Württemberg generated detailed inventories, which survive from the

³⁶ Borscheid 1979; Borscheid 1980, 89-93.

³⁷ Quoted in Borscheid 1980, 89.

³⁸ Borscheid 1980, 90; Küpker, Maegraith, and Ogilvie 2015.

seventeenth century until 1899 for many communities, as in the case of Auingen and Wildberg. Out-migration means that not all recorded weddings or burials in a community can be linked to a marriage or death inventory in the same community. This makes it the more striking that more than 98 per cent of couples in our family reconstitutions for Wildberg (1558-1914) and Auingen (1677-1914) could be linked to at least one surviving inventory relating to either the marriage or the death of one spouse. More than 65 per cent of marriages recorded in Wildberg between 1600 and 1803 and more than 78 per cent of marriages recorded in Auingen between 1677 and 1899 have a marriage inventory associated with that couple. By c. 1700, there was at least one surviving inventory for 75 per cent of taxpayers (i.e. household heads) in Wildberg and 50 per cent in Auingen; by c. 1750, this proportion had risen to 85 per cent in Wildberg and 75 per cent in Auingen; during the most of the nineteenth century, the proportion of household heads with at least one surviving inventory lay close to 90 per cent.³⁹ These figures mean that a large and increasing majority of those who survived to marry and form a household in Auingen and Wildberg were recorded in at least one marriage inventory and are thus represented in our data set.

4. Measuring Human Capital

Our measure of human capital is whether an individual signed his or her marriage inventory. The strict Württemberg legal framework governing the drawing up of inventories required that at the end of a marriage inventory, both the bride and the groom sign their names to testify to the contents; the same was required of the

³⁹ K pker, Maegraith, and Ogilvie 2015, 44-6.

surviving spouse at the end of a “contingent inheritance inventory”, the type of death inventory drawn up for a couple when one spouse died.⁴⁰

Signatures are not perfect indicators of human capital investment. For one thing, social customs may distort the information content of a signature as a signifier of true human capital. Gender norms, for instance, may put pressure on the marginal male to pretend to literacy by practising the formal ability to sign when he cannot actually write, while the same norms may put pressure on a female to allow a male representative to sign when she is actually able to sign for herself. Fortunately, we know the latter pressure not to have been in operation in Württemberg, where it was expected that a woman would sign her name if she could. When a female failed to sign her inventory, it was not because of a social expectation that she would refrain from doing so if her father or legal representative (*Kriegsvogt*) were present: where a woman could sign her name, both she and her male representative would sign; and if she did not sign, the inventory often records an explicit explanatory note from the clerk, to the effect that the signature was missing “because she cannot write”, or “the *Kriegsvogt* signed upon request of the wife because she is uninstructed in writing”.⁴¹

Two other disadvantages of signatures, by contrast, cannot be dismissed in the Württemberg context. For one thing, more education is needed to write than to read, so the percentage of individuals who can sign their names will tend to be an *under-*estimate of the percentage who can read and thus have the ability to engage with information and ideas that are written or printed. In the opposite direction, it is possible to learn to write one’s signature without learning to write anything else, and thus the ability to sign will tend to *over-*estimate people’s ability to express

⁴⁰ Quarthal 1989, 350; Quarthal 1995; Mannheims 1991, 28-35, 49; Maisch 1992, 21-7; Schad 2002, 65, 67, 70, 74-94.

⁴¹ For a detailed discussion of this issue, see Maisch 1992, 377; Schad 2002, 78-9.

themselves in writing.⁴² These two disadvantages operate in opposing directions, and we cannot know which predominated in practice. However, they must be borne in mind in assessing our findings, as in the case of all studies measuring literacy in terms of signatures.

On the other hand, signatures also have a number of advantages. One major advantage is that they are the most frequently recorded indicator of literacy and thus provide the greatest scope for comparison across time and space. A second advantage for the economic historian is that signatures testify to a more active degree of literacy than mere reading ability and thus may be a better indicator of productivity-enhancing human capital. This can be seen from documents which pre-modern Württemberg inhabitants signed, and often themselves wrote up, recording property transfers, debts, testamentary dispositions, wage claims, craftsmen's invoices, and bills for goods provided in shops and inns.⁴³ A third advantage of using signatures as an indicator of literacy is that when the signatures in question are associated with detailed documents, as in the case of the marriage inventories analyzed here, literacy can be attached to other socio-economic characteristics, making it possible to investigate what variables are associated with higher or lower human capital.⁴⁴

This paper analyzes the literacy of individuals at the point at which they married for the first time. People in Württemberg were also inventoried when they remarried after being widowed, but we deliberately excluded remarrying individuals from our analysis in this paper. There are two reasons for making this decision. The less important is that previous studies of Württemberg literacy based on marriage inventories have exclusively analyzed individuals at first marriage, both to avoid

⁴² See the general arguments to this effect in Furet and Sachs 1974, 715; Prass 1988, 178-84. For further reflections in the context of analyzing signatures in Württemberg inventories, see Schad 2002, 75-7.

⁴³ Schad 2002, 7.

⁴⁴ For a discussion of this advantage, see Borscheid 1980, 89-93.

double-counting the same person at first and subsequent marriages and to ensure that the group of people under analysis are approximately the same age.⁴⁵ By focussing solely on first-marrying individuals, we ensure that our figures are comparable with those for other places in Württemberg.

The second reason for focussing solely on individuals at first marriage, however, is more important. Excluding people who are remarrying enables us to exclude a major source of endogeneity between human capital and economic outcomes. Endogeneity is a widespread problem in research on human capital, although it is not always recognized and even when it is recognized it is not always easy to address. There are good reasons to expect a two-way causal relationship between education and wealth: wealth makes it possible to consume more of all good things, including education; but education makes it possible to be more productive, and hence to increase one's wealth. Observing an association between education and wealth does not provide information on the relative importance of these two influences; indeed, it does not even guarantee that one or the other is non-zero.

This is our main motivation for focussing here on literacy at first marriage. Choosing this early point in the life-cycle makes it possible to exclude a large component of the process by which literacy affected wealth. Most of the phase in the life-cycle of a person in pre-modern Württemberg during which education could increase wealth necessarily took place after the individual married. Before entering into marriage for the first time, people in pre-modern Württemberg almost never conducted independent households or produced independently: they were offspring still living in the parental household, servants earning legally capped wages, or (in a

⁴⁵ Maisch 1992, 377; Schad 2002, 79;

few cases) lodgers restricted to low-earning jobs in spinning or day-labouring.⁴⁶ The majority of the wealth which individuals took into their first marriages came not from their own earnings (which might reflect education-influenced productivity) but from their family, as gifts, marriage portions, or inheritances (and thus did not reflect the individual's own productivity). This contrasts strongly with the state of affairs when someone remarried after having been widowed. At that point, wealth was influenced not only by what had been inherited from the parental generation but by the individual's productivity as an independent householder between first marriage and widowhood, and thus reflected a potential influence of education on wealth. This paper therefore analyzes the determinants of education at first marriage, at which point it could be influenced by existing wealth but would not have had much opportunity to contribute to that wealth.

Table 3 provides an illustration of one of the major advantages of measuring human capital through the ability to sign one's name, the opportunity to compare literacy across societies. The top panel of the table shows literacy in the period around 1800 for eight Württemberg communities, four small towns (including Wildberg), and four villages (including Auingen). For male literacy, by c. 1800 Württemberg towns and villages show a rate of 99-100 per cent (with only the village of Gruorn as an outlier at the relatively low level of 92 per cent). For females, by c. 1800 literacy in Württemberg communities was in the 90-95 per cent range, with Beutelsbach and Wildberg on the low end at 78-87 per cent and Gruorn on the high end at 96 per cent. The figures in Table 3 provides reassurance that the two communities from which our data are drawn were not unusual cases, but rather closely resembled the literacy rates observed in other Württemberg settlements.

⁴⁶ For greater detail on the life-cycle of females and males in pre-modern Württemberg, see Ogilvie 2003, 39-78.

Table 3:
Literacy in Various European Societies c. 1800

Country	Date	Male	Female	All
Württemberg: Auingen (village)	1800-09	100	93	96 ^a
Württemberg: Wildberg (town)	1800-09	99	87	92 ^a
Württemberg: Bissingen (town)	1790-99	100	95	— ^b
Württemberg: Nürtingen (town)	1770-79	—	90	— ^c
Württemberg: Bondorf (village)	1795-1829	99	92	— ^d
Württemberg: Gruorn (village)	1795-1829	92	96	— ^d
Württemberg: Gebersheim (village)	1795-1829	100	95	— ^d
Württemberg: Beutelsbach (town)	1792-1812	94-100	78-81	— ^e
England	c. 1800	60	40	— ^f
Scotland	c. 1800	65	15	— ^f
France: all	c. 1800	48	27	— ^f
France: northern	c. 1800	71	44	— ^f
France: southern	c. 1800	44	17	— ^f
Belgium	c. 1800	60	37	— ^f
Netherlands: all 11 provinces	1813-17	75	60	— ^g
Germany: Saxony	c. 1800	80	44	— ^f
Germany: Hesse	c. 1800	91	43	— ^f
Norway	c. 1800	—	—	21 ^f
Sweden	c. 1800	—	—	20-25 ^f
Portugal (rural)	c. 1800	—	—	<20 ^f
Italy: Piedmont (1848)	1848	—	—	25 ^f
Italy: Duchy of Parma	c. 1800	45	23	— ^f
Italy: Marche	c. 1800	17	6	— ^f
Hungary	c. 1800	—	—	6 ^f

Notes:

Literacy: % of adults who could sign their name.

Sources:

^a Present study (marriage inventories for first-marrying individuals).

^b Schad 2002, pp. 80-1, Tables 8a-8b (marriage inventories, both partners marrying for first time).

^c Benschmidt 1985, 45 (craftsmen's marriage and death inventories).

^d Maisch 1992, p. 378 (marriage inventories, both partners are marrying for the first time).

^f Bauman 2013, p. 39, Table 7 (community census and church court minutes).

^f Reis 2005, p. 203 (Table 8.2).

^g Graff 1987, p. 302-3 (with Table 7.9).

Further reassurance concerning the methodology used in this paper is provided by the figures in Table 3 for the Württemberg community of Beutelsbach. Literacy rates in this small Württemberg town were calculated from a community census and from signed cases in church court minutes, whereas the literacy rates for the other seven Württemberg communities were calculated from marriage inventories. One would expect the literacy rates recorded in the Beutelsbach documents to be lower

than those recorded in the documents for the other Württemberg communities, because they recorded a different sample of the population. The Beutelsbach census covered all inhabitants, including older people whose literacy was likely to have decayed over the years since they left school at age 14. The Beutelsbach church court signatures were primarily provided by malefactors (e.g. parents of illegitimate children) and thus probably over-represented less advantaged socio-economic groups. The Beutelsbach sources do indeed record lower literacy rates than the other Württemberg communities in Table 3, but not strikingly lower. For males, in fact, the figures for Beutelsbach are in the 92-100 per cent range recorded for the other seven Württemberg communities on the basis of marriage inventories. For females, the Beutelsbach figures are 6 to 9 percentage points lower than those for Wildberg, which in turn had lower female literacy than the other six Württemberg communities. But even Beutelsbach females manifested a literacy rate which was impressively high, resembling females in other Württemberg communities much more than females anywhere else in Europe at the time.

This can be seen from the second panel of Table 3, which places literacy for Württemberg in the context of literacy rates calculated for other European societies in the period around 1800. For males, literacy rates outside Württemberg ranged from a low of 17 per cent in the Marche of Italy to a high of 91 per cent in Hesse (not coincidentally another German Protestant territory, as was Saxony, the society with the second-highest male literacy rate). The Netherlands had only 75 per cent male literacy at this date and England only 60 per cent. For female literacy, Württemberg was even more extraordinary. Nowhere in Europe had anything approaching the 90-95 per cent female literacy observed even in small Württemberg villages around 1800. At this date, female literacy was only 60 per cent in the Netherlands and only 40 per

cent in England. The German Lutheran societies of Saxony and Hesse again had higher literacy than England, at 43-44 per cent, but still less than half the level observed in Württemberg.

The international comparisons in Table 3 pose a stark challenge for economic history and for theories of economic growth. There does not seem to be any association between human capital levels and economic performance. Certainly, there are some countries with very low literacy rates in Table 3 which also appear in Table 1 with low per capita GDP: examples are Portugal and Hungary. On the other hand, the Italian territories in Table 3 also show very low literacy, even though Italy was one of the richest countries in Europe as late as 1600, and still surpassed Germany in per capita GDP as late as 1820, according to Table 1. Even more strikingly, Table 1 shows England and the Netherlands to have been the richest countries in Europe, yet Table 3 shows that English literacy was nothing out of the ordinary; Dutch literacy was high by European standards, but still much lower than Württemberg literacy, especially for females.

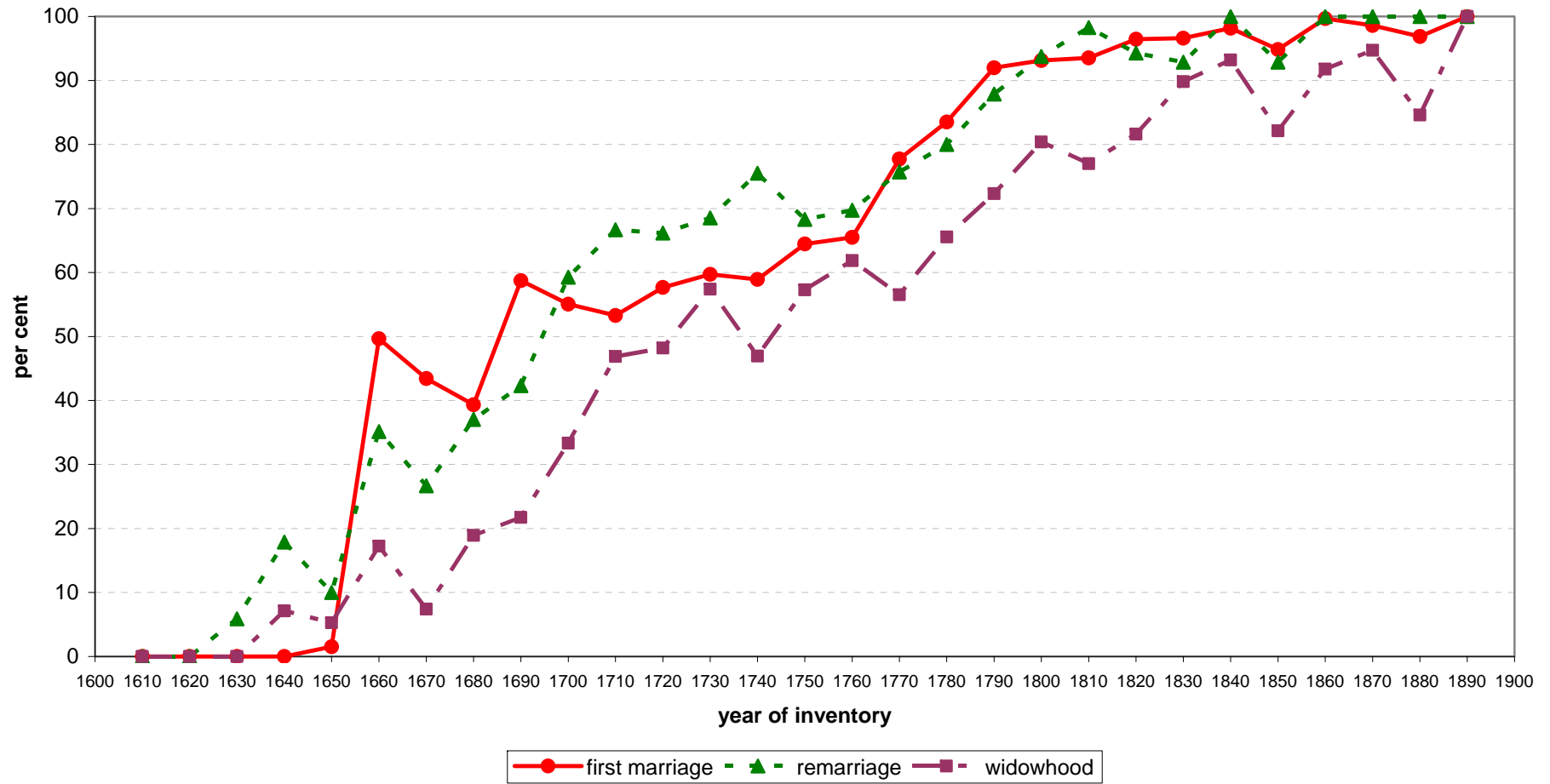
Indeed, Württemberg provides the starkest example of this lack of association between economic performance and human capital levels. As we saw in Tables 1-2, Württemberg was one of the poorer economies in Germany, which in turn had somewhat below average per capita GDP for western Europe. Yet Württemberg had literacy rates for both males and females that were strikingly higher than those observed in much richer England and the Netherlands. Württemberg also had higher literacy than other German societies such as Saxony, which Table 2 shows to have had a much higher per capita GDP.

This raises the question of what history actually tells us about the relationship between human capital and economic growth. Theory has suggested the attractive

proposition that a high level of human capital is good both for the individual who has it and for the wider economy. Yet historical evidence suggests that the relationship between human capital and economic performance was not so straightforward. This creates a serious reason to investigate the empirical evidence much more deeply, especially in cases where the gap between the human capital level and economic performance is very wide. The remainder of this paper undertakes such an investigation by examining what path the poor, slow-growing and late-developing economy of Württemberg followed to achieve such an enviable literacy rate, and how it was related to economic factors on the micro-level. Examining the socio-economic correlates of the high level of human capital achieved in this slow-growing economy may provide some lessons from history for understanding the relationship between human capital and economic factors in other developing economies.

A first step is to examine how literacy developed over time in our two Württemberg communities, the town of Wildberg and the village of Auingen. As already discussed, for motives of comparability and to exclude reverse causation as much as possible, our multivariate analyses in this paper focus on literacy at first marriage. But to set literacy at first marriage in context, it is useful to trace its chronological development alongside literacy at remarriage and widowhood. Figure 1 shows literacy rates in Auingen and Wildberg for each decade between 1610 and 1899. The percentages are calculated for three sets of people: 5,586 individuals drawing up their inventories at first marriage; 939 individuals drawing up their inventories at a second or subsequent marriage; and 1,910 individuals whose spouses had died, giving rise to a “contingent death inventory”. The literacy of individuals at first marriage rose from very low levels in the early seventeenth century to around 50 per cent by 1660, declined slightly to 40 per cent in the later seventeenth century, rose

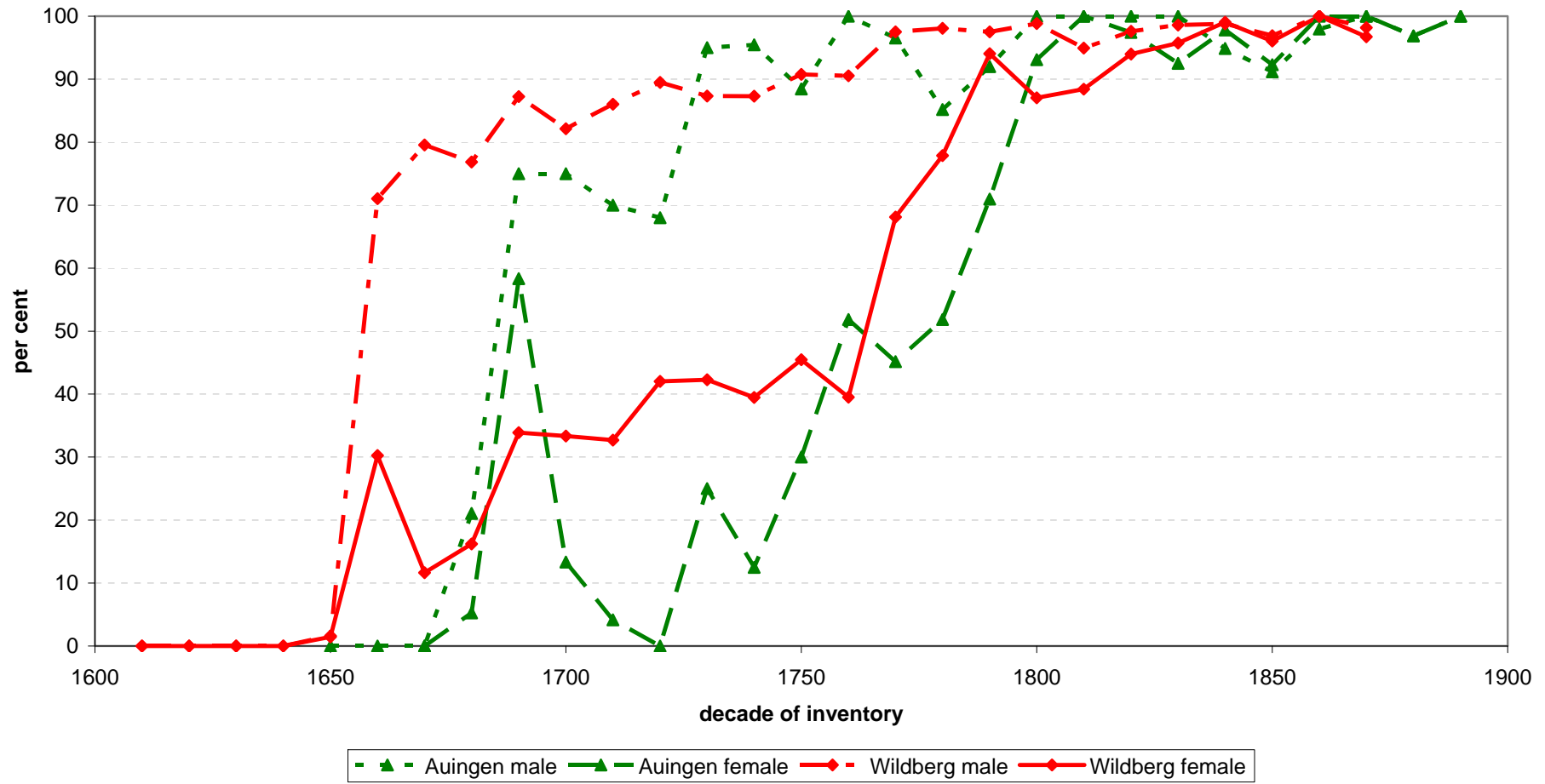
Figure 1:
Percentage of Individuals Signing Name at First Marriage, Remarriage,
and Widowhood, Auingen and Wildberg, 1610-1899



again to hover around 55 per cent during the first half of the eighteenth century, averaged around 75 per cent in the second half of the eighteenth century, hovered around 95 per cent in the first half of the nineteenth, and accomplished a final, gradual rise towards 100 per cent between 1850 and 1900. For individuals entering their second or subsequent marriages, the chronological trajectory was similar, with slightly lower literacy rates than first-marriers in the 1650-1700 period, but slightly higher rates in the 1700-80 period, and nearly identical rates thereafter. Literacy at widowhood was about 10 per cent lower than literacy at marriage or remarriage throughout the whole period under analysis, a difference which is consistent with the fact that widowed individuals were predominantly female and older, two characteristics which, as we shall see in the multivariate analysis below, tended to be associated with lower literacy.

Figure 1 suggests a relatively smooth and continuous growth of literacy in these two communities over a period of two and a half centuries, from low levels around 1650 to nearly universal literacy after c. 1800. However, Figure 2 reveals a much more differentiated picture, with a multiplicity of different development paths for different subgroups of the population. The ability to sign one's name increased first among males in the town of Wildberg, followed by females in that town, who were then surpassed by males in the village of Auingen, followed after a half-century's delay by females in that village. A level of 50 per cent literacy was achieved by the mid-seventeenth century among urban males, by 1690 among rural males, but only after 1760 among urban females, and only after 1780 among rural females. Literacy surpassed 90 per cent by 1750 among males, but did not achieve this level until around 1800 among females. There also appears to have been much more

Figure 2:
Percentage of Individuals Signing Name at First Marriage by Sex and Community,
Auingen and Wildberg, 1610-1899 (entire sample, n=5,586)



variation over time in literacy among females and villagers than there was among males or townspeople.

These differences according to gender and rural-urban location provide only specific instances of the more general consideration that literacy can be associated with a multiplicity of socio-economic variables. Thus the ability to sign one's name might also be influenced by one's age, wealth, or other characteristics. Even differences across time might have varied more (or less) continuously than can be observed through decadal averages. Such multivariate differences cannot easily be represented in cross-tabulations or graphs, since they involve breaking down the sample into smaller and smaller subgroups. Even with a large sample of thousands of individuals, such as we have here, this can lead to very small numbers of observations in individual cells, making it difficult or impossible to test hypotheses about whether a particular variable affected literacy, controlling for other potential influences. To investigate differences in literacy according to any given variable, holding other possible influences constant, requires a multivariate analysis, to which we now turn.

5. Multivariate Determinants of Human Capital

Whether an individual signed his or her name at first marriage might in theory be associated with a number of different variables. One was the gender of the individual, since in developing economies both social norms and economic opportunities tend to reduce the supply of and demand for education among females. Another variable potentially related to literacy was whether the individual was a villager or a townspeople, since urbanization is widely regarded as encouraging human capital investment through economies of scale in the supply of education and

occupational influence on the demand for education. Literacy might also change with age, either falling if human capital decayed over time after leaving school, or rising if writing skills were honed or increased in practical working situations. Total wealth is also likely to be associated with literacy, since wealth typically increases consumption of all good things, including education. The intention to practise particular economic activities might be associated with high or low literacy, and these intentions might be proxied by particular types of production-related material possession.

Literacy, as has been shown, varied across time between 1610 and 1899, and it seemed possible that the relationship between literacy and other variables might also vary across time. This motivated us to include the year of inventorying and interaction terms between year on the one hand, and gender, rural-urban community, and wealth respectively. We also postulated that the link with gender might vary by community and wealth, the link with urban-rural community by gender and wealth, the link with age by gender and community, and the link with wealth by gender and community, so we included corresponding interaction variables to register these relationships.

Generally, our regression specification can be written as follows:

$$\begin{aligned}
 \textit{Literacy} = & \alpha + \beta_1(\textit{Year}) + \beta_2(\textit{Gender}) + \beta_3(\textit{Community}) + \beta_4(\textit{Age}) + \beta_5(\textit{Wealth}) + \\
 & \beta_6(\textit{Production Goods}) + \beta_7(\textit{Year}*\textit{Gender}) + \beta_8(\textit{Year}*\textit{Community}) + \\
 & \beta_9(\textit{Gender}*\textit{Wealth}) + \beta_{10}(\textit{Gender}*\textit{Community}) + \beta_{11}(\textit{Community}*\textit{Wealth}) + \\
 & \beta_{12}(\textit{Year}*\textit{Wealth}) + \beta_{14}(\textit{Community}*\textit{Age}) + \beta_{15}(\textit{Gender}*\textit{Age}) + \varepsilon ,
 \end{aligned}$$

where *Literacy* is a categorical variable denoting whether the individual signed the inventory at first marriage, *Year* the year of the inventory, *Gender* a categorical variable denoting whether the individual was male or female, *Community* a

categorical variable denoting whether the individual was rural (i.e. from Auingen) or urban (i.e. from Wildberg), *Age* the individual's age at the time of inventorying, *Wealth* the total value of real estate and moveable possessions brought into marriage, *Production Goods* the value of various production-related possessions, *Year*Gender* an interaction term between year of inventory and gender of individual, *Year*Community* an interaction between year of inventory and rural-urban community, *Gender*Wealth* an interaction between gender and total wealth, *Gender*Community* an interaction between gender and community, *Community*Wealth* an interaction between community and wealth, *Community*Age* an interaction term between rural-urban community and individual's age, and *Gender*Age* an interaction term between the individual's gender and age; ε denotes an error term.

All variables but one were recorded in the marriage inventory, which meant that they were available for all observations. The one variable not recorded in the inventory itself was *Age*, which was derived from our family reconstitutions for Auingen and Wildberg and matched to inventoried individuals using record linkage. Ages could be reconstructed and linked for 4,893 individuals, 88 per cent of the full sample of 5,586. Figure 3 displays the extent to which the dependent variable diverged between the entire sample of first-marrying individuals and the sample of known age. The dashed line graphs the development of literacy across time for all 5,586 first-marrying individuals in these two communities, while the solid line shows literacy for the sub-sample of 4,893 persons whose age could be reconstructed from the family reconstitutions. The two curves are almost identical except for a very small divergence around 1680, providing reassurance that we are not analyzing a different literacy trajectory by excluding the individuals of unknown age.

Figure 3:
Percentage of Individuals Signing Name at First Marriage,
According to Availability of Information on Age, Auingen and Wildberg, 1610-1899

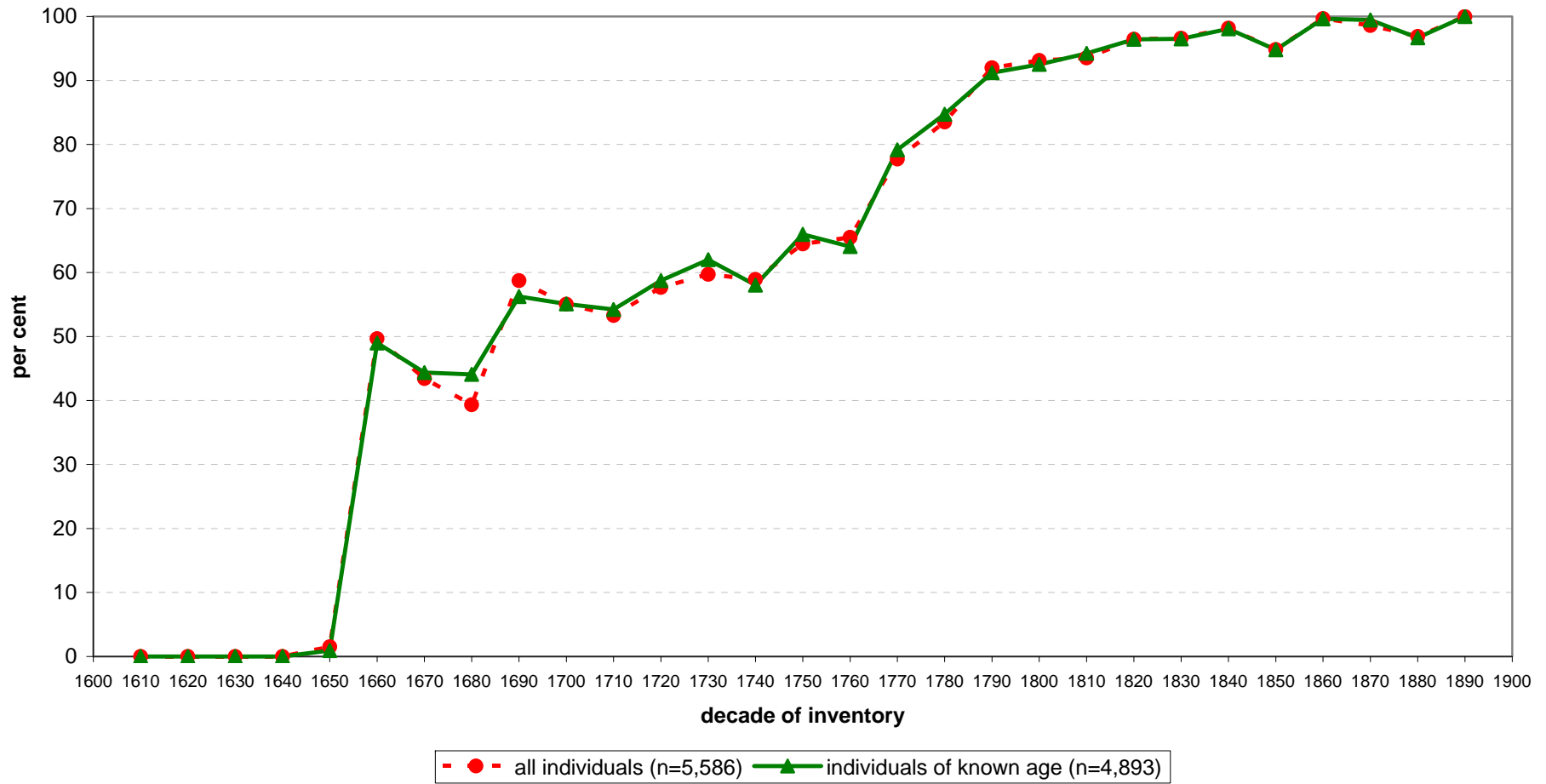


Table 4 shows summary statistics for the regression variables. It is clear that this was a society with very high literacy rates. Literacy was high not just around 1800, as Table 3 had indicated, but throughout the period from 1610 to 1899 as a whole. This is illustrated by the high average value of this variable in our regression sample, with 74 per cent of individuals signing their name to their inventory at first marriage.

Table 4:
Summary Statistics for Regression Variables

Variable	Standard		Median	75th percentile	90th percentile
	Mean	deviation			
Literacy (0=does not sign, 1=signs)	0.741	0.438	n/a	n/a	n/a
Year (of inventory)	1774.669	67.784	1779	1831	1863
Gender (0=male, 1=female)	0.540	0.498	n/a	n/a	n/a
Community (0=Auingen, 1=Wildberg)	0.755	0.430	n/a	n/a	n/a
Age (at inventory)	28.506	6.581	27	31	37
Wealth	298.027	808.983	132.209	293.804	632.843
Production goods: Land	70.088	278.556	0	11.154	174.020
Production goods: Draft Equipment	0.743	8.194	0	0	0

Variable	Variable takes the		Variable takes the		Total
	value 0		value 1		
	N	%	N	%	
Literacy (0=does not sign, 1=signs)	1,268	25.9	3,625	74.1	4,893
Gender (0=male, 1=female)	2,253	46.1	2,640	54.0	4,893
Community (0=Auingen, 1=Wildberg)	1,201	24.6	3,692	75.5	4,893

The data set covers the entire period from 1610 to 1899, with the sample mean of year of inventory lying at 1775 and the sample median at 1779. However, although the data as a whole cover a period of 289 years, the period covered differs between the two communities. The inventories for Wildberg begin in 1610, and cover the 262 years between then and 1872, while those for Auingen begin only in 1677, but cover the 222 years between then and 1899. The absence of coverage for Auingen in the early seventeenth century and for Wildberg in the late nineteenth are not a serious matter for concern given that, as illustrated in Figures 1-3, almost all the change in literacy rates took place between 1680 and 1850.

An attractive characteristic of the literacy data derived from Württemberg marriage inventories is that women are more than equally represented. In our data set, females comprised 54 per cent of the sample, a desirable reversal of the usual under-representation of women in studies of human capital in developing economies, whether historical or modern. This preponderance of females in our data arises from the fact that in Württemberg, as in many pre-modern societies, widowhood for males was almost always followed by remarriage, often to a never-married female; widowhood for females was much less often followed by any remarriage. Remarriage was thus more common among males and first marriage more common among females. The consequence for our data is that a given number of marriage inventories involved more first-marrying females and more remarrying males.

In our data, the balance between urban and rural observations is strongly tilted in favour of the town. Over 75 per cent of the sample consisted of inhabitants of Wildberg. The preponderance of individuals from the town arises from two factors. First, the data for Wildberg cover a period of 262 years while those for Auingen cover only 222 years, and thus the village is represented by a period only 85 per cent as long as the town. Second, Wildberg had a much larger population, with four times as many inhabitants as Auingen in the seventeenth century and twice as many as late as 1850, so there was a much larger population of town inhabitants whose marriages could generate inventories.

The sample mean age in our dataset, for first-marrying individuals at the time of their marriage inventory, was 28.5 years and the sample median was 27 years. Table 5 sets the mean age in our dataset for each gender and community alongside the mean age at first marriage calculated from the family reconstitutions. Although not strictly comparable because the inventory ages are calculated by decade and the

Table 5:
Age at First Marriage in Inventories Data and Family Reconstitution,
by Sex and Community, Auingen and Wildberg, 1610-1899

Decade	Auingen males		Auingen females		Wildberg males		Wildberg females	
	in-ventories	recon-stitution	in-ventories	recon-stitution	in-ventories	recon-stitution	in-ventories	recon-stitution
1610-1619					26.8		28.2	
1620-1629					28.3	26.0	26.4	25.6
1630-1639					32.5		38.8	
1640-1649					34.5		33.6	
1650-1659	26.0	25.4			30.4	25.4	29.8	25.2
1660-1669					26.8		26.8	
1670-1679		26.4	27.0	26.2	26.4	26.4	25.8	26.2
1680-1689	29.4		26.0		27.3		26.1	
1690-1699	27.7		26.3		29.9		29.5	
1700-1709	29.8	26.7	28.7	27.0	27.8	26.7	27.3	27.0
1710-1719	27.5		28.1		29.0		28.6	
1720-1729	28.4	26.2	27.7	27.6	27.3	26.2	27.5	27.7
1730-1739	26.9		27.0		27.5		29.0	
1740-1749	26.8		25.6		29.0		29.3	
1750-1759	27.0	27.0	28.2	28.3	27.8	27.0	28.4	28.3
1760-1769	28.3		28.3		27.9		29.0	
1770-1779	27.4	28.1	25.6	28.6	27.7	28.1	28.3	28.6
1780-1789	26.3		27.3		28.2		28.5	
1790-1799	27.3		26.8		28.8		29.0	
1800-1809	26.6	28.5	24.4	28.1	28.1	28.5	28.9	28.1
1810-1819	29.6		27.1		30.9		29.8	
1820-1829	31.2	29.3	31.3	28.9	28.7	29.3	29.5	28.9
1830-1839	29.4		29.5		28.5		29.1	
1840-1849	29.3		28.3		29.0		29.4	
1850-1859	28.7	30.6	28.3	28.8	29.7	30.6	28.4	28.8
1860-1869	29.4		27.9		31.6		30.5	
1870-1879	28.9	28.2	27.7	27.7	32.0	28.2	28.0	27.7
1880-1889	27.8		27.3					
1890-1899	29.5	28.0	29.0	26.8				
Total	28.5		27.8		28.6		28.6	
N	563	2,697	638	3,207	1,690	867	2,002	993

Source:

"Inventories": Inventories sub-sample of known age (see text).

"Reconstitution": Guinnane and Ogilvie 2014, 92 (Table 3), 94 (Table 5).

Note:

The marriage age from the reconstitution applies to the quarter-century beginning in the decade shown.

reconstitution ages by quarter-century, the mean age at inventorying for these first-marrying individuals is reassuringly similar to the mean age at first marriage in the wider population. The same is true for the median age at inventorying and at first marriage, which was c. 27 for both males and females in both communities throughout the period under analysis.⁴⁷ This provides reassurance that the population

⁴⁷ Guinnane and Ogilvie 2014, 92 (Table 3), 94 (Table 5).

of individuals analyzed in this paper is similar to the wider population of those marrying for the first time in these two communities between 1610 and 1899.

The total wealth of an individual was calculated as the inflation-adjusted value of his or her real estate (buildings and land) plus his or her moveable goods (cash, jewellery, silver and gold, clothing, books, bedding, household linen, household vessels, furniture, general household goods, draft equipment, craft tools, business wares, animals, food and grain stores). The value of these possessions was measured in Württemberg *Gulden* (fl) or (beginning in the nineteenth century) *Mark* (M), adjusted for the rate of inflation, with an index year of 1565. The index year was chosen because the data for the wider project of which this is a part begin at that date, and the inflation index is the one used in previous publications from this project.⁴⁸ In the regression sample, the mean value of total wealth was 298 fl, but the median was 132 fl. The fact that the median was so much lower than the mean indicates that the distribution was skewed towards the lower end. For this reason, when we calculate marginal effects and elasticities based on the regression equation, we evaluate them at the sample *mean* for the other regression variables, but at the sample *median* for wealth.

Although it is occasionally claimed that inventories were based on a standardized set of prices, and cannot be regarded as reflecting the value of the possessions in concrete economic situations, there are strong reasons to believe that in Württemberg, the prices recorded in inventories reflected prices in the wider economy. For one thing, inventory-makers were not casual amateurs but specially appointed community officials (*Inventierer*) assisted by professional clerks (*Amtschreiber*), an important part of whose training consisted in learning how to draw

⁴⁸ See the discussion in Ogilvie, Küpker and Maegraith 2012, 141.

up inventories carefully so as to avoid conflicts over inheritances and debts. Inventory-makers even sometimes asked women to assist them in valuing gender-specific items. Furthermore, certain items in the inventories themselves were explicitly described as having been paid for personally by a particular individual, such as the father or mother of the bride or groom. Moreover, prices for the same item type in the same inventory varied with quality. Finally, inheritance shares were legally allocated and debts were legally paid according to inventory valuations, a practice to which heirs, creditors, and law-courts would hardly have consented had the valuations not been accurate. Prices of all items in an inventory would have had to be “wrong” to precisely the same degree in order to satisfy sharp-eyed heirs and creditors. It was surely more straightforward for inventory-makers simply to use the prices paid for these items on the market, which the evidence suggests they did.

Particular types of material possession might be expected to be associated with the intention to practice particular occupations, which in turn might require higher levels of education. For this reason, we initially included in our regressions the value of a number of different “production-related” goods in the individual’s inventory. These were categories of possession that might register the intention to practise particular economic activities: entering marriage with land, draft equipment, or animals would indicate the intention to practise agriculture, while possessing industrial raw materials, craft tools, or wares would indicate the intention to practise a craft or commercial business. When we estimated the regression models, however, the value of animals, raw materials, craft tools, and wares brought into first marriage showed no statistically significant association with literacy.⁴⁹ Not only was the null hypothesis of no association between literacy and these production goods rejected at

⁴⁹ Throughout this paper, “statistically significant” means the null hypothesis is rejected at the 0.05 level or above; “of borderline statistical significance” means the null hypothesis is rejected at the 0.10 level but not at the 0.05 level.

or above conventional levels, but the size of the estimated coefficient was in all cases extremely small and thus, even if it had been statistically significant, it would have been economically unimportant. The only categories of possession that showed an association with literacy that was even of borderline statistical significance were land and draft equipment, registering the intention to pursue a partly or wholly agricultural livelihood.

An individual's land was measured in inflation-adjusted Württemberg *Gulden*, as for total wealth. Most land consisted of arable fields and pastures, though inventories also recorded meadows, gardens, woods, and fishing-waters. The presence of land in the marriage inventory registered the probability that the individual came from a family involved in agriculture and envisaged continuing that involvement. In the regression sample, the mean value of land was 70 fl, and thus comprised about 23 per cent of total average wealth. But the sample median was zero, so at least half of all brides and grooms entered marriage with no land at all.

Draft equipment (also measured in inflation-adjusted Württemberg *Gulden*) consisted of ploughs, harrows, carts, yokes, chains, and other associated paraphernalia used for the cultivation of arable fields. Typically it was recorded in the inventory under a separate rubric, though where such items appear under other rubrics they were included in our valuation of draft equipment. The mean value of these objects in our regression sample was very low, at less than 1 inflation-adjusted *Gulden*. The median was zero since, as discussed below, a large majority of brides and grooms possessed no draft equipment at all.

Our dependent variable, *Literacy*, is a binary outcome variable which can take only two values: 0 if the individual did not sign the marriage inventory, 1 if he or she did sign. We deliberately defined literacy in the most conservative possible way, by

recording the value 1 only if there was a full signature present on the inventory. The *Literacy* variable took the value 0 if the inventory stated explicitly that the individual was unable to write, if the individual recorded a mark which was not a signature, and also if the individual was present at the signing of the inventory by the officials and all involved parties, and would normally have been expected to sign it, but did not do so. This procedure therefore deliberately maximized the number of persons defined as illiterate in our analyses.

A Probit or Logit model has better properties than an OLS model when dependent variable is dichotomous. Table 6 reports the Probit, Logit and OLS results from estimating our model. All three models yielded estimated coefficients, marginal effects, predicted values, and levels of statistical significance which were very similar for almost all variables. In the discussion that follows, we focus mainly on the Probit results, while pointing out the very occasional differences compared to the other two models.

As Table 6 shows, most of the interaction terms are statistically significant. This means that in order to interpret the relationship between literacy and each of the independent variables in the regression, it is necessary to allow for the interactions between those independent variables. Since the presence of interaction terms means that the size and statistical significance of the relationship with literacy cannot easily be deduced from the regression coefficients, we calculated marginal effects, standard errors, predicted values, and elasticities for each value of the interaction between each set of independent variables and tracked their development over time. In the following sections, in which we use the regression models to explore the various factors associated with literacy across time, space, and gender, it is these marginal effects and elasticities that we discuss.

6. The Gender Gap

Gender is one of the characteristics most commonly expected to show an association with human capital. Whereas in modern rich economies literacy is slightly higher for females, in poor economies it is typically much higher for males. The gender gap is one of the most tenacious literacy differences, and usually only disappears very late in the process of economic development. The seriousness of this gap in Europe as late as 1800 can be seen in Table 3. England and the Netherlands, for instance, are supposed to have endowed women with a particularly favourable position, and some scholars have ascribed the economic success of these societies to their extraordinary degree of female autonomy, in which high levels of education for women are held to have played a major role.⁵⁰ But as Table 3 illustrates, Dutch and English literacy rates were 15-20 percentage points lower for females than males in the period around 1800. The Netherlands in particular is often portrayed as having the most egalitarian gender norms in pre-modern Europe.⁵¹ But in the 11 provinces of the Netherlands in 1813-17, literacy was 75 per cent for males and only 60 per cent for females. In England, which is also supposed to have endowed women with a comparatively high social and economic status, literacy was 60 per cent for males and only 40 per cent for females. In the German state of Hesse, literacy was 91 per cent for males, but nearly 50 percentage points lower for females; in Saxony, literacy was 80 per cent for males, but 36 percentage points lower for females; in Scotland, literacy was 65 per cent for males, but 50 percentage points lower for females.

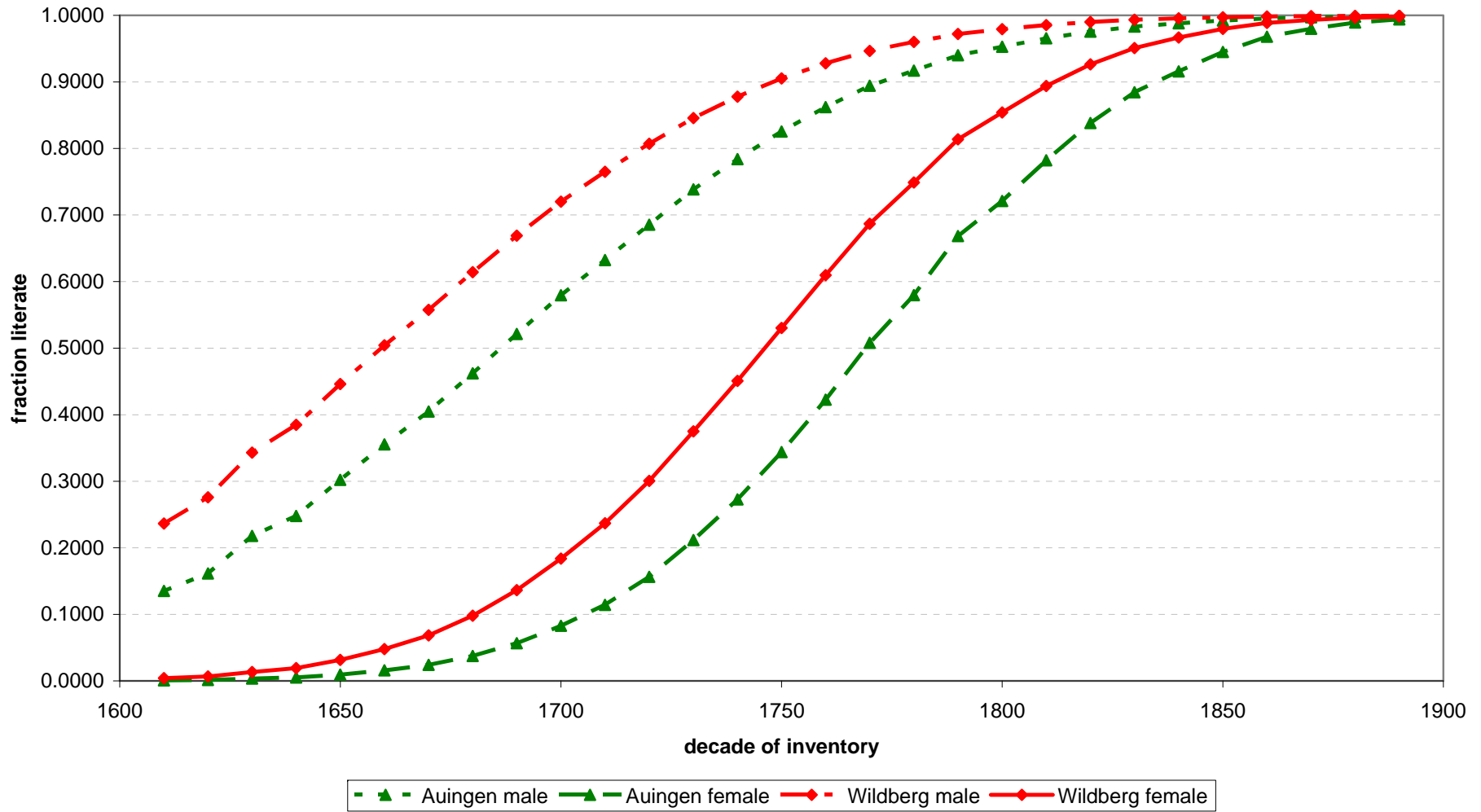
⁵⁰ On the view that women's position, including their education levels, were outstandingly good in the Netherlands and England, see De Moor and Van Zanden 2010a.

⁵¹ On the outstanding levels of female human capital in the Netherlands (using numeracy as an indicator), see De Moor and Van Zanden 2010b.

In Württemberg, by contrast, Table 3 gives the impression that there was virtually no gender gap. This is not quite true. The figures in Table 3 are for 1800, by which time the gender gap had greatly narrowed. Moreover, the raw figures do not control for other variables associated with literacy. The regression models reported in Table 6 cover the whole period from 1610 to 1899 and control for rural-urban location, age, wealth, landholding, and ownership of draft equipment. These show that females had significantly lower literacy than males even in Württemberg, although the gap varied across time and space.

This can be seen in Figure 4, which graphs the predicted values of literacy for both females and males in town and village, based on the Probit regression in Table 6. The predicted values are assessed separately for each decade, at the decadal median of total wealth and the sample mean for all other regression variables. The *predicted* literacy rates shown in Figure 4 differ from the *raw* literacy rates shown in Figure 2, of course, because the regression controls for all the other variables included in the model. The literacy gap between women and men remained statistically significant in both town and village for every decade between 1610 and 1900. However, as Figure 4 illustrates, the *size* of the gap, and thus its economic importance, became quite small after 1800. As Table 3 showed, a gender gap of between 15 and 50 percentage points was normal for western European countries around 1800. In Württemberg, by contrast, the gender gap was rapidly disappearing by that date. In the town of Wildberg, the estimated gender gap reached its maximum at nearly 54 percentage points around 1700, but had fallen to only about 9 percentage points by 1810, and to less than 2 percentage points by 1850. In Auingen, the gender gap reached its maximum at nearly 53 percentage points in 1730, but had fallen to 18 percentage

Figure 4: Predicted Literacy by Sex and Community at Decadal Median Wealth, Probit Model



points by 1810, and to less than 5 percentage points by 1850; by 1870 the gender gap in Auingen, though still statistically significant, was less than 2 percentage points.

Württemberg thus continued to have a gender gap in literacy which remained statistically significant to the end of the nineteenth century. But by 1810 male literacy was virtually 100 per cent in Wildberg and the gender gap had narrowed to less than 10 percentage points. By 1830 the same was true in Auingen. Württemberg was thus extraordinary in achieving, at a very early date, not only very high levels of literacy but also a very narrow gender gap, compared to other European societies. Examining the other variables that influenced literacy in Württemberg may help shed light on the factors that played a role in this development.

7. Rural-Urban Differences

One of these variables was urbanization. Theoretical considerations suggest several potential links between urban centres and higher human capital levels. First, urban agglomeration economies increase economies of scale in providing education. Second, urban centres have an occupational structure more dominated by secondary and tertiary occupations which are widely regarded as being activities in which literacy has a greater impact on productivity than in primary production. Third, people in urban centres were typically richer, enabling them to consume more of all good things, including education for themselves and their offspring.

A number of studies have indeed found that literacy was historically high in large urban centres. One example is Amsterdam, one of the largest cities in Europe, which had 85 per cent literacy for males and 64 per cent for females as early as 1780, whereas more than a generation later, in 1813-17, the Netherlands as a whole

recorded only 75 per cent literacy for males and 60 per cent for females.⁵² However, there are also counter-examples. One is northern Italy, which was very highly urbanized but had very low literacy, as can be seen in Table 3. Another is Württemberg, where 86 per cent of the population lived in settlements smaller than 5,000 inhabitants as late as 1834, yet literacy was extraordinarily high in the tiniest towns and villages.⁵³ Moreover, even when we observe literacy to be higher in urban centres, we do not know whether it is urbanization in itself that is causing literacy to be higher, or whether urbanization is just picking up the effect of an underlying variable such as wealth or occupation. We still lack systematic quantitative studies of whether literacy was indeed higher in urban than rural settlements controlling for other variables.

As discussed above, our data are drawn from the town of Wildberg and the village of Auingen. Wildberg was not a large urban centre, having only 1,000 to 1,600 inhabitants throughout the period, but it had the legal status of a town, it performed administrative functions for the surrounding district, it was larger than most villages, and it had an occupational structure that was more industrial and commercial than agricultural. Auingen, by contrast, had the legal status of a village, was subject to the administration of a nearby district town, was much smaller (300 to 600 inhabitants for most of the period), and relied much more on agriculture. Comparing our two communities enables us to investigate the extent to which the small-town pattern of urbanization, which was characteristic of much of pre-modern Europe outside the catchment areas of the few big cities, was associated with higher literacy.

The predicted values of literacy in town and village in Figure 4, together with post-estimation hypothesis-testing on the regression coefficients and standard errors

⁵² Graff 1987, p. 302-3 (with Table 7.9).

⁵³ Twarog 1997, 288.

in Table 6, reveal three things about town-country differences in the Württemberg context. First, although literacy was significantly lower in the village than the town for some of the period under analysis, the rural-urban gap was much narrower than the gender gap. At its widest, the rural-urban gap was only about 15 percentage points for males (between 1670 and 1690) and about 19 percentage points for females (between 1750 and 1770) – far smaller than the gender gap, which at its widest exceeded 50 percentage points.

Second, the town-village gap was more important for females than for males. As already mentioned, the rural-urban gap for males only reached 15 percentage points at its widest, and that was only for a couple of decades in the seventeenth century. By contrast, the rural-urban gap for females remained above 15 percentage points for the entire half-century from the 1730s to the 1780s, and lay at nearly 19 percentage points in the 1750s and 1760s. Village location had a larger, and hence more economically important, negative association with literacy for women than for men. This is consistent with much other evidence from pre-industrial Europe indicating that women enjoyed a better position in towns than villages, mainly because of their higher relative productivity at secondary- and tertiary-sector activities than at primary-sector ones.⁵⁴

Third, the rural-urban gap narrowed to virtually zero and became statistically insignificant during the period under analysis, though earlier among men than women. For males, the town-country gap was still statistically significant but narrower than 3 percentage points in 1800; by 1810 it was only 2 percentage points and of borderline statistical significance; and from 1820 onwards it was never statistically significant. Rural location thus had no negative association with male literacy from the early

⁵⁴ See, e.g., Smith 1990; Laurence 1994, 129, 132-4.

nineteenth century onwards. For females, the town-country gap was still statistically significant in 1870, though narrower than 2 percentage points. Rural location thus continued to have a negative association with literacy for females for half a century longer than for males, although the gap was very small throughout most of the nineteenth century.

The small-town urbanization that characterized Württemberg thus did show a significant positive association with literacy, but a very mild one. The rural-urban gap was narrow throughout the entire period under analysis. To the extent that it existed, it was wider for females than for males. Finally, it was a phenomenon mainly of the period before 1800. By the early nineteenth century, rural location had no negative association with literacy for males and even for females the gap was rapidly disappearing.

8. Age and Literacy

In theory, age may show either a positive or a negative association with a person's literacy. These potential associations arise not so much from any direct causal effect of age on literacy, but rather from underlying variables correlated with age – either characteristics of the *individual* or causal *processes* arising from human life experiences.

A first set of associations between age and literacy can arise if age is a proxy for an underlying characteristic of the individual which is associated with literacy. Our data record both literacy and age at first marriage. This means that a negative association between age and literacy could arise if a high age at marriage indicates that the individual has characteristics that make him or her an undesirable spouse and

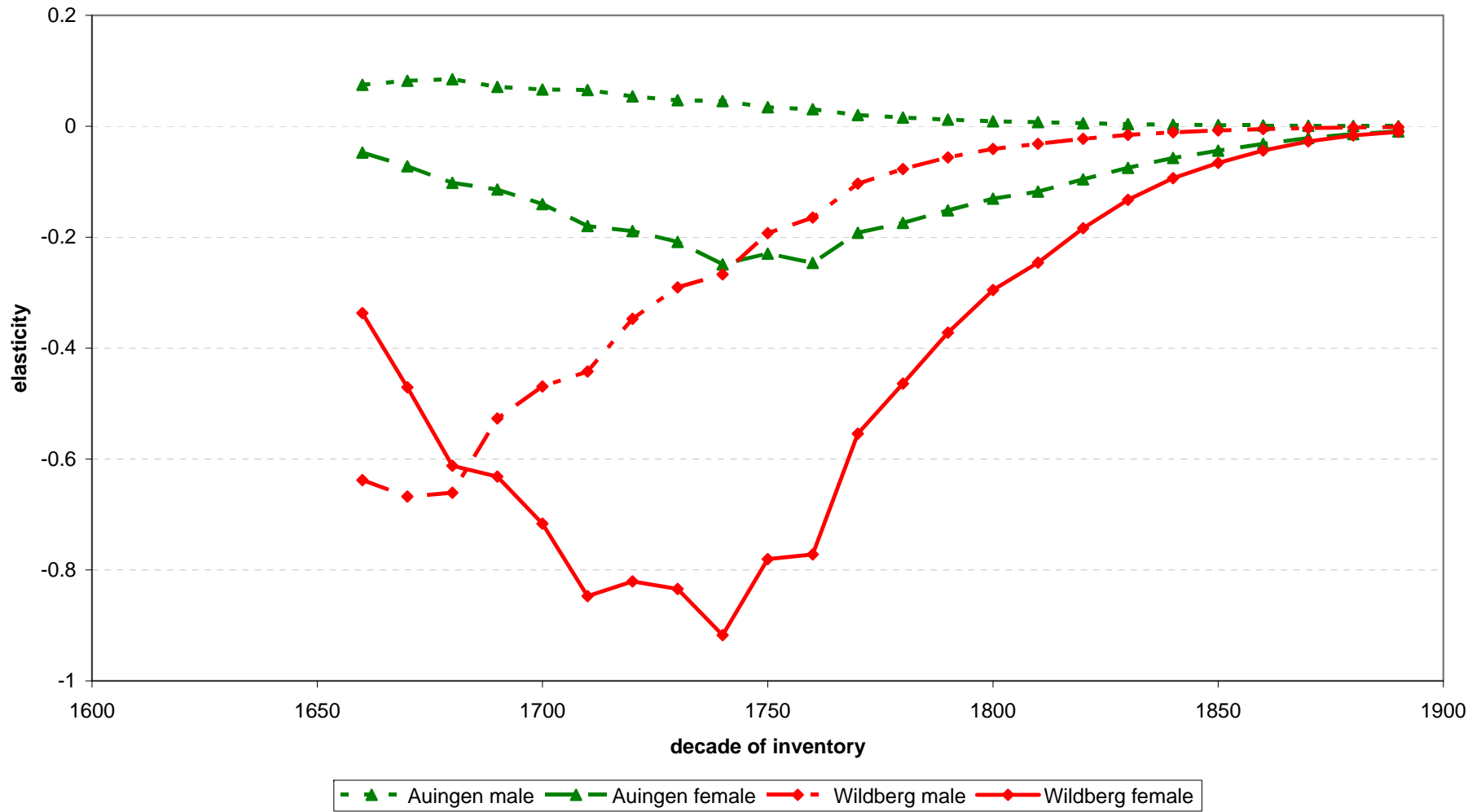
these characteristics (e.g. poverty) are correlated with low literacy. A positive association, by contrast, will arise if a high age at marriage indicates that the individual has characteristics that increase the opportunity cost of marrying instead of staying in the labour market, and these characteristics (e.g. high earnings) are correlated with high literacy; this mechanism would be more relevant for females, since it is they whose labour market participation is most likely to be curtailed by marriage.

A second set of associations between age and literacy can arise if age is a proxy for causal processes arising from human life experiences. A negative association will arise if literacy is acquired through formal schooling but subsequently seldom used, and thus decays as time passes after the individual leaves school but before they enter first marriage. A positive association will arise if literacy is cumulatively developed over time after leaving school, for instance through acquiring and using the skill of writing in practical situations.

Both positive and negative associations between age and literacy are thus theoretically possible. However, they work in opposite directions. Consequently, the association we observe between age and literacy will be the net outcome of a number of countervailing processes: on the negative side, unattractiveness as a marriage partner or economic irrelevance of schooling; on the positive side, high earning potential outside marriage or post-school accumulation of writing skills.

Our regression results show that in pre-modern Württemberg, the net outcome of these various opposing mechanisms was always non-positive. However, the age-literacy relationship differed across time, space, and gender. Figure 5 shows the elasticity of literacy with respect to age by decade, assessed on the basis of the Probit regression at the decadal means of all variables and the decadal median of wealth.

Figure 5: Elasticity of Literacy with Respect to Age (at Decadal Means), Probit Model



Elasticities are not reported for the decades before 1660 because literacy was so low in that period that the elasticities were meaninglessly high.

The size of the elasticity follows a distinctive pattern depending upon the time-period, whether the individual was male or female, and whether he or she was from the village or the town. These differences are the more striking in that the mean age of these different subgroups at the point at which they drew up their marriage inventories did not differ greatly. As Table 5 illustrates, the mean age at signing one's marriage inventory lay in the very narrow range between 27.8 and 28.6 years for both men and women in both Wildberg and Auingen over the period as a whole. Although mean age at inventorying fluctuated across time, even those fluctuations were typically small from one decade to the next. Yet despite drawing up their marriage inventories at very similar ages on average, different subgroups of the population showed noticeably different responsiveness of literacy to variations in age.

Overall, the association between age and literacy was always either negative or not statistically significant; it was never significantly positive. Village males differed from town males and all females in that the elasticity of their literacy with respect to age was virtually zero, and not statistically significant, throughout the entire period. For all other groups – village females and both females and males in the town – the older a person was at first marriage, the less likely it was that he or she would sign the marriage inventory. This negative association between literacy and age remained statistically significant until the later nineteenth century, even though it gradually diminished in size.

The existence of a negative association between literacy and age implies the operation of one or both of the two mechanisms discussed above. The first possibility is that individuals' writing skills were decaying as time passed after leaving school,

rather than being maintained or increased by being used in practical economic situations. The second possibility is that a high age at first marriage was associated with other characteristics (such as family poverty) that were correlated with low literacy. The latter explanation, at least as far as it is related to family poverty, can be ruled out since our regressions control for total wealth brought into marriage, which is primarily a function of family background. This makes it much more likely that the negative association between age and literacy registers a progressive decay of writing skills after leaving school. If true, this would imply that much of the literacy transmitted by the impressive Württemberg educational system was economically irrelevant in individuals' post-school lives.

Although the relationship between age and literacy was systematically non-positive in our Württemberg population, the size and chronology of this non-positive relationship differed greatly between subgroups. One major difference was between village and town. For village males, as already mentioned, the association between age and literacy was virtually zero and never statistically significant at any period. Village females, by contrast, showed a greater responsiveness of literacy to age, especially around the mid-eighteenth century, when a 1 per cent increase in a woman's age was associated with a 0.2 per cent decrease in the probability of her signing. But although the link was statistically significant in the OLS model it was not significant in either the Probit or the Logit model. This does not mean that it was zero, just that it was not well determined. Nonetheless, we cannot state definitively that there was a difference between village males and village females in the responsiveness of their literacy to age. What we can say with certitude is that literacy did not accumulate for villagers as they passed through young adulthood, and thus even if villagers' writing skills were not actually *decaying* as time passed after leaving

school, they were certainly not being maintained or increased by being used in practical economic situations.

In the town, by contrast, the negative association between age and literacy was both larger and statistically significant than in the village, and prevailed for most of the period under analysis. At its greatest, the elasticity of literacy with respect to age was a strongly negative -0.7 for males and -0.9 for females. Urban literacy may have been higher than rural literacy, but it was also much more likely to be lost as the individual aged. In the town, it seems clear that the extraordinarily high literacy achieved by the impressive Württemberg educational system not only was not added to by the individual during adult life, but was sufficiently irrelevant in practical terms that it decayed with each year between leaving school and entering marriage.

The association between age and literacy also differed between females and males. Within each community, male literacy showed a smaller elasticity with respect to age than did female literacy. This is intuitively comprehensible in terms of male and female economic opportunities. Although Württemberg women were active in the labour force, guilds institutionally excluded them from working independently in most secondary- and tertiary-sector activities. Instead, Württemberg women were disproportionately employed in domestic service, spinning, and day-labouring, and conversely were seldom observed engaging independently in crafts and commerce, occupations most likely to make use of writing skills.⁵⁵ This employment pattern made it more probable that females would allow their writing skills to decay after leaving school, explaining the more strongly negative elasticity of their literacy with respect to age.

⁵⁵ See the detailed quantitative analyses of gender-specific work patterns in Württemberg, including in one of the communities under analysis here, in Ogilvie 2003, 116, 122, 130-4, 142, 151-2, 208, 258-65, 274, 305-8, 329-31; Ogilvie 2004a; Ogilvie 2004b; Ogilvie 2004c.

The age-literacy relationship also displays a distinctive chronological profile, a U-shaped development across time. The exception was the case of village males for whom there was never any age-literacy relationship. For females in the village and both females and males in the town, however, Figure 5 shows an initial intensification in the negative relationship between age and literacy, followed by a very gradual diminution. The trough, in the sense of the most negative elasticity, occurred first for town males (in 1650-70), then for town females (in 1710-40), and finally (although only mildly) for village females (in 1740-60). After those troughs, each group experienced a continuous diminution of the age-literacy relationship until it all but disappeared in the second half of the nineteenth century. The period of the most intense age-literacy link for each of these groups approximately coincides with the period when that group experienced its most rapid growth in the literacy rate. The degree of disconnection between the literacy skills imparted by schooling and those required in subsequent economic life may therefore have been aggravated in periods in which the education system was expanding literacy to previously uneducated groups. Overall, however, the strongly negative age-literacy relationship in pre-modern Württemberg testifies to the serious potential for young people, especially females, to lose human capital after leaving school if they are living in an environment in which they cannot put it to practical economic use.

9. Wealth and Human Capital

The theoretical literature on human capital expresses little doubt that education will be positively associated with wealth. The question is why. As discussed above, the relationship is inherently endogenous. Greater wealth makes it possible to obtain

more of all good things, including education. But education makes it possible to increase one's economic productivity and thus one's wealth.

Our research design aimed to exclude the second component of this endogeneity – the effect of education on economic productivity – as much as possible, by restricting the analysis to young people entering marriage for the first time. Admittedly, individuals in Württemberg typically often worked for a decade or so between finishing compulsory schooling at age fourteen and marrying in their mid to late twenties.⁵⁶ But unmarried persons in pre-modern Württemberg had a limited range of economic options. They were not allowed to set up independently as farmers, craftsmen, or providers of services – even labouring services – on their own account: that was reserved for married persons. Instead, they were restricted to two main options: work as co-resident offspring for their parents, in which case they would probably not even receive a wage at all; and employment as a servant in a household headed by their master, in which they earned a wage but one that was legally capped by state, community and guild wage ordinances.⁵⁷ The few unmarried persons who lived as lodgers and worked quasi-independently as labourers (if male) or spinners (if female) tended to move from servanthood into those activities only after the mean age of marriage, i.e. only after the age of 27-28.⁵⁸ The restricted range of options open to unmarried persons meant that they were excluded from virtually all the economic activities in which education might have increased their productivity sufficiently to make them enter marriage with notably higher wealth. The wealth with which a young person entered first marriage therefore predominantly reflected the wealth of his or

⁵⁶ For an analysis of the typical life-cycle of inhabitants of the small towns and villages of pre-modern Württemberg, see Ogilvie 2003, ch. 2.

⁵⁷ Ogilvie 2003, 111-4.

⁵⁸ Ogilvie 2003, 55-62.

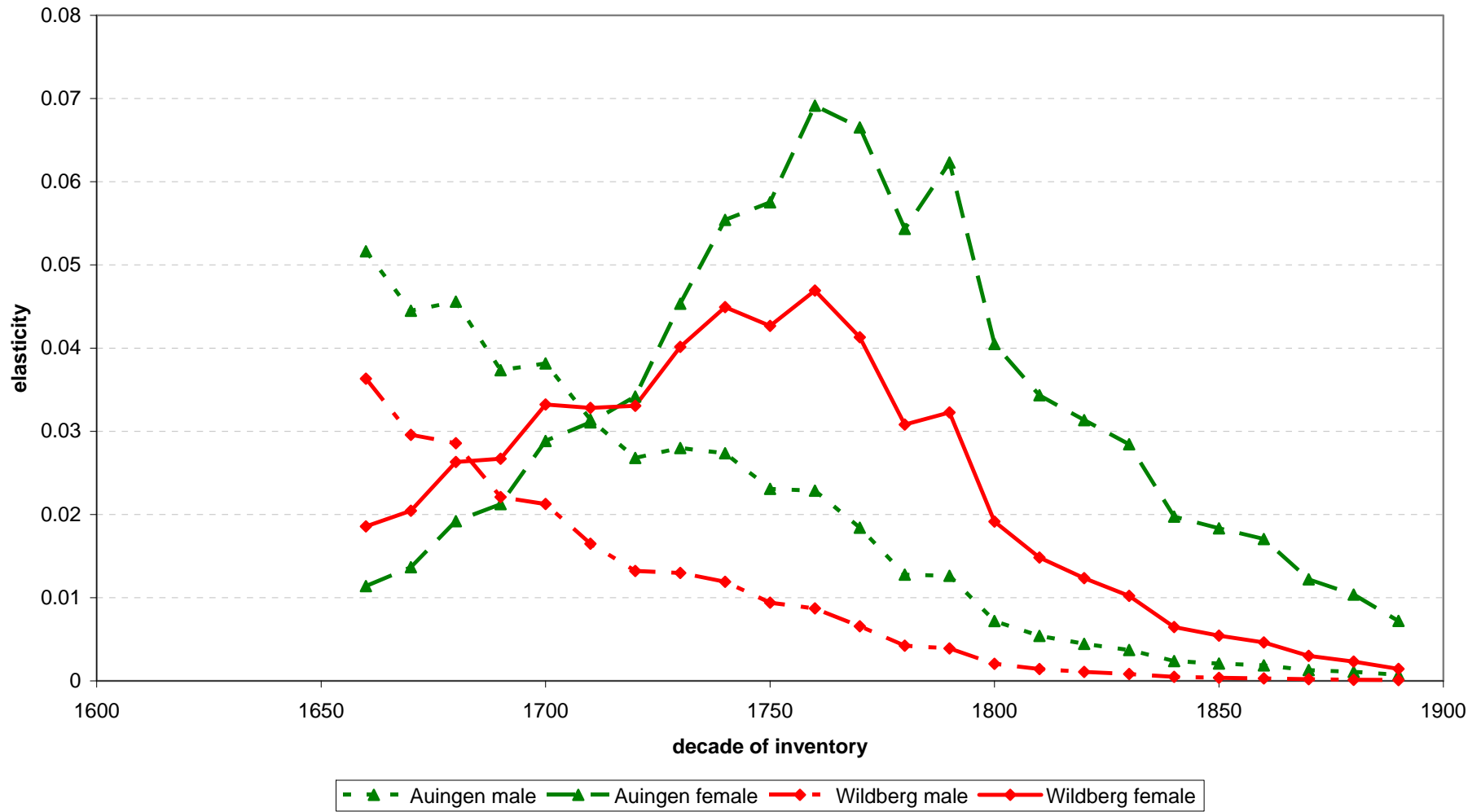
her family, with only a small portion (if any) having been amassed through the young person's earnings in the labour market.

Any positive relationship between wealth and education which emerges from our analysis, therefore, should be interpreted as indicating predominantly a causal relationship running from wealth to education rather than vice versa. The interesting question in this context, consequently, is not which direction causation ran: it ran from wealth to literacy. Rather, the question is how large the effect was, and how it differed by time-period, gender, and rural-urban location.

Figure 6 shows the elasticity of literacy with respect to wealth, calculated from the Probit model. Again, elasticities are not reported for the decades before 1660 because literacy was so low in that period that the elasticities were meaninglessly high. Wealth exercised the predicted positive effect on literacy for all time-periods and subgroups of the population. But the size of the effect, though sometimes statistically significant, was extremely small. Even at its greatest, the elasticity of literacy with respect to an individual's wealth was about one-tenth the size of its elasticity with respect to the individual's age. Wealth thus had very minor *economic* significance for literacy.

For men, wealth had its largest effect on literacy in the seventeenth century, at the very beginning of the period under analysis. Even then, at its maximum, the elasticity of literacy with respect to wealth was tiny: 0.04 for men in the town and 0.05 for men in the village. That is, a one per cent increase in a man's wealth was associated with about one-twentieth of one per cent increase in his literacy. The economic importance of wealth for male literacy, even at its greatest, was miniscule.

Figure 6: Elasticity of Literacy with Respect to Wealth (at Decadal Medians), Probit Model



From the mid-seventeenth century onwards, moreover, the association between literacy and wealth declined continuously for men in both town and village, and by the later eighteenth century it had fallen nearly to zero. The effect of wealth on literacy for males was never well determined even at its highest, initially hovering on the borderline of conventional statistical significance, and becoming statistically insignificant among town men around 1730 and among village men around 1770. Wealth was associated with male literacy when that literacy was low, and even then the effect was only of borderline statistical significance and was so small that it lacked any economic importance. As male literacy rose, the trivial association it may have initially had with wealth disappeared completely.

For females, the association between literacy and wealth followed a different chronology than for males, but was also very small. It was extremely low in the mid-seventeenth century, increased gradually up to the mid-eighteenth century and then declined again gradually to the end of the nineteenth. Although it was statistically significant from 1610 to 1800 among town women and from 1670 to 1830 among village women, even at its highest, around 1750, the elasticity of literacy with respect to wealth for females was tiny, at less than 0.05 in the town and 0.07 in the village. That is, a one per cent increase in wealth was associated with less than one-tenth of one per cent increase in literacy. Although the association between wealth and literacy was slightly larger for women than for men, it was very small for both groups. To achieve high literacy in Württemberg, it does not seem to have been important at any date for either women or men to come from a well-off family background.

The degree of association between literacy and wealth differed slightly between town and village. In the town, the association between literacy and wealth for males was already quite low by the mid-seventeenth century; in the village, it took

until about 1700 to fall to that low level. For females, likewise, the association between wealth and literacy was higher in the village than the town. Again, however, the size of the association between wealth and literacy was extremely small, with maximum elasticity of 0.05-0.07. Neither in the village nor in the town was it ever at all important to come from a well-off family background in order to achieve higher literacy.

The Württemberg evidence is thus consistent with the theoretical expectation that literacy should be positively associated with wealth. But this positive association, even at its greatest, was strikingly small for all subgroups of the population – even females and villagers. A one per cent increase in wealth was associated with less than one-tenth of one per cent increase in literacy. Thus wealth had almost no economic importance for literacy in Württemberg for any social group, whether female or male, in the village or in the town, at any period between the mid-seventeenth and the late nineteenth century.

10. Production-Related Material Possessions

Particular types of production-related possession might be expected to be associated with literacy, if not actually to cause it to be high or low, since the ownership of material objects can signal the intention to practise particular economic activities. Therefore, as mentioned above, we included in our initial regressions the inventoried value of the newly marrying individual's land, draft equipment, animals, industrial raw materials, craft tools, and wares for craft workshops or commercial businesses.

Only two of these categories of production-related possession – land and draft equipment – showed a statistically significant association with literacy. The association was negative, which is consistent with the theoretical argument already examined in the context of urbanization, according to which an occupational structure more weighted towards primary-sector activities which are more dependent on physical strength than communicating or transacting are less likely create incentives for people to acquire and maintain education-related skills. However, although land and draft equipment showed a *statistically* significant negative association with literacy, the size of this association was tiny. Neither these nor any other production-related possessions showed a relationship with literacy that was *economically* significant, in the sense of involving more than a miniscule increase or decrease in literacy.

Landholding was relatively widespread in the Württemberg context because of the partible inheritance system, according to which parental property was divided equally among all offspring, including females. For this reason, a non-trivial minority of people owned at least a small quantity of land. Thus in our sample of inventories across the entire period under analysis, about 27 per cent of individuals entered marriage with land, 22 per cent in the town and 42 per cent in the village. Consistently with the strictly partible inheritance system which did not discriminate against females, there was little gender inequality, with 29 per cent of grooms and 25 per cent of brides in our sample entering marriage with at least some land. However, although many people had some land, most did not have enough to provide a full livelihood. Instead, they combined farming with another occupation: craft, proto-industry, labouring, commerce, or some minor office or service. Entering marriage with land, therefore, did not necessarily imply the intention to be a full-time farmer. However, it

did imply that the individual planned to engage in some agricultural activity, even if it was in combination with another occupation.

It is against this background that we must interpret Figure 7, which graphs the elasticity of literacy with respect to landholding, based on the Probit regression in Table 6. Despite the fact that landholding was relatively widespread in this society, and did not invariably imply an intention to pursue a full-time agricultural occupation, it was associated with lower literacy. However, the size of this negative association was extremely small for all subgroups throughout the whole period. Even at its most negative, in the 1740s and the 1790s, the elasticity of literacy with respect to landholding was just -0.012, and for the rest of the time it was -0.01 or less. Thus a one per cent increase in the value of an individual's land was associated with a maximum of about one one-hundredth of one per cent decrease in his or her literacy, an association of no conceivable economic significance.

Draft equipment also showed a statistically significant, if tiny, negative association with literacy. Such equipment signalled the intention to pursue agriculture with some intensity, since it implied the ownership of arable (crop-bearing) land, and probably a sufficient acreage to make it economical to own lumpy items of capital equipment such as ploughs and harrows. For this reason, ownership of draft equipment was much less common than ownership of land. In our sample, only 6 per cent of people entered marriage with draft equipment, 13 per cent in the village and 3 per cent in the town. Although, as we saw, nearly as many brides as grooms owned land, only 2 per cent of women entered marriage with draft equipment compared to 10 per cent of men. This is consistent with the widespread pattern in European agriculture whereby women were more active in pastoral activities (since animals could be tended nearer to the home and required less upper-body strength) while men

Figure 7: Elasticity of Literacy with Respect to Landholding (at Decadal Medians), Probit Model



were more productive in arable farming (which required spending long days in the fields and demanded the highest levels of upper-body strength).

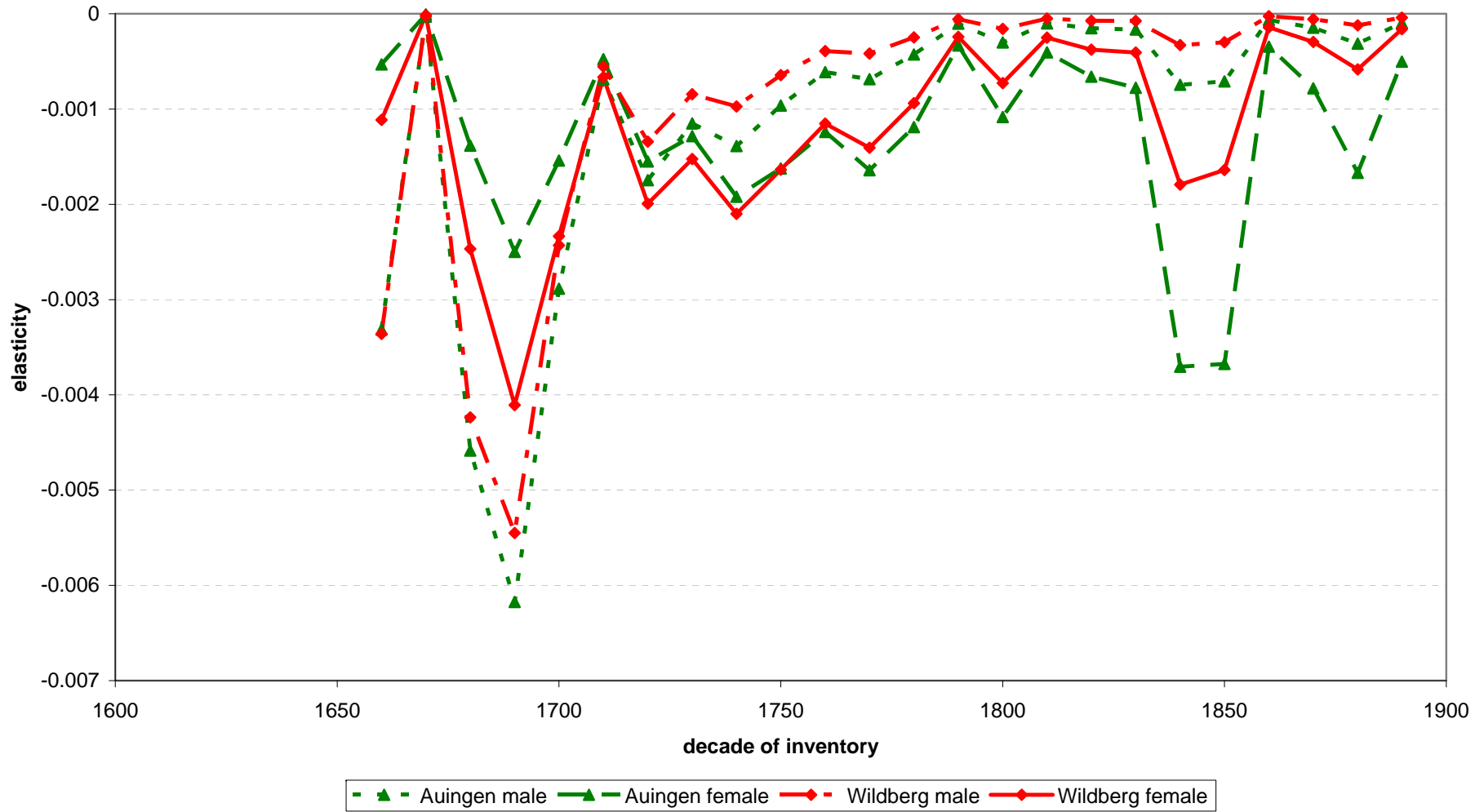
Against this background, we can interpret the elasticity of literacy with respect to ownership of draft equipment, shown in Figure 8. In this case, the negative association with literacy was statistically significant in the Probit and Logit models but not in the OLS model. The size of the association between the two variables was never more than very tiny for any subgroup at any time-period. Even at its most negative, in the 1690s, the elasticity of literacy with respect to ownership of draft equipment was just -0.006. Thus a one per cent increase in the value of an individual's draft equipment was associated with less than one one-hundredth of one per cent decrease in his or her literacy, an association of no conceivable economic importance.

The lack of association between production-related material possessions and literacy is very striking. Despite the availability of very detailed quantitative information on individuals' possessions, which might be taken to signal their production intentions very precisely, these showed no economically significant association with their literacy. These data reveal a society in which, over a period of several centuries, human capital levels were almost wholly unconnected with economic indicators on the individual level – just as they were unconnected with economic performance on the level of the society as a whole.

11. Conclusion

What can we conclude from this historical case study about the more general relationship between human capital and economic factors? Modern growth theories

Figure 8: Elasticity of Literacy with Respect to Draft Equipment (at Decadal Medians), Probit Model



postulate that education plays a central causal role in economic growth by reducing diminishing returns to physical capital, accelerating adoption of productivity-enhancing innovations, and motivating a shift from quantity to quality of offspring, thereby reducing fertility, slowing population growth, increasing capital per worker, and enhancing labour productivity. But economic history has yet to establish whether education was associated with such economic benefits. Nor has it yet identified what lessons can be drawn from those historical societies which were most successful in achieving high educational outcomes.

This paper addresses these questions by examining literacy in Württemberg, a late-developing economy in German-speaking central Europe, across nearly three centuries before and during industrialization. The women and men we analyze were inhabitants of two small communities which, even by the modest standards of Württemberg, were not centres of economic dynamism. Württemberg in turn was a society in which, compared to other parts of Germany, per capita incomes were low, agricultural development was gradual, and industrialization was late. Germany in turn had below-average per capita incomes and slow economic growth by European standards until the mid-nineteenth century.

Despite their mediocre economic performance, these small and stagnant settlements in southwest Germany achieved extraordinarily high literacy at an early date. Württemberg far surpassed the literacy not only of higher-performing German economies, but also of the richest and most advanced European societies, England and the Netherlands. Comparisons between Württemberg and other parts of western Europe demonstrate definitively that high and pervasive human capital investment in the form of education was neither necessary nor sufficient for a European economy to perform well during the crucial centuries before and during industrialization.

Our multivariate analysis of Württemberg's impressively high literacy found that it was associated with many of the social and economic characteristics linked to educational outcomes in other less developed economies, both historical and modern. Literacy was lower for women than men, for villagers than townsmen, and for the poor than the better-off. In these respects, Württemberg was not *sui generis*, but rather showed patterns that are recognizable for most less developed economies. But literacy in Württemberg was distinctive in two important respects – in addition to its high level – and these have far-reaching implications for understanding the relationship between human capital and economic factors in developing economies.

The first distinctive characteristic is the small *size* of the relationship between literacy and socio-economic variables in Württemberg, and the early date at which even this very weak relationship disappeared. Gender, urbanization, and wealth showed an association with literacy which was significant *statistically*, but so diminishingly small that it lacked *economic* importance. Even in the case of gender, the association with literacy was substantial only for a brief period, during the transition from low to high education; by c. 1800 the gender gap had become very narrow, and in the course of the nineteenth century it virtually disappeared. More strictly economic factors – urbanization, wealth, agricultural involvement – never showed more than a very weak association with literacy, and even this relationship largely vanished by 1800, generations before agricultural modernization or industrialization even began. In this respect, the educational success story of early modern Württemberg prefigures that of twentieth-century Kerala: a society strikingly successful in achieving high and egalitarian educational outcomes for virtually all its inhabitants at a very early date.

This lack of association between human capital and socio-economic variables was two-edged, however. The decoupling of education and the economy went in both directions. On the one hand, educational human capital in Württemberg never responded strongly to socio-economic factors, and by c. 1800 had ceased to do so almost completely. On the other hand, nor did Württemberg's economic performance show any sign of responding significantly to its extraordinary level of education. By c. 1800, other western European economies were undertaking both agricultural modernization and industrialization, adopting productivity-enhancing practices which were internationally well known and could have been emulated in highly educated Württemberg. But this did not happen. Württemberg, like Kerala two centuries later, did not parlay its educational miracle into an economic success story.

This is consistent with the second distinctive characteristic of Württemberg literacy: the fact that it never increased, and for most groups markedly decreased, with individual age. In Württemberg among all social groups and during all time-periods, as people got older their literacy levels did not rise. That is, people did not accumulate writing ability across their economic lives. Furthermore, for all groups except village men, there was a *negative* association between literacy and age which was not only statistically significant but also quite sizeable, and thus economically important. Especially for women and in the urban setting, individuals displayed a progressive decay of their writing skills for each year of advancing age between school and marriage. These findings imply that much of the literacy transmitted so successfully and pervasively by the Württemberg educational system was lacking in practical relevance to the real-life economic demands of individuals' lives after leaving school. These findings provide further quantitative testimony to the decoupling of human

capital and the economy in the Württemberg context. Virtually the entire population was highly educated at a very early date, but in an economically useless way.

Nor, in the Württemberg context, were high human capital levels for the whole social spectrum associated with correspondingly high *welfare* levels for the whole social spectrum. Low per capita incomes, poor agricultural productivity, long-term stagnation in crafts and proto-industries, a backward commercial sector, and late factory industrialization not only reduced economic growth but also depressed human development indicators. The less-well-off members of Württemberg society, despite their near universal literacy, suffered famine in 1816 and 1845-6 and faced severe economic crises in the 1850s, 1880s and 1890s.⁵⁹ Infant mortality in mid-nineteenth-century Württemberg was half again as high as in many other areas of Germany and more than double that in England, France, Belgium, Denmark, Sweden, or Norway.⁶⁰ Heights in nineteenth-century Württemberg were notably lower than the average for Germany, France, England or the Netherlands, instead resembling those observed in the poor countries of eastern and south-eastern Europe.⁶¹ Heights for Württemberg males born in the mid-nineteenth century were below the first percentile of modern height standards, reflecting widespread nutritional deprivation, especially for infants and children.⁶² Württemberg was unable to provide attractive economic opportunities or even basic livelihoods for its highly educated inhabitants, resulting in epidemic emigration to North America and eastern Europe: an estimated 7 to 10 per cent of its inhabitants emigrated in the five years from 1851 to 1855, with the result that the kingdom's total population declined between 1852 and 1861, and the economic

⁵⁹ Twarog 1997, 288; Mann 2006, 216.

⁶⁰ Twarog 1997, 307, 312; Guinnane and Ogilvie 2014, 84, 97-104.

⁶¹ Coppola 2010, 87 (with Table 3), 93-4 (with Table 4).

⁶² Twarog 1997, 324.

tribulations of the 1880s saw a further surge in mass emigration.⁶³ Württemberg women were not allowed to pursue many of the secondary- and tertiary-sector occupations in which female productivity was highest because guilds and other institutionalized special-interest groups excluded them from independent practice;⁶⁴ the mortality of women in Württemberg was higher than for women elsewhere in Germany to the end of the nineteenth century.⁶⁵ The state and local authorities in nineteenth-century Württemberg regarded the economic situation as so severe that they legislated to prevent access to marriage by individuals whose communities regarded them as welfare risks, creating a two-tiered demographic system in which until 1870 the less-well-off were institutionally prevented from marrying and thus from pursuing livelihoods as independent householders.⁶⁶ The stratospheric human capital levels in Württemberg were so completely decoupled from the economy that they were accompanied not only by slow economic growth, therefore, but also by low human development indicators. Many vulnerable and disadvantaged members of Württemberg society suffered chronic unemployment, permanent celibacy, hunger or outright famine, physical stunting, high mortality, and mass emigration.

The Württemberg human capital miracle thus casts doubt on theoretical models that ascribe education a central role in economic growth. Württemberg in the eighteenth and nineteenth century, to an even greater degree than Kerala in the twentieth and twenty-first, achieved exceptionally high and egalitarian levels of literacy. But this proved to be insufficient to achieve successful economic growth or to improve welfare for the poorest in society. Having the most highly educated population of producers ever observed in eighteenth- and nineteenth-century Europe

⁶³ Marschalck 1973, 204; Twarog 1997, 316-7 with Table 8.14; Benz 2011, 206.

⁶⁴ Ogilvie 2003; Ogilvie 2004b; Ogilvie 2004c.

⁶⁵ Twarog 1997, 315-6 with Table 8.13.

⁶⁶ Matz 1980; Benz 2011, 199; Guinnane and Ogilvie 2014, 82-3, 91, 108-11.

was not sufficient for Württemberg to achieve outstanding – or even average – economic performance. It is even possible that the degree of social surveillance and institutional regulation which enabled universal literacy to be achieved made Württemberg it a difficult place in which to earn a living or respond flexibly to economic opportunities.⁶⁷ Whatever the causes, the Württemberg experience showed that neither a high absolute level nor a high equality of human capital was sufficient to create productive economic activities in which that human capital could be deployed. The broader institutional framework had to provide opportunities for people to use their human capital in economically productive ways, even if that meant weakening some of the institutions that gave rise to exceptional human capital investment to begin with. Württemberg failed to reap a return on its extraordinary levels of human capital investment until it undertook the difficult institutional reforms required for its inhabitants to deploy their human capital in ways that could increase economic well-being both for themselves and for the rest of society.

⁶⁷ On this institutional surveillance and control, see Ogilvie 1986; on its wider economic repercussions, see Ogilvie 1997; Ogilvie 2015.

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