Technology of cultural transmission I: the printing press*

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Abstract

Existing theories of the effects of the printing press treat it as speeding up the transmission of technical knowledge. This cannot explain why a large proportion of both manuscripts and early printed books was religious. We argue that books transmitted prudential and moral rules as well as technical information. These culturally transmitted rules encouraged work and saving, and mitigated problems of trust in early modern markets. We detail the contexts, content, and demand for enculturation. We then model the effect of the printing press on economic growth. We show that cultural change may be necessary to increase productivity before the development of knowledge and the take-off into modern economic growth can happen.

Keywords: culture • economic transition • overlapping generations model • unified growth model

JEL-classification: D11 • D62 • E13 • N13 • O41

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1 Overview

We propose a new hypothesis about the role of the printing press in modern economic growth. Cultural change was necessary for the transition to the modern economy. This change was enabled by the printing press, which allowed more efficient transmission of cultural norms. The resulting cultural change was a necessary precursor before the printing press could be useful in spreading technical knowledge.

The conventional theory of the printing press focuses exclusively on its role in transmitting technical knowledge. This theory faces an empirical puzzle: for a long period, the most common topics of printed books were not technical, but religious. 45% of Italian incunabula – the earliest printed books – were on religious topics (Hirsch, 1974). In England, about 40% of the editions published from 1480-1640 were religious – by far the largest category (Klotz, 1938). Across Europe, 35% of all editions between 1454 and 1600 were on religious topics (Dittmar and Seabold, 2017).

We argue that the written word is a technology of cultural transmission as well as information transmission. Cultural norms are rules of behaviour that benefit the individual, or those around him. The early modern economy increased the demand for a set of cultural norms including work effort, self-control, saving and foresight, and honesty and cooperation with business partners and employers. In our model, printing lowers the cost of transmitting these norms. Individuals purchase printed religious material so as to enculturate themselves (or their children) and thus increase their productivity. This was the initial driver of demand for books. In turn, these individual choices create a surrounding culture where productivity is expected and valued, and this makes the enculturation process more effective. Eventually, individuals' increased productivity makes it worthwhile for them to work in the modern sector and invest in technical skills by buying technical literature. This in turn causes the stock of technical knowledge to grow, and there is a takeoff into modern growth.

In our model, for some parameter values, this indirect path is the only way that the takeoff can happen. Cheaper technical literature on its own does not increase growth, because when the stock of knowledge is low and/or individuals are not highly enculturated, then the modern sector of the economy cannot develop. (The

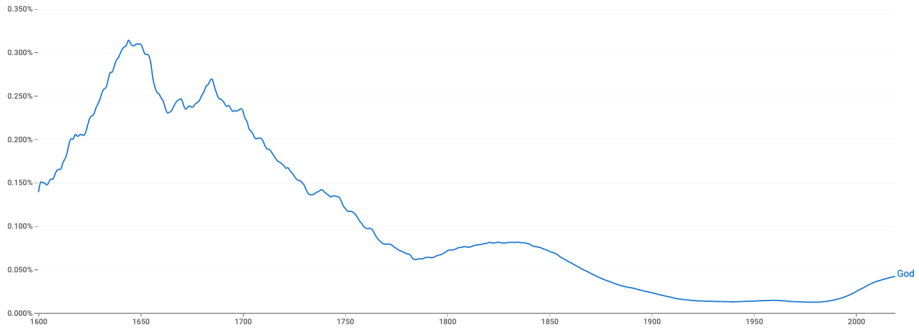

Figure 1: Occurrences of "God" in Google ngrams database, 1600-2019. Smoothing 10.

underlying idea is that the modern economy requires productive workers to make investment in capital, machinery etc. viable – cf. Mokyr (2009).) In turn, without an active modern sector, individuals have no incentive to invest in technical knowledge, and the stock of knowledge does not grow.

Below, we support our story with qualitative evidence on the role of reading and the content of books in early modern Europe. We then introduce our model of the transition to modern economic growth.

Figure 1 pictures the change we study. it shows occurrences of the word "God", as a proportion of all words, among works in English in the Google ngrams database. The peak is about 1650, or two centuries after the invention of print. After that there is a slow decline. Put simply, we explain why Gutenberg's first major printed work was a Bible.

2 The argument

The invention of the printing press has long been acknowledged as a key step in European development. The press dramatically lowered the cost of books, allowing information to spread faster (Baten and Van Zanden, 2008; Dittmar, 2011). This in turn increased the rate of innovation and/or the level of human capital, leading to faster growth, and perhaps contributing to the Great Divergence between Europe and the rest of the world (Romer, 1986; Becker, Murphy and Tamura, 1990). This view was put by Condorcet (1795):

> These multiplied copies, spreading themselves with greater rapidity, facts and discoveries not only acquire a more extensive publicity, but

> acquire it also in a shorter space of time. Knowledge has become the object of an active and universal commerce.

At the broadest level, this story is highly plausible, since technical progress and new ideas are central to modern economic development, and (until very recently) ideas were communicated overwhelmingly via books.

However, one fact seems not to fit the narrative: a very substantial proportion of book sales consisted of religious works. The numbers given above probably underestimate the proportion of physical printed matter that was religious, for two reasons. First, religious works probably had more copies per edition. Certainly, the bestsellers of the early modern period were overwhelmingly religious – most obviously the Bible, but also classics of piety like Thomas à Kempis's *The Imitation of Christ* and the *Ars Moriendi* (Art of Dying); Luther's polemical works; and later Puritan and Pietist works such as the *Whole Duty of Man*, *Pilgrim's Progress*, or Johann Arndt's *Wahres Christentum* (True Christianity). Second, a large mass of cheap printed matter including broadsides and pamphlets is not recorded in book databases, and a high proportion of this may have been religious (Watt, 1994).

A second problem for the mainstream theory is that the link between scientific progress and economic growth developed only slowly. Improvements to knowledge transmission are only useful if they meet demand, that is, if workers find it worthwhile to purchase technical knowledge. In turn, this requires technical skills to be in demand. While skilled workers were important in the early modern economy, the majority of their knowledge was "tacit" – knowledge learned by practice, or direct transmission from master to apprentice (Cipolla, 1972; Kelly, Mokyr and O'Grada, 2020). Books and patents played a relatively marginal role (Epstein, 2013). The "second industrial revolution", beginning in the 1870s, was the first wave of innovations to be underpinned by theoretical science (Mokyr, 2005; Allen, 2009). This is long after English productivity began to grow at around 1600 (Bouscasse, Nakamura and Steinsson, 2021). Thus, in our period book transmission of technical knowledge appears relatively unimportant. A possible reason for this is that a capital-intensive modern sector, which demands technical skills, cannot develop unless workers are productive enough. If workers are unproductive, and the stock of knowledge starts off low, then even when knowledge transmission becomes cheaper, this does not guarantee that the modern sector will emerge.

Indeed, Clark (1987) argues that the US and Britain's higher productivity was a result of more intense labour rather than technical change. In turn, technical knowledge only grows when it is being used in the economy. In the extreme, there could be a static equilibrium where knowledge does not grow and the modern sector is small to non-existent.

Although technical books may not have been demanded, evidence suggests that consumer demand drove the purchase of religious works. While some publications were bought in bulk by Church authorities, in 1530, there were 64,000 clandestine copies of Tyndale's New Testament in England, at a time when owning it was illegal (Zaret, 1985). The demand in Huguenot Lyon for Protestant works was supplied by smugglers (Watson, 2002). By contrast, Galileo's epoch-making *New Science* was only of interest to a tiny group of specialists.

These facts motivate us to modify the traditional story of the printing press' effects. Writing is a technology not just for information transmission, but also for cultural transmission. That is, written communication not only provides information about how to do things efficiently; it can also alter behaviour. The early modern economy opened up opportunities for people with particular behaviour, specifically working hard as well as being being patient and cooperative. This made it advantageous for people to change their own behaviour, or for parents to seek to change their children's behaviour, in this direction. A large part of the early market for books was for works that could do this. So, this theory addresses the two issues above. The demand for books-as-cultural-transmission provides an initial market that motivates entrepreneurs to invest in printing press technology, even before scientific progress has got going. And it explains the empirical evidence that religious works make up a large proportion of early printed material, which then declines over time as more valuable scientific ideas are transmitted in print.

The simplest competing hypothesis is that religious books were consumption goods, with economic effects no different from any other consumption good. Much early modern literature was certainly bought for entertainment, from cheap ballads and romances to the first European novels. Religious work also often strove to be entertaining, from the sumptuous Books of Hours printed in Paris, to religious versions of popular ballads. However, there are two kinds of evidence against this "consumption hypothesis". First, many early modern reading

practices seem to be aimed at changing behaviour. We describe these in detail below. Second, evidence shows the printing press had economic effects. German cities with a press saw much higher economic growth in the 16th century Dittmar (2011). Some of these effects may have been mediated by religious change. Cities with more printers before 1517 saw more Protestant publications (Dittmar and Seabold, 2017); in turn, Protestantism had substantive economic effects, increasing literacy, especially women's literacy, and possibly affecting economic growth (Becker and Woessmann, 2008, 2009; Becker, Pfaff and Rubin, 2016). These results better fit the story that the press's early economic effects came from cultural change, rather than from technical knowledge.

Our argument is linked to the literature on cultural transmission and evolution (Cavalli-Sforza and Feldman, 1981; Boyd and Richerson, 1988; Bisin and Verdier, 2001). On this account, human behaviour, i.e. rationalizable choice patterns, are not inborn but are the result of "enculturation" – learning cultural rules, transmitted from parents, peers and others in society. These rules, rather than explicit calculation, allows human behaviour to be well-adapted to its environment, even when that environment is "causally opaque" (Henrich, 2015). Indeed, according to the theory of cultural evolution, in the long run human rules will evolve to increase individuals' fitness, similarly to biological genes, driven by the same forces of mutation and selection (Boyd and Richerson, 1988). However, some "moral" rules or "social norms" may increase the fitness not of the individual, but of their social group. Because on average it is fitness-enhancing to learn from parents and others, humans are "docile": they tend to accept what they are told.[1] This allows teachers to teach not only fitness-enhancing rules that benefit the child himself, but also moral rules that benefit those around him (Simon, 1990; Gintis, 2003). For example, a mother may encourage her children to share fairly with each other. Rules may be transmitted vertically from parents to children, obliquely from non-parents in the previous generation, or horizontally among peers of the same generation.

The emergence of the early modern economy created a new environment where existing rule sets, perhaps transmitted within rural communities, and tightly

[1]Evidence from developmental psychology supports the idea of docility (Clément, Koenig and Harris, 2004; Harris and Koenig, 2006; Jaswal et al., 2010). For the credibility of written material, see Eyden et al. (2013); Einav, Robinson and Fox (2013).

tied to specific agricultural and social contexts, were no longer optimal. Instead, thriving in the economy required more general principles including foresight, planning, thrift and saving; trustworthiness and reliability in economic relations such as employment; later, resistance to the new temptations of the urban economy, including alcoholism, gambling and prostitution (Rorabaugh, 1991; Evans, 1976).

Theories of cultural transmission usually treat the transmission process as fixed. However, there may be innovations in cultural transmission just as in information transmission.[2] The printing press lowered the cost of books and pamphlets, which could be used for both information transmission and cultural transmission.

The broader context of our work is the literature on the emergence of modern economic growth. Other people have argued that culture is important to this process. A famous early contribution is Weber (1904). Mokyr (2016) described how role models spread the culture behind scientific innovation. Clark (2008) argues that middle-class values spread through the English population over the long run, as rich parents had more children. Doepke and Zilibotti (2008) model preference formation as an explanation for the rise of the middle class work ethic during early capitalism. Bisin et al. (2021) model the coevolution of culture and institutions to explain the "long divergence", during which the Middle East fell behind Europe economically. Our contribution is to model technology as an input into the cultural transmission process. In a sense, we put technology back in place as an exogenous source of growth, with culture as a mediating variable.

We next describe the process of cultural transmission via reading at this period. We detail the contexts in which reading took place; some relevant formats of printed material; and the content of the norms which were transmitted. Finally, we discuss the private and public demand for enculturation.

[2]We can distinguish these within a microeconomic framework: information transmission changes people's perceptions, while cultural transmission changes their behaviour. From the perspective of cultural evolution, the distinction is unimportant, since humans do not maximize their expected utility given their beliefs, but simply follow transmitted norms and rules. But the distinction helps us clarify our differences with previous theories.

3 Contexts of reading as cultural transmission

Early modern reading was different from reading today. Apart from a small cultured elite, people had fewer books. They read them "intensively" (Engelsing, 1974), or as a contemporary marginal note in a work of Ramus put it: "This whole book... continually, and perpetually to be meditated, practiced and incorporated into my boddy & souwle.... by perpetual meditations, recapitulations, reiterations... sounde and deepe imprinting as well in ye memory as in the understanding" (Sherman, 2010). A single book might be studied for a year. A tailor's apprentice staying in Coventry found a history of Britain in his master's house; over three months, he learnt most of it by heart (Spufford, 1979*b*).

Protestantism in particular made intensive reading, especially of the Bible, central to religious practice. "To reade the word, and to meditate thereon, is a daily part of a Christian holy life," said the New England Puritan John Cotton (Hambrick-Stowe, 2013). The Bible was supplemented by a whole literature on self-improvement. Some works were on nearly as many bookshelves as the Bible itself, and remained there for centuries: in English, *Foxe's Book of Martyrs*, the *Whole Duty of Man*, *Plain Man's Pathway to Heaven*, and later *Pilgrim's Progress*; in Germany, the anonymous *Theologia Germanica*, and Johann Arndt's *Das Wahre Christentum* ("True Christianity"), which was popular throughout Protestant Europe.

The private reading encouraged by Protestants could be highly methodical and intellectual. In his text for preachers *The Art of Prophesying*, the Puritan William Perkins (1996) recommended cataloguing-style techniques for Bible study, using a commonplace book: "divide the right-hand pages of your book into columns... Head each of these pages with a major topic...". He also suggested creating an alphabetical index for ease of reference. Devotional manuals laid down rules for reading, including making it part of one's daily routine and avoiding wandering thoughts, and provided model prayers to be said before reading. But reading was not just an intellectual activity: the Bible was to be read and meditated upon, and manuals suggested visualization techniques like imagining Christ on the cross to bring the message home (Hambrick-Stowe, 2013).

Print was not solely used for the private reading that we are most familiar with today. And even private reading was always embedded in social contexts,

including the household and the community. A literate person might read works to his illiterate peers. Householders were expected to read aloud to their families, including servants. Many works of English Puritanism focused on the government of children, in particular on how to teach children to read; as the preachers Dod and Cleaver put it, "we are changed and become good not by birth but by education" (Walzer, 1965). Families prayed together, read the Bible together, and catechized each other. These practices aimed at *vertical* or *oblique transmission* of norms across the generations. Teaching servants was part of this: many servants and apprentices were literally children, and the master-apprentice relationship was an institution for education as much as for employment (Cambers, 2011).

Reading was affected by its supporting social context, and in their turn, readers of the new literature could change that context. Most simply, "Godly" followers of new norms might band together to support each other. An early English protestant encouraged people to "take the Scripture in their hands" at the alehouse and to "talk, commune and reason of it" (Collinson and Murphy, 1988). 16th century French peasants and Huguenot artisans held similar Bible discussions (Davis, 1991). A visiting Jesuit priest described a Puritan meeting in 1580s England (Spufford, 1979*a*, via Fulbrook, 1983):

> Each of them had his own Bible, and sedulously turned the pages and looked up the texts cited by the preachers, discussing the passages among themselves to see whether they had quoted them to the point.... Also they would start arguing among themselves about the meaning of passages from the Scriptures – men, women, boys, girls, rustics, labourers and idiots....

This is an example of *horizontal transmission* among peers of the same age cohort. Later, Puritan groups would hire lecturers in order to expound the Bible to them (Seaver, 1970). Readers might follow the text, take notes on the sermon, and afterwards discuss it in the household. The sermon in turn might subsequently be printed. In economic terms, then, reading was often a complement to verbal transmission, rather than a substitute.

The new readership also led to new, more specialized literary forms. A believer's diary, written in private, might later be published as a spiritual autobiography for the benefit of others (Cambers, 2011). Puritans developed the first chil-

dren's books, along with specialized catechisms for young children (Sommerville, 1992).

Lastly, at the highest level, a sufficient mass of enculturated individuals could engage political actors to alter the social context. Lutherans appealed to princes to achieve their educational goals (Strauss, 1978). Elizabethan bishops spoke of the need to "print" the Reformed religion in the hearts and minds of their countrymen (Zaret, 1985). Frederick I, the Great Elector, and his Prussian successors formed a partnership with the Pietists in shaping values to support the state (Gawthrop, 1993). Puritan Massachussetts aimed to be "God's commonwealth".[3]

Feedback between individual reading and its social context is crucial to our argument, because it allows for a slow build-up of new norms in society. In our model, we encapsulate the context of reading in an economy-wide state variable, "industriousness", on the analogy of the economy-wide state variable for the knowledge frontier in standard models of technical change. Industriousness and individual enculturation are in a feedback loop: a higher level of industriousness in the surrounding society makes enculturation more effective; conversely, individuals' total enculturation levels shift the total level of industriousness. We allow industriousness, unlike knowledge, to decay over time if individuals' enthusiasm wanes. The resulting dynamics mean that the printing press causes total productivity to grow incrementally over time, as individual enculturation increases and feeds back into industriousness. This opens up a gap in time between the invention of the printing press and the shift to modern economic growth: only when industriousness and productivity have grown high enough is it worthwhile for firms to move production to the modern sector.

The use of books for cultural transmission was not limited to Protestantism, nor did it only happen after the invention of print. The Brethren of the Common Life, founded in the fourteenth century by the Dutch mystic Geert Groote, emphasized religious reading, including of the Bible in vernacular translation, as a means to a holy life. Brethren themselves copied books as a means to earn a living, moving into printing after 1454. The order also established public schools, and its ideas on education influenced both humanists and Protestants. There is evidence that cities with a BCL order saw higher literacy, and greater economic growth, as a result (Akçomak, Webbink and Ter Weel, 2016). In 17th century Rome, the

[3]See also Section 6 below.

Order of the Pious Schools was founded by St Joseph of Calasanz, in order to provide free tuition to the children of the poor, with instruction books translated into the vernacular. Calasanz's central focus was on moral education, although Piarist schools also provided optional technical training in Latin and mathematics (Tanturri, 2011). Lastly, the most famous Catholic example of a book as a vehicle for cultural transmission is the the *Spiritual Exercises* of Ignatius Loyola. However, print did make these kinds of books cheaper and more widely available.

4 Print formats of enculturation

In Protestant Europe, the most widespread and important single source of enculturation was the Bible itself. This did not necessarily mean the canonical single text. Summaries, verse-a-day collections, or children's stories extracted from the Bible were all common alternatives (Bottigheimer, 1993). Stories from the Old and New Testaments were used as illustrations of vice and its punishment. Solomon's Proverbs and Paul's epistles were widely referred to for life advice. Catholics read Bibles, including vernacular Bibles, as well, despite the opposition of the church hierarchy (François, 2018).

Probably the best-known format designed for cultural transmission is the conduct manual. These originated among Christian humanists and were developed over the 16th and 17th centuries, culminating in England in Puritan manuals such as the *Whole Duty of Man*, the *Plain Man's Pathway to Heaven*, or *Goldengrove*. A further subgenre was the manual of household government, such as Whitforde's *Werke for Housholders* (1533); Batty's *Christian Man's Closet*; Griffith's *Bethel: A Forme for Families* (1633); Perkins' *Oeconomia Christiana* ; Gouge's *Of Domestical Duties;* Rogers' *Matrimonial Honour*; or Dod and Cleaver's *Godly Form of Household Government.* These tended to specify separately the duties of husbands, wives, parents, children, masters and servants. They combined religious exhortation with practical advice. Still more specific were mothers' manuals, which were typically framed as deathbed advice or a legacy to children, continuing the advice given in life.

Printed work could even reach the illiterate. The early Lutherans used woodcuts extensively to get their message across (Scribner, 1994); a third of German woodcuts were on religious topics (Houston, 2014). Swedish *skillingtryck*, French

fatras and Russian *lubki* were similar formats. Texts might be read out by one literate person to an illiterate audience. In England, a large proportion of the very cheapest printed work contained religious or moral precepts (Watt, 1994). These works included religious ballads, sold for singing and often reusing secular tunes, and printed posters which would be hung on the walls of taverns or private houses. In one eighteenth-century catalogue of cheap woodcuts, about a quarter were on religious subjects. Among chapbooks (sold by travelling pedlars or "chapmen"), the cheapest "penny godlies" were available for 2 pence. Subjects included polemics against drunkenness; life advice handed down by a parent on their deathbed; and ABCs of religion and morality, which used the alphabet as a mnemonic device. By one estimate, a third of chapbooks were "godly" in the 1680s. A 24-page abridgment of the *Plain Man's Pathway to Heaven* went through 17 editions in three years. These works catered to the desire for entertainment as well as for moral improvement: the most popular and longest-lasting forms often included elements of narrative or dramatic interest, such as the biblical tale of the Prodigal Son.

Catechisms were another key format. These were short, self-contained texts, often in question-and-answer format, designed to be learned by heart, and meant to be taught by clergy as well as by householders to their children and servants. The 16th century saw an explosion of catechisms; later, many countries settled on a single catechism, often mandated by law to be taught in schools and/or churches. This uniformity allowed cheaper and larger print runs, and could also make the norms they contained common knowledge. ("Common knowledge" means that everyone in a given group knows the norm, knows that everyone else in the group knows it, et cetera. This is advantageous for rules governing interpersonal interactions, since it helps coordinate people's expectations that everybody will follow the norm.) The Anglican catechism, learned by children in the Church of England from the 16th to the early 20th century, ran in part:

> My duty towards my neighbour is to love him as myself, and to do all men as I would they should do unto me: to love, honour, and succour my father and mother: to honour and obey the King and all that are put in authority under him: to submit myself to all my governors, teachers, spiritual pastors and masters: to order myself lowly and reverently to all my betters: to hurt nobody by word nor deed: to be true

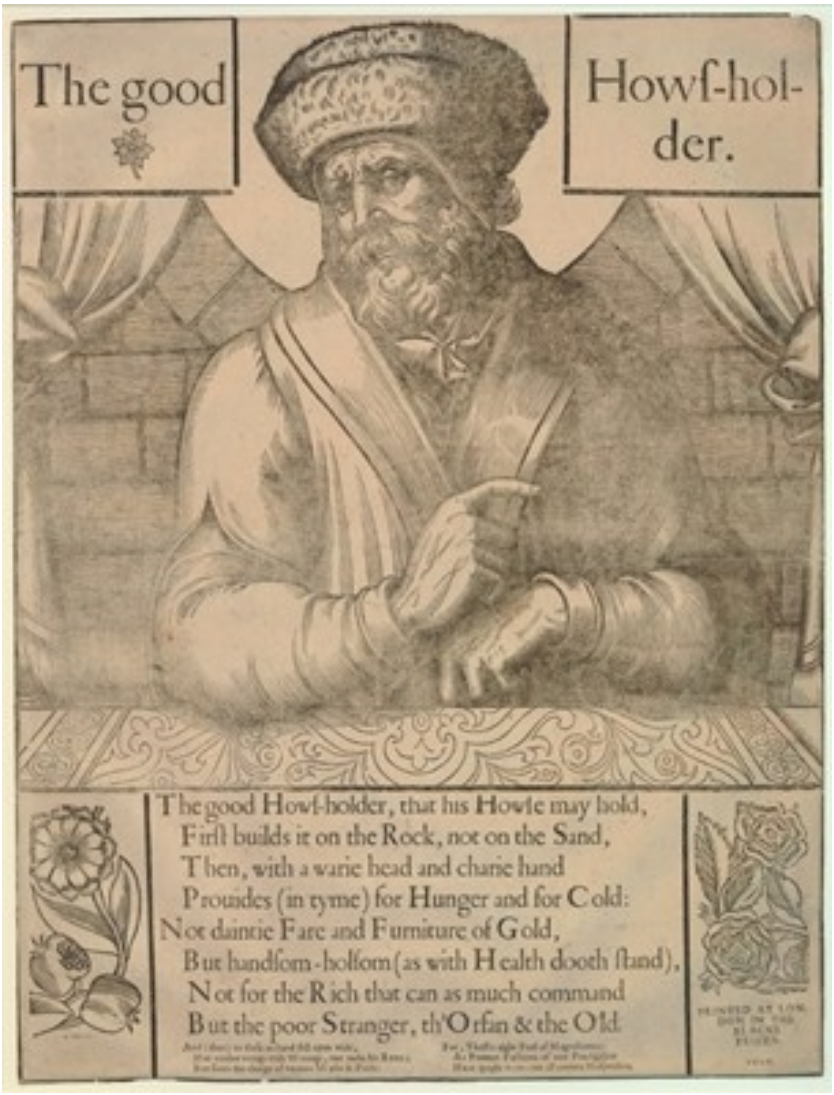

Figure 2: The Good Howsholder. Sixteenth-century woodcut from Watt (1994).

> and just in all my dealings: to bear no malice nor hatred in my heart: to keep my hands from picking and stealing, and my tongue from evil-speaking, lying and slandering; to keep my body in temperance, soberness, and chastity: not to covet nor desire other men's goods; but to learn and labour truly to get mine own living, and to do my duty in that state of life unto which it shall please God to call me.

Despite the authoritarian elements in this, catechisms were not merely imposed on the population by central authorities. A large number of "unofficial" catechisms were published in Elizabethan England (Green, 1986). These were not always aimed at children: many were explicitly designed for adults who were new to religion – "novices in the schoole of Christ". Perhaps a million copies of catechisms, official and unofficial, circulated in early seventeenth-century England.

5 The content of enculturation

These formats transmitted various messages to the reader. We can distinguish between advice that would benefit the individual, and social norms that would benefit those around him. The former included *hard work* and *self-control*. The latter included *cooperation* and *trustworthiness*. The content also included *social roles*, which set the terms of cooperation, not necessarily in an equal way.

Hard work: *Bethel, or a Forme for Families* commended "getting our substance by honest labour". The *Whole Duty of Man* described "honest industry and labour" as "the means by which God... gives us the necessaries of this life"; "the sluggish person shall never thrive". The *Plain Man's Pathway to Heaven* included a chapter condemning idleness, and gave four reasons for hard work in one's calling: "First, to bear the yoke laid upon mankind; by the Lord; secondly, to get the necessaries of this life ; thirdly, to live unto the profit of human society; lastly, to avoid evil thoughts and actions." *Of Domestical Duties* said that slothfulness led to ""poverty, servitude...hunger, beggary and death", and warned of the habit-forming nature of laziness. Well-known Bible quotes included Proverbs 6.6 ("Go to the ant, o sluggard, behold her ways, and be wise...") and Proverbs 24.33 ("Yet a little sleep, a little slumber, a little folding of the hands to sleep...").

Conduct manuals enjoined *self-control* with respect to several specific, widespread temptations, including food, drink, sex and violence. *Bethel* advised young people to be sober-minded and "fly the lusts of youth" (2 Timothy 2.22). *Domestical Duties*, the *Whole Duty* and *Plain Man's Pathway* all warned against "whoredom". The *Whole Duty* also included a chapter on temperance in drinking. The *Pathway* and others treated anger as a forerunner to murder, and therefore as a breach of the Sixth Commandment.

Truth-telling was praised, and lying condemned, in general and specifically in the context of trade. *Bethel* said "shun lying and equivocation"; honesty for sellers included giving prices appropriate to the true quality of goods. *Domestical Duties* recommended "preferring honesty before commodity". The *Whole Duty* called speaking truth "a common debt we owe to all mankind". The *Pathway* described lying as a sign of damnation, especially to be found in "shopkeepers and servants".

The *social roles* defined in conduct manuals included masters and servants, husbands and wives, and parents and children. Regarding *servants*, the manuals could build on a large body of New Testament parables concerning the employment relation, including the Parables of the Faithful Servant (Luke 12.35-48), the Master and Servant (Luke 17.7-10) the Wedding Feast (Matthew 22.1-14), the Unforgiving Servant (Matthew 18.21-35) and the Wicked Husbandmen (Matthew 21.33-46). Servants should be obedient to their master's commands; this specifically included when monitoring was absent, as distinct from "eye-service". Cleaver's *Godly Form of Household Government* made the same point: unless servants "serve God in their labours,... their obedience can never be constant, but will be by fits and starts, and hang only on the master's eye." Of course this was also a reason for masters to hire Godly servants. *Bethel* and *Domestical Duties* gave servants a broad duty to increase their master's profit. Servants were expected not to answer back, and not to leave their employment before the end of the contract. The context would typically be an apprenticeship lasting several years. Early exit was a problem for masters, because the costs of educating apprentices were front-loaded (De la Croix, Doepke and Mokyr, 2017). Servants also shouldn't marry without their master's consent. Luther's *Small Catechism* made similar points.

The books also laid out the corresponding duties of *masters*, including paying wages on time, not imposing excessive working hours (especially on Sundays,

when time should be allowed for religious observance) and supporting servants when they fell ill.

A similar set of mutual duties governed *husbands* and *wives*, not, of course, on equal terms. The *Godly Form of Household Government* laid out the division of labour in the household:

> The duty of the husband is to get goods: and of the wife to gather them together, and save them. The duty of the husband is to travel abroad to seek living: and the wife's duty is to keep the house. The duty of the husband is to get money and provision: and of the wife, not vainly to spend it. The duty of the husband is, to be a giver; and of the wife to be a saver. The duty of the husband is, to be Lord of all: and of the wife, to give account of all. The duty of the husband is, to dispatch all things without door; and of the wife, to oversee and give order for all things within the house.

Not all this printed material was intended to increase people's success in the early modern economy. Much was purely religious, such as the literature on "dying well". Other content was quite anti-capitalistic. For example, many books condemned greed strongly, and some, like the *Plain Man's Pathway to Heaven* saw it as pervasive in contemporary society. In other words, the transmitted content was not optimized so as to maximize one's long-run earnings. Instead, we should think of a slow process by which economically advantageous messages spread and won out over other material. At the endpoint of this process are works like Benjamin Franklin's *Autobiography*, where economic advantage plays a much more explicit role.

Although many of our citations come from English Puritan conduct manuals, we do not argue that these norms were unique to Puritanism. In fact, many Catholics and non-Puritan Anglicans had made similar points (Todd, 1980; Allen, 2009).

6 The demand for enculturation

The behaviour transmitted by print could be valuable commodities in the early modern labour market. Modern employers value "soft skills" as much as techni-

cal skills (Heckman, Stixrud and Urzua, 2006). This is likely to have been even more in an earlier era, when human behaviour was markedly less polished than it is today. The sociologist Norbert Elias (1994) argues that from the Renaissance, humans went through a "civilizing process" in which previously acceptable forms of behaviour became unacceptable. The History of Myddle is a seventeenth-century record of life in a small Shropshire town (Gough, 1981). Its index begins:

> Absenteeism
>
> Abusive language towards parents
>
> Accident, death due to
>
> Adoption
>
> Adultery
>
> Aggression (see Fighting, Quarrelling, Homicide)
>
> Alcoholism (see also Drunkenness)

... and that's just the A's. Quantitative data indeed suggests that alcohol consumption (Spring and Buss, 1977), child abandonment (Cunningham, 2005) and violence (Eisner, 2003) were more common than today. At the same time, formal controls on behaviour were rarer. In communities, there were no police forces. Employers lacked clocks for timekeeping, and the telephone to keep in touch with remote agents. Contract enforcement in court might be prohibitively expensive, and courts might be corrupt in any case.

So, in this period, employers faced serious principal-agent problems, with little monitoring ability. They therefore urgently needed reliable, sober, trustworthy apprentices. A recurrent concern is that servants might provide "eye-service" – working when they were under observation, but shirking otherwise. The apprenticeship relation, which involved masters exchanging work for training (typically in "tacit" knowledge), involved a risky gamble that the apprentice might break off the contract before he had repaid the cost of his training. This could be to take a more attractive position, but perhaps also because of an apprentice's low discount rate between present toil and future rewards (Wallis, 2008). Masters were also consistently apprehensive that their apprentices might drink, visit brothels, seduce their daughters, steal from them, get into fights, or riot (Smith, 1973, 1981).

Apprentices, in turn, needed to save money in order to open a workshop or to pay for admission to mastership.

For these reasons, behaviour associated with high discount factors, a preference for work, and a cooperative personality were advantageous traits in the early modern labour market. Adults often paid to purchase these things themselves, just as people now buy self-help books. Parents often paid for vertical transmission of values to their children. Most education was privately funded by parents, and it was widely agreed that the purpose of education was character formation, at least as much as technical skills (Cunningham, 2005). As well as paying for employees' soft skills via wages, masters might also find it worthwhile to provide enculturation themselves, just as they provided technical training. This was particularly true since apprenticeship typically started at a young age. As Archbishop Tillotson put it: "it is really of our service and advantage that those that belong to us should serve and fear God; Religion being the best and surest Foundation of the Duties of all Relations" (quoted in Schücking, 1970). Or Bullinger: "the good man of the house, by planting godliness in his family, doth not a little advance and set forward his private profit...; for wicked servants are for the most part pickers and deceitful; whereas, on the other side, the godly are faithful" (quoted in Hill, 1997).

Because it transmits social norms of cooperation, enculturation is in part a public good. Furthermore, if a community benefits when individuals coordinate on the *same* norm, then it will wish to encourage or enforce uniformity of moral teaching. Indeed, schools were not always set up in response to private demand. Instead many were established by religious reformers, sometimes in partnership with the secular authorities. Examples before the invention of printing include the Brethren of the Common Life mentioned above. After the printing press, Lutheran reformers in Germany made a century-long effort to develop teaching throughout their areas of influence (Strauss, 1978). In doing so they appealed to secular as well as religious motivations (though they would probably have rejected this distinction). Luther wrote "A city's prosperity does not consist alone in the accumulation of treasure... but its greatest wealth, its health and power, does consist in [...] sensible, honest, and well-disciplined citizens" (cited in Kemp, 1912). Similarly, Sweden's very early development of widespread literacy was mandated by the Protestant monarch, but put into practice by local communities

(Johansson, 2009). There were similar literacy drives in Calvinist Scotland and Geneva (Watt, 2002). English mass education was provided predominantly by churches until the late 19th century (Bowen, 1981).

Publicly-provided curricula typically included Bible-reading and the memorization of religious texts; catechisms played a central role (Laqueur, 1976; Wrightson, 2002). Writing was less important than reading. In Utrecht primary schools, reading and learning the catechism each took up ten times more space in the curriculum than writing, and twenty times more space than either arithmetic or history (Benedict, 2004).

Some emergent nation-states started national literacy campaigns, although these were often limited in scope and effect. State authorities worked with religious reformers to develop curricula. The stated purpose of these campaigns was not technical education but citizenship, social order and political obedience (Houston, 2014). Indeed, these public goods provided a stronger rationale for state intervention than the benefits of technical training, which mostly fell to the student. However, much of the support for publicly-provided education came from the local community, rather than the nation-state (Schmidt, 1995); in England, Puritan lectureships were funded by town notables (Seaver, 1970). This suggests that the primary public good being produced was local-level social order, rather than political indoctrination.

Both Protestants and Catholics tried to enforce uniform teaching according to their religion, wherever they could do so (Watt, 2002). As the Lutheran Dietrich Reinkingk wrote, "One religion in one country and state connects the minds of the subjects among themselves and with their superiors" (cited in Reinhard, 1989). Later, in the 19th century, there were regular conflicts between religious denominations over the content of education in both Britain and Holland.

A last piece of evidence for the "enculturation" view of print is the increase in female literacy. In the early modern period, women played a role in the economy as part of the household, which was both a site of childrearing, and the basic unit of economic activity. However, they did not typically perform skilled labour. If the only purpose of literacy were to learn skills for use in the labour market, then we would not expect female literacy to be affected by the availability of print. On the other hand, if reading transmits values that affect work effort, irrespective of skill, then these could be valuable for both men and women. In fact, though men's

literacy increases more, there are substantial increases in female literacy in many countries. In Sweden, for instance, female literacy equalled male literacy in the 18th century, and even surpassed it in some areas (Johansson, 2009).

7 Related literature

Our topic is at the intersection of three literatures: the history of print and reading; the economics of cultural transmission; and growth economics, specifically the role of knowledge. We mention just some key works from each.

There is a vast literature on the history of books and print. Eisenstein (1980) and Febvre and Martin (1997) are key contributions. More specific work is cited above. Within economics, Baten and Van Zanden (2008) and Buringh and Van Zanden (2009) measure per capita book production in the long run and relate it to economic growth.

Bisin and Verdier (2001) developed a microeconomic framework to study cultural transmission. Doepke and Zilibotti (2008) argue that parent-child cultural transmission can explain the development of the "spirit of capitalism", and why aristocratic landowners eventually fell behind the middle class during the industrial revolution. They don't model the mechanism of cultural transmission. Here, we use a reduced form in which books can increase productivity, implicitly by the mechanisms detailed above: altering behaviour towards hard work.

Unified growth theory aims at explaining the transition from stagnation to sustained growth. The literature includes Boucekkine, de la Croix and Licandro (2002), Boucekkine, de la Croix and Peeters (2007), Doepke (2004), Galor and Moav (2002), Galor and Mountford (2008), Galor and Weil (2000), Jones (2001), Kögel and Prskawetz (2001), Lucas (2002), Strulik (2003), Strulik and Weisdorf (2008), Tamura (2002), Weisdorf (2004). A focus of the literature has been on the demographic transition from parents having many children with low levels of human capital to parents having few children with high levels of human capital. Another focus of the literature has on the economic transition from agricultural production to industrial production. Our focus is on the role of cultural transmission in bridging the transition from stagnation to sustained growth. We model cultural transmission by formalizing two new notions, namely encultura-

tion and industriousness, and their interaction with each other as well as labour productivity.

8 Introduction to the model

Before we introduce the model formally let us briefly explain and discuss it. We formalize the effect of the printing press on economic growth in an overlapping generations model where a new generation of consumers enters the economy and an old generation of consumers leaves the economy at every date. Our model is an enriched combination of the Diamond model (Diamond, 1965) and the Lucas model (Lucas, 1988) to obtain a model of unified growth.

In the model there are two different production technologies: *traditional* production with *unskilled* labour and capital as inputs like in the Diamond model; and, *modern* production with *skilled* labour and capital as inputs like in the Lucas model. Both forms of production are available at every date, so a possible transition from traditional production to modern production happens because consumers choose to supply skilled labour instead of unskilled labour and firms choose to use the modern technology instead of the traditional technology. And both consumers and firms choose their behaviour because it is the best choice among their alternatives.

Unskilled labour used in traditional production depends on productivity and hours worked. Skilled labour used in modern production depends on human capital in addition to productivity and hours worked. Therefore the difference between the two forms of labour is that human capital matters for skilled labour but not for unskilled labour. The novelty in our model is the inclusion of culture.

We split activities that are neither leisure nor work into enculturation and education. Enculturation is acquisition of non-cognitive and non-technical cognitive skills and influences productivity, and education is acquisition of technical cognitive skills and influences human capital. The known non-cognitive and non-technical cognitive skills in society are denoted industriousness in society and the known technical cognitive skills in society are denoted knowledge in society.

Human capital and knowledge in society are standard in economic models of endogenous growth. Knowledge reflects what is known about how to use technology in society. Education is the process of acquiring technical skills and the

outcome of the process is human capital. Using more time on education increases productivity of skilled workers but not unskilled workers. We imagine a feedback loop between education and knowledge: individual time spent on education and knowledge influence human capital and average individual time spent on education in society and knowledge influences future knowledge.

The two novel notions of our model, namely enculturation and industriousness in society, are similar to education and knowledge, but for non-cognitive and non-technical cognitive skills. Enculturation is the process of acquiring these skills, but it could also have effects on cooperation, honesty and patience. Using more time on enculturation increases productivity of unskilled and skilled workers. Industriousness reflects the degree to which these skills, and time spent on enculturation, are supported, valued and normative in the surrounding society. For example, industriousness is high when hard work is highly valued in society. As described in Section 3, we imagine a dynamic feedback loop between enculturation and industriousness: individual time spent on enculturation and industriousness influence individual productivity; and, industriousness and average individual time spent on enculturation in society influence future industriousness.

Consumers choosing to work as unskilled workers will spend their time on leisure, enculturation and work. Consumers choosing to work as skilled workers will spend their time on education in addition to leisure, enculturation and work. Consumers choose how to allocate their time and what kind of labour to supply and firms choose technology and how to produce based on economic incentives. Therefore: the wage for unskilled and skilled labour as well as the effectiveness of enculturation in raising productivity and education in raising human capital matter for the choices made by the consumers; and, the price for capital, the wage for unskilled and skilled labour as well as productivity and human capital of individual workers matter for the choice of technology. Our central claim is that the invention of the printing press increased the effectiveness of both enculturation and education.

Obviously, the invention of the printing press made transmission of culture and information between people cheaper relative to other forms of transmission and to other commodities. We imagine religious books were an important component in the transformation of industriousness in society into individual productivity with demand for religious books being increasing enculturation and industriousness.

And, we imagine technical books are an important component in the transformation of knowledge in society into individual human capital, with demand for technical books being increasing in knowledge and education. Consequently, the use of religious books is monotonic in industriousness and the use of technical books is monotonic in knowledge.

With traditional production, sustained growth is not possible because industriousness and productivity cannot grow without bounds. With modern production sustained growth is possible because knowledge and human capital can grow without bounds. Our story about the effect of the printing press on economic growth involves four steps. First, at some early date the levels of industriousness and knowledge were so low that modern production was not economically viable. Second, the invention of the printing press made the transmission of industriousness into individual productivity more effective. Thereby, industriousness and productivity start to grow because of the feedback loop between them. Third, at some later date productivity was so high that modern production became economically viable inducing a transition from traditional to modern production. Fourth, knowledge and human capital grow without bounds because of the feedback loop between them. Before the transition, the build up of industriousness induced the use of religious books to increase, but the use of technical books was constant because knowledge was constant. After the transition, the build up of knowledge induced the use of technical books to increase, but the use of religious books decreased because industriousness decreased.

9 Setup

We introduce our setup and study the problems of consumers and firms.

Consider the overlapping generation model with time extending from minus infinity to plus infinity, $t \in \mathbb{Z}$. There are three standard goods, namely a consumption good, capital and labour, and two non-standard goods, namely industriousness in society and knowledge in society. Let $Z_t > 0$ be industriousness in society and $E_t > 0$ knowledge in society, both at date t.

Consumers can work as unskilled or skilled workers. For unskilled workers the labour supply is productivity times time spent on work. Productivity depends on time spent on enculturation and industriousness in society. The supply of un-

skilled labour is

$$\lambda_t^u \;=\; \underbrace{Bn_t^{\beta} Z_t^{\beta^u}}_{\text{productivity}} \; \underbrace{\ell_t}_{\text{time}}$$

with $B > 0$ and $\beta, \beta^u \in]0,1[$, where n_t is time spent on enculturation and ℓ_t is time spent working. The $Bn_t^{\beta^u} Z_t^{\beta^u}$-part can be interpreted as productivity, which is increasing in enculturation and industriousness in society. The constant B measures how efficient the transformation of enculturation and industriousness into productivity is. Therefore, making religious books more widely available increases the supply of unskilled labour as it increases B. For skilled workers the labour supply is human capital times productivity times time spent on work.

$$\lambda_t^s \;=\; \underbrace{Ce_t^{\gamma} E_t Z_t^{\beta^s - \beta^u}}_{\text{human capital}} \; \underbrace{Bn_t^{\beta} Z_t^{\beta^u}}_{\text{productivity}} \; \underbrace{\ell_t}_{\text{time}}$$

with C and $\gamma, \beta^s \in]0,1[$, where $\beta^s > \beta^u$ and e^t is time spent on (technical) education. The $Ce_t^{\gamma} E_t Z_t^{\beta^s - \beta^u}$-part can be interpreted as human capital, which is increasing in education as well as knowledge and industriousness in society. The constant C measures how efficient the transformation of education and knowledge into human capital is. Hence, making technical books more widely available increases the supply of skilled labour as it increases C.

Consumers transform consumption good at date t into capital at date $t+1$ by putting the consumption good under their pillows at date t and bringing out capital from under their pillows at date $t+1$.

Firms are identical and have access to two different constant returns to scale technologies at every date to focus on other changes than technical innovations. The traditional technology transforms capital and unskilled labour into the consumption good,

$$F^u(K_t, L_t^u) \;=\; A(K_t)^{\sigma} (L_t^u)^{1-\sigma}$$

with $A > 0$ and $\sigma \in]0,1[$. The modern technology transforms capital and skilled labour into the consumption good,

$$F^s(K_t, L_t^s) \;=\; A(K_t)^{\sigma} (L_t^s)^{1-\sigma}$$

with $A > 0$ and $\sigma \in]0,1[$. Capital depreciates completely for both technologies. The two production functions are assumed to be identical to focus on how other things influence the transition from traditional production to modern production.

The consumption good is the numeraire, the price of capital is r_t with $r_t > 0$ and the wages for unskilled and skilled labour are $w_t^u, w_t^s > 0$. Therefore $r_t - 1$ is the real interest rate and w_t^u and w_t^s are the real wages.

The consumer problem

Consumers decide to supply their labour as unskilled or skilled in order to maximize their utilities. First the consumer problems for the two cases are stated and solved. Second utilities in the two cases are compared.

Suppose a consumer in generation t decides to work as an unskilled worker. Then the consumer problem is:

$$\max_{(o_t,n_t,e_t,\ell_t,\lambda_t^u,c_{t+1})} \quad \alpha\ln(o_t)+\ln(c_{t+1})$$

$$\text{s.t.} \quad \begin{cases} c_{t+1} &= r_{t+1}w_t^u\lambda_t^u \\ \lambda_t^u &= Bn_t^\beta Z_t^{\beta^u}\ell_t \\ o_t+n_t+e_t+\ell_t &= 1. \end{cases}$$

where o_t is leisure time, n_t is time on spent enculturation, e_t time spent on education and ℓ_t time spent on work. The solution is:

$$\begin{cases} o_t^u &= \dfrac{\alpha}{1+\alpha+\beta} \\ n_t^u &= \dfrac{\beta}{1+\alpha+\beta} \\ e_t^u &= 0 \\ \ell_t^u &= \dfrac{1}{1+\alpha+\beta} \\ c_{t+1}^u &= (1+r_{t+1})w_t^u\dfrac{\beta^\beta}{(1+\alpha+\beta)^{1+\beta}}BZ_t^{\beta^u} \end{cases}$$

and the savings are $s_t^u = w_t^u\lambda_t^u$,

$$s_t^u = w_t^u\frac{\beta^\beta}{(1+\alpha+\beta)^{1+\beta}}BZ_t^{\beta^u}.$$

Since the use of time is constant across dates, the time index is dropped, (o^u, n^u, e^u, ℓ^u). The supply of unskilled labour is $\lambda_t^u = B(n^u)^\beta Z_t^{\beta^u}\ell^u$, which is increasing in the efficiency of enculturation B and industriousness Z_t.

Suppose a consumer in generation t decides to work as a skilled worker. Then the consumer problem is:

$$\max_{(o_t,n_t,e_t,\ell_t,\lambda_t^s,c_{t+1})} \quad \alpha\ln(o_t)+\ln(c_{t+1})$$

$$\text{s.t.} \quad \begin{cases} c_{t+1} &= r_{t+1}w_t^s\lambda_t^s \\ \lambda_t^s &= Ce_t^\gamma E_t\, Bn_t^\beta Z_t^{\beta^s}\,\ell_t \\ o_t+n_t+e_t+\ell_t &= 1. \end{cases}$$

The solution is:

$$\begin{cases} o_t^s &= \dfrac{\alpha}{1+\alpha+\beta+\gamma} \\ n_t^s &= \dfrac{\beta}{1+\alpha+\beta+\gamma} \\ e_t^s &= \dfrac{\gamma}{1+\alpha+\beta+\gamma} \\ \ell_t^s &= \dfrac{1}{1+\alpha+\beta+\gamma} \\ c_{t+1}^s &= (1+r_{t+1})w_t^s\dfrac{\beta^\beta\gamma^\gamma}{(1+\alpha+\beta+\gamma)^{1+\beta+\gamma}}CE_t\,BZ_t^{\beta^s} \end{cases}$$

and the savings are $s_t^s = w_t^s\lambda_t^s$,

$$s_t^s \;=\; w_t^s\frac{\beta^\beta\gamma^\gamma}{(1+\alpha+\beta+\gamma)^{1+\beta+\gamma}}\,CE_t\;BZ_t^{\beta^s}.$$

Since the use of time is constant across dates the time index is dropped, (o^s,n^s,e^s,ℓ^s). The supply of skilled labour is $\lambda_t^s = C(e^s)^\gamma E_t\;B(n^s)^\beta Z_t^{\beta^s}\ell^s$ which is increasing in efficiency of enculturation B, industriousness Z_t, the efficiency of education C, and, knowledge E_t.

Let U_t^u (U_t^s) be the indirect utility of working as an unskilled (skilled) worker. Then $U_t^u \lesseqgtr U_t^s$ if and only if

$$w_t^u \;\lesseqgtr\; \left(\frac{o^s}{o^u}\right)^\alpha(e^s)^\gamma\left(\frac{n^s}{n^u}\right)^\beta\frac{\ell^s}{\ell^u}\,CE_t\,(Z_t)^{\beta^s-\beta^u}\,w_t^s.$$

Let $\phi\in\,]0,1[$ be defined by

$$\phi \;=\; \left(\frac{o^s}{o^u}\right)^\alpha(e^s)^\gamma\left(\frac{n^s}{n^u}\right)^\beta\frac{\ell^s}{\ell^u} \;=\; \left(\frac{1+\alpha+\beta}{1+\alpha+\beta+\gamma}\right)^{1+\alpha+\beta}\left(\frac{\gamma}{1+\alpha+\beta+\gamma}\right)^\gamma.$$

Then consumers in generation t will supply unskilled labour in case $w_t^u > \phi\, CE_t\,(Z_t)^{\beta^s-\beta^u}\, w_t^s$ and skilled labour in case $w_t^u < \phi\, CE_t\,(Z_t)^{\beta^s-\beta^u}\, w_t^s$.

The efficiency of the transformation of enculturation and industriousness into productivity, B, does not matter for whether consumers will supply unskilled labour or skilled labour. However, the efficiency of the transformation of education and knowledge into human capital, C, matters for whether consumers will supply unskilled or skilled labour. In addition, knowledge E_t and industriousness Z_t matter for whether consumers will supply unskilled or skilled labour.

The firm problem

Naturally, firms decide to use the traditional technology or the modern technology to maximize their profits subject to technology constraints. First, the firm problems for the two scenarios are stated and solved. Second, we consider the decision to use the traditional or the modern technology.

For firms using technology $i \in \{u,s\}$ the technology constraint is that output is determined by the amounts of capital and unskilled labour. Therefore the firm problem is:

$$\begin{array}{ll} \max\limits_{(Y_t,K_t,L_t^i)} & Y_t - r_t K_t - w_t^i L_t^i \\ \text{s.t.} & Y_t \;=\; A(K_t)^\sigma (L_t^i)^{1-\sigma}. \end{array}$$

For $k_t^i = K_t/L_t^i$ being the capital intensity the first-order conditions are:

$$\left\{ \begin{array}{rcl} \sigma A(k_t^i)^{\sigma-1} & = & r_t \\ (1-\sigma)A(k_t^i)^\sigma & = & w_t^i. \end{array} \right.$$

Clearly, there is a non-trivial solution $k_t^i > 0$ to the firm problem for the firm using technology i if and only if:

$$w_t^i \;=\; (1-\sigma)A\left(\frac{\sigma A}{r_t}\right)^{\sigma/(1-\sigma)}.$$

Consequently, the wages for unskilled labour and skilled labour are identical. However, the wages are per unit of labour and not per unit of time. Indeed, the wages per unit of time are $w_t^u\, Bn_t^\beta\, Z_t^{\beta^u}$ for unskilled labour and $w_t^s\, Ce_t^\gamma E_t\, Bn_t^\beta\, Z_t^{\beta^s}$ for skilled labour. Consequently, the wages per unit of time are typically not

identical. Firms are indifferent between using the traditional technology and the modern technology for the price of capital and the wages satisfying the first-order conditions.

Industriousness and knowledge formation

Industriousness at date $t+1$ is formed by industriousness at date t and average individual productivity at date t with $Z_{t+1} = (1-\delta)Z_t + \tau B n_t^{\beta} Z_t^{\beta}$ where $\beta, \delta \in]0,1[$ and $\tau > 0$. The parameter δ is the depreciation rate of industriousness and the parameter τ measures the impact of average effective individual enculturation average on industriousness. Since $n_t, \beta, \delta \in]0,1[$, industriousness is bounded from above. Lowering the printing cost for religious books corresponds to increasing B, which makes the enculturation process more effective, which again increases future industriousness.

Knowledge in society at date $t+1$ is formed by knowledge in society at date t and average time spent on education at date t with $E_{t+1} = E_t + \tau C e_t^{\gamma} E_t$ where $\tau > 0$ measures the strength of the impact of average human capital on knowledge. There is no depreciation in knowledge – old ideas never die, they just become obsolete. Knowledge is not bounded from above. Lowering the printing cost for technical books corresponds to increasing C, which makes the transmission of effective education into human capital more effective, which again increases knowledge at the next date.

10 Equilibrium dynamics

Three scenarios are considered. In the first, labour is unskilled and production is traditional; in the second, labour is skilled and production is modern; and, finally in the third consumers choose the type of labour they want to supply and firms choose the type of technology they want to use.

Equilibrium with traditional production

At an equilibrium with traditional production, consumers maximize utility subject to the constraint that labour has to be unskilled, firms maximize profits subject to the constraint that production has to be traditional and markets clear.

Definition 1 *An **equilibrium with traditional production** is prices, consumption plans and production plans as well as industriousness and knowledge,*

$$((\bar{r}_t,\bar{w}_t^u)_{t\in\mathbb{Z}},(\bar{o}_t^u,\bar{n}_t^u,\bar{e}_t^u,\bar{\ell}_t^u,\bar{\lambda}_t^u,\bar{c}_{t+1}^u)_{t\in\mathbb{Z}},(\bar{y}_t^u,\bar{k}_t^u)_{t\in\mathbb{Z}},(\bar{Z}_t^u,\bar{E}_t^u)_{t\in\mathbb{Z}}),$$

such that for every t:

- *Consumers maximize utilities: $(\bar{o}_t^u,\bar{n}_t^u,\bar{e}_t^u,\bar{\ell}_t^u,\bar{\lambda}_t^u,\bar{c}_{t+1}^u)$ is a solution to the consumer problem.*
- *Firms maximize profits: $(\bar{y}_t^u,\bar{k}_t^u)$ is a solution to the firm problem.*
- *Markets clear:* $\left\{\begin{array}{rcl}\bar{c}_t^u+\bar{w}_t^u\bar{\lambda}_t^u &=& \bar{y}_t^u\bar{\lambda}_t^u\\ \bar{k}_{t+1}^u\bar{\lambda}_{t+1}^u &=& \bar{w}_t^u\bar{\lambda}_t^u.\end{array}\right.$
- $\left\{\begin{array}{rcl}\bar{Z}_{t+1}^u &=& (1-\delta)\bar{Z}_t^u+\tau B(\bar{n}_t^u)^\beta(\bar{Z}_t^u)^\beta\\ \bar{E}_{t+1}^u &=& \bar{E}_t^u+\tau C(\bar{e}_t^u)^\gamma\bar{E}_t^u.\end{array}\right.$

Equilibria are described by the following dynamical system:

$$\left\{\begin{array}{rcl}k_{t+1}^u\lambda_{t+1}^u &=& (1-\sigma)A(k_t^u)^\sigma\lambda_t^u\\ Z_{t+1}^u &=& (1-\delta)Z_t^u+\tau B(n^u)^\beta(Z_t^u)^\beta\\ E_{t+1}^u &=& E_t^u+\tau C(e^u)^\gamma E_t^u\\ \lambda_t^u &=& B(n^u)^\beta(Z_t^u)^{\beta^u}\ell^u.\end{array}\right. \tag{1}$$

Hence, if $(k_t^u,\lambda_t^u,Z_t^u,E_t^u)_{t\in\mathbb{Z}}$ is a solution to the dynamical system, then

$$\left\{\begin{array}{rcl}\lim\limits_{t\to\infty}k_t^u &=& [(1-\sigma)A]^{1/(1-\sigma)}\\ \lim\limits_{t\to\infty}Z_t^u &=& \bar{Z}^u \;=\; [(\tau/\delta)B(n^u)^\beta]^{1/(1-\beta)}\\ E_t^u &=& E_0^u\\ \lim\limits_{t\to\infty}\lambda_t^u &=& B(n^u)^\beta(\bar{Z}^u)^{\beta^u}\ell^u.\end{array}\right. \tag{2}$$

Clearly, capital per unit of unskilled labour, industriousness, knowledge and unskilled labour per worker are all bounded from above in the long run.

Definition 2 *A **steady state** is an equilibrium at which every variable is time independent.*

The right side of Equations (2) characterizes the unique steady state with traditional production.

Equilibrium with modern production

At an equilibrium with modern production, consumers maximize utility subject to the constraint that labour has to be skilled, firms maximize profits subject to the constraint that production has to be modern and markets clear.

Definition 3 *An **equilibrium with modern production** is prices, consumption plans and production plans as well as industriousness and knowledge,*

$$((\bar{r}_t^s, \bar{w}_t^s)_{t\in\mathbb{Z}}, (\bar{o}_t^s, \bar{n}_t^s, \bar{e}_t^s, \bar{\ell}_t^s, \bar{\lambda}_t^s, \bar{c}_{t+1}^s)_{t\in\mathbb{Z}}, (\bar{y}_t^s, \bar{k}_t^s)_{t\in\mathbb{Z}}, (\bar{Z}_t^s, \bar{E}_t^s)_{t\in\mathbb{Z}}),$$

such that for every t:

- *Consumers maximize utilities: $(\bar{o}_t^s, \bar{n}_t^s, \bar{e}_t^s, \bar{\ell}_t, \bar{\lambda}_t^s, \bar{c}_{t+1}^s)_{t\in\mathbb{Z}}$ is a solution to the consumer problem.*
- *Firms maximize profits: $(\bar{y}_t^s, \bar{k}_t^s)$ is a solution to the firm problem.*
- *Markets clear:* $\begin{cases} \bar{c}_t^s + \bar{w}_t^s \bar{\lambda}_t^s &= \bar{y}_t^s \bar{\lambda}_t^s \\ \bar{k}_{t+1}^s \bar{\lambda}_{t+1}^s &= \bar{w}_t^s \bar{\lambda}_t^s. \end{cases}$
- $\begin{cases} \bar{Z}_{t+1}^s &= (1-\delta)\bar{Z}_t^s + \tau B(\bar{n}_t^s)^\beta (\bar{Z}_t^s)^\beta \\ \bar{E}_{t+1}^s &= \bar{E}_t^s + \tau C(\bar{e}_t^s)^\gamma \bar{E}_t^s. \end{cases}$

Equilibria are described by the following dynamical system:

$$\begin{cases} \lambda_{t+1}^s k_{t+1}^s &= (1-\sigma)A(k_t^s)^\sigma \lambda_t^s \\ Z_{t+1}^s &= (1-\delta)Z_t^s + \tau B(n^s)^\beta (Z_t^s)^\beta \\ E_{t+1}^s &= E_t^s + \tau C(e^s)^\gamma E_t^s \\ \lambda_t^s &= C(e^s)^\gamma E_t B(n^s)^\beta (Z_t^s)^{\beta^s} \ell^s. \end{cases} \tag{3}$$

Hence, if $(k_t^s, Z_t^s, E_t^s)_{t\in\mathbb{Z}}$ is a solution to the dynamical system, then

$$\begin{cases} \lim\limits_{t\to\infty} k_t^s &= [(1-\sigma)A]^{1/(1-\sigma)} \\ \lim\limits_{t\to\infty} Z_t &= \bar{Z}^s = [(\tau/\delta)B(n^s)^\beta]^{1/(1-\beta)} \\ E_{t+1}^s/E_t^s &= 1+\tau C(e^s)^\gamma \\ \lim\limits_{t\to\infty} \lambda_{t+1}^s/\lambda_t^s &= 1+\tau C(e^s)^\gamma. \end{cases} \tag{4}$$

Clearly, capital per unit of skilled labour, industriousness and the growth rates of knowledge and skilled labour per worker are bounded in the long run, but since the growth rates of knowledge and skilled labour per worker are larger than one, knowledge and skilled labour per worker grow sustained.

Definition 4 *A **steady state** is an equilibrium at which every variable has a constant growth rate.*

The right side of Equations (4) characterizes the unique steady state with modern production.

Equilibrium dynamics with mixed production

The invention of the printing press made the transmission of culture and information between people cheaper. In the model, the invention of the printing press corresponds to an increase in (B,C). The increase in B makes the effects of enculturation and past industriousness on productivity and present industriousness stronger. The increase in C makes the effects of education, past knowledge and industriousness on human capital and present knowledge stronger. An increase in (B,C) can result in a transition from traditional production with stagnation to modern production with sustained growth. Indeed, an increase in B alone can result in the transition as shown in Corollary 1 below.

Labour can be unskilled or skilled and production can be traditional or modern. Naturally, agents choose the maximizing behaviour. If prices are determined by the first-order conditions of the firms, then they are indifferent between traditional production and modern production and the wages for unskilled labour and skilled labour will be identical $w_t^u = w_t^s$. Therefore, if $\phi\, CE(Z)^{\beta^s-\beta^u} < 1$, then consumers will supply unskilled labour and if $\phi\, CE(Z)^{\beta^s-\beta^u} > 1$, then consumers will supply

skilled labour. However, if $\phi CE(Z)^{\beta^s-\beta^u}=1$, then consumers are indifferent between supplying unskilled labour and skilled labour.

Let $\pi_t^i \in [0,1]$ with be the fraction of consumers who supply labour of type $i \in \{u,s\}$ so $\bar{\pi}_t^u+\bar{\pi}_t^s=1$. Then an equilibrium, where consumers choose quality and quantity of labour and firms choose type of production and quantity, can be defined.

Definition 5 *An **equilibrium** is prices, consumption plans and production plans as well as industriousness, knowledge and fractions of consumers supplying unskilled labour and skilled labour,*

$$((\bar{r}_t,(\bar{w}_t^i)_{i\in\{u,s\}})_{t\in\mathbb{Z}},((\bar{o}_t^i,\bar{n}_t^i,\bar{e}_t^i,\bar{\ell}_t^i,\bar{\lambda}_t^i,\bar{c}_{t+1}^i)_{i\in\{u,s\}})_{t\in\mathbb{Z}},((\bar{y}_t^i,\bar{k}_t^i)_{i\in\{u,s\}})_{t\in\mathbb{Z}},(\bar{Z}_t,\bar{E}_t,(\bar{\pi}_t^i)_{i\in\{u,s\}})_{t\in\mathbb{Z}}),$$

such that for every t:

- *Consumers maximize utilities: $(\bar{o}_t^i,\bar{n}_t^i,\bar{e}_t^i,\bar{\ell}_t^i,\bar{\lambda}_t^i,\bar{c}_{t+1}^i)$ is a solution to the consumer problem provided $\bar{\pi}_t^i>0$.*
- *Firms maximize profits: $(\bar{y}_t^i,\bar{k}_t^i)$ is a solution to the firm problem provided $\bar{\pi}_t^i>0$.*
- *Markets clear:* $\left\{\begin{array}{rcl} \bar{\pi}_{t-1}^u\bar{c}_t^u+\bar{\pi}_{t-1}^s\bar{c}_t+\bar{\pi}_t^s\bar{w}_t^u\bar{\lambda}_t^u+\pi_t^s\bar{w}_t^s\bar{\lambda}_t^s &=& \bar{\pi}_t^u\bar{y}_t^u\bar{\lambda}_t^u+\bar{\pi}_t^s\bar{y}_t^s\bar{\lambda}_t^s \\ \bar{\pi}_t^u\bar{k}_{t+1}^u\bar{\lambda}_{t+1}^u+\bar{\pi}_t^s\bar{k}_{t+1}^s\bar{\lambda}_{t+1}^s &=& \bar{\pi}_t^u\bar{w}_t^u\bar{\lambda}_t^u+\bar{\pi}_t^s\bar{w}_t^s\bar{\lambda}_t^s. \end{array}\right.$
- $\left\{\begin{array}{rcl} \bar{Z}_{t+1} &=& (1-\delta)\bar{Z}_t+\tau B(\bar{\pi}_t^u\bar{n}_t^u+\bar{\pi}_t^s\bar{n}_t^s)^\beta(\bar{Z}_t)^\beta \\ \bar{E}_{t+1} &=& \bar{E}_t+\tau C(\bar{\pi}_t^u\bar{e}_t^n+\bar{\pi}_t^s\bar{e}_t^s)^\gamma\bar{E}_t. \end{array}\right.$

For $E>0$ being knowledge let $P(E)\subset\mathbb{R}^2_{++}$ be the set of parameters (B,C) such that at steady state with traditional production consumers would like to supply skilled labour:

$$P(E) \;=\; \{\,(B,C)\in\mathbb{R}^2_{++} \mid \phi CE(\bar{Z}^u)^{\beta^s-\beta^u}>1\,\}.$$

Then for $(B,C)\in P(E)$ production cannot be traditional forever. Indeed, in the long run production will be modern.

Suppose production has been traditional up to and including date $t=0$. Consider a change from (B,C) to (B',C') between dates $t=0$ and $t=1$. Assume Z_1

and E_1 are not affected by the change because they are formed at the end of date $t = 0$, but λ_1^u and λ_1^s are affected by the change because they are formed at date $t = 1$. If $(B',C') \in P(E_0)$, then there is a permanent transition from traditional production to modern production at some date but not necessarily at date $t = 1$.

Theorem 1 *Assume* $\phi CE_t(Z_t)^{\beta^s-\beta^u} < 1$ *for every* $t \leq 0$. *Suppose* $(B',C') \in P(E_0)$. *Then at all equilibria there is a permanent transition from traditional production to modern production at some date* $t \in N$.

Proof: Clearly, $\pi_t^s = 0$ in case $\phi C'E_t(Z_t)^{\beta^s-\beta^u} < 1$ and $\pi_t^s = 1$ in case $\phi C'E_t(Z_t)^{\beta^s-\beta^u} < 1$. Therefore, if $\pi_t^s \in]0,1[$, then $\phi C'E_t(Z_t)^{\beta^s-\beta^u} = 1$. Obviously, the sequence of knowledge $(E_t)_{t\in\mathbb{Z}}$ is non-decreasing because

$$E_{t+1}-E_t \;=\; \tau C(\pi_t^s e^s)^\gamma E_t \;\geq\; 0.$$

Two cases are considered: $\lim_{t\to\infty} E_t = \infty$; and, $\lim_{t\to\infty} E_t < \infty$.

First, $\lim_{t\to\infty} E_t = \infty$. For all $\varepsilon > 0$ there is $T \in \mathbb{N}$ such that for every $t \in \mathbb{N}$, if $t > T$, then $Z_t \in]\bar{Z}^{s\prime}-\varepsilon, \bar{Z}^{u\prime}+\varepsilon[$. Therefore, there is $T' \in \mathbb{N}$ such that for every $t \in \mathbb{N}$ if $t > T'$, then

$$\phi C'E_t(Z_t)^{\beta^s-\beta^u} \;>\; 1.$$

Consequently, production is modern after date T'.

Second, $\lim_{t\to\infty} E_t < \infty$. Clearly, if $\lim_{t\to\infty} E_t < \infty$, then $\lim_{t\to\infty} \pi_t^s = 0$ because

$$\lim_{t\to\infty} \tau C'(\pi_t^s e^s)^\gamma E_t \;=\; \lim_{t\to\infty} E_{t+1}-E_t \;=\; 0.$$

Since $\lim_{t\to\infty} \pi_t^s = 0$, $\lim_{t\infty} Z_t = \bar{Z}^{u\prime}$. Hence, there is $T'' \in \mathbb{N}$ such that for every $t \in \mathbb{N}$ if $t > T''$, then

$$\phi C'E_t(Z_t)^{\beta^s-\beta^u} \;>\; 1.$$

Consequently, for every $t > T''$, $\pi_t^s = 1$ contradicting $\lim_{t\to\infty} \pi_t^s = 0$. □

A change from (B,C) to (B',C') makes industriousness go through up to four phases: (1) before the change Z_t converges to $\bar{Z}^u$; (2) after the change but before the first switch to modern production Z_t converges to $\bar{Z}^{u\prime} > \bar{Z}^u$; (3) after the change and the first switch but before the last switch Z_t switches between converging to $\bar{Z}^{u\prime}$ and $\bar{Z}^{s\prime} < \bar{Z}^{u\prime}$; and, (4) after the change and the transition Z_t converges to $\bar{Z}^{s\prime} < \bar{Z}^{u\prime}$. The four phases are illustrated in Figure 3.

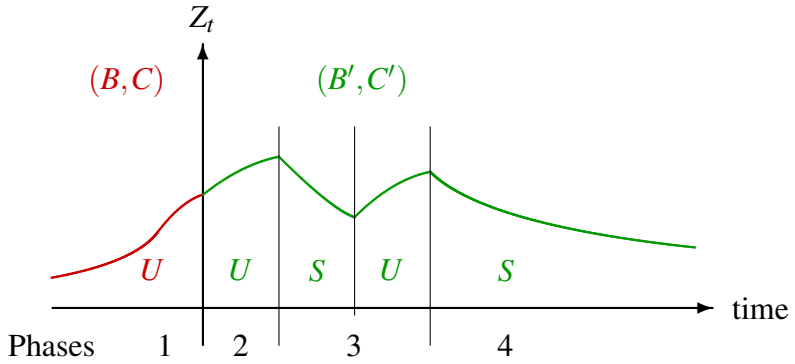

Figure 3: Phases in the transition from traditional production to modern production

How $\bar{Z}^u$ and $\bar{Z}^{s\prime}$ compare depends on the parameters of the model:

$$\frac{\bar{Z}^{s\prime}}{\bar{Z}^u} = \left[\left(\frac{1+\alpha+\beta}{1+\alpha+\beta+\gamma}\right)^{\beta}\frac{B'}{B}\right]^{1/(1-\beta)}.$$

Naturally, knowledge is constant in the first and second phases, increases some in the third phase and grows sustained in the fourth phase. Neither the second phase nor the third phase are bound to happen.

Whether equilibria go through the second phase depends on the size of the increase in C: if $\phi C'E_1(Z_1)^{\beta^s-\beta^u} > 1$, then there is no second phase. Whether equilibria go through the third phase depends on the sign and size of the change in industriousness and size of the change in knowledge: $Z_{t+1}-Z_t = -\delta Z_t+\tau B'(n_t)^{\beta}(Z_t)^{\beta}$ and $E_{t+1}-E_t = \tau C'(e_t)^{\gamma}E_t$. Industriousness can go down: if Z_t is in a neighborhood of or above $\bar{Z}^{u\prime}$ just before enculturation changes from n^u to $n^s < n^u$, then $Z_{t+1} < Z_t$. Education goes up: education switches from $e^u = 0$ to $e^s > 0$. Consequently, $\phi C'E_{t+1}(Z_{t+1})^{\beta^s-\beta^u} < 1$ is possible even though $\phi C'E_t(Z_t)^{\beta^s-\beta^u} > 1$ provided knowledge increases a little and industriousness decreases a lot.

A transition from traditional production to modern production can happen because of effects of enculturation and past industriousness on productivity, present industriousness and human capital increase. Hence, the effects of education do not have to increase.

Corollary 1 *For all* $(B,C) \in \mathbb{R}^2_{++}$ *There is* $(B',C') \in P(E_0)$ *with* $C' = C$.

Proof: Since $\lim_{B\to\infty}\bar{Z}^u = \infty$, $\lim_{B\to\infty}\phi CE_0(\bar{Z}^u)^{\beta^s-\beta^u} = \infty$. □

For a transition caused by an increase in B as in Corollary 1, all equilibria will go through the second phase where Z_t converges to $\bar{Z}^{u\prime}$.

Trivially, a transition from traditional production to modern production can happen because effects of education increase.

Corollary 2 *For all* $(B,C) \in \mathbb{R}^2_{++}$ *there is* $(B',C') \in P(E_0)$ *with* $B' = B$.

Proof: Since $\bar{Z}^u$ is independent of C, $\lim_{C\to\infty} \phi\, CE_0(\bar{Z}^u)^{\beta^s-\beta^u} = \infty$. □

For a transition caused by an increase in C as in Corollary 2, no equilibrium will go through the second phase.

A transition from traditional production to modern production can happen without any changes in the effects of enculturation and education industriousness vanishes as time tends to minus infinity $\lim_{t\to-\infty} Z_t = 0$.

Corollary 3 *Assume* $\phi\, CE_t(Z_t)^{\beta^s-\beta^u} < 1$ *for some* $t \in \mathbb{Z}$ *and* $\phi\, CE_t(\bar{Z}^u)^{\beta^s-\beta^u} > 1$. *Then there is a permanent transition from traditional production to modern production.*

Proof: Production is traditional at date $t \in \mathbb{Z}$ and according to Theorem 1 there will be a permanent transition from traditional production to modern production. □

For a transition caused by Z_t converging to $\bar{Z}^u$ as in Corollary 3, obviously no equilibrium will go through the second phase.

For our model a transition from traditional production to modern production can happen but is not bound to happen. For some parameter values there is no transition and for others there is a transition. Indeed, if $\phi\, CE_0\,(\bar{Z}^u)^{\beta^s-\beta^u} < 1$ and $Z_t \leq \bar{Z}^u$ at some $t \in \mathbb{Z}$, then no transition will take place, and, if $(B,C) \in P(E_0)$, then a transition will take place.

Comments on the model

Agents are assumed to be identical resulting in bang-bang equilibria where the transition from all consumers switch to skilled labour and all firms switch to modern production. It could be explored whether heterogeneity in characteristics of

agents would result in a gradual transition. Moreover, it is assumed there is one sector with two different ways of producing. It could be explored whether multiple sectors including agriculture using land, manufacturing and service would result in a richer model of the transition. Finally, agents are assumed to be rational. Some could find it interesting to study how different kinds of behavioural biases influence whether there is a transition or not.

Many models of unified growth rely on intertemporal links in preferences in form of paternalistic preferences. In our model, consumers care about themselves solely. Especially, consumers do not care about the number of children they have or the welfare of their children. On the one hand, empirically the assumption is questionable, at least. On the other hand, the assumption shows that paternalistic or altruistic concerns are not necessary to explain the transition from traditional production to modern production. However, our model rely on intertemporal links in industriousness and knowledge instead of preferences.

In our model, the parameters (B,C) are exogenous. Naturally, it would be interesting to explore how these parameters come about. Perhaps a possibility could be to have agents who engage in the transmission of industriousness and knowledge like religious societies and educational institutions.

11 Further topics

Our motivating evidence is the pattern of religious content in books over time. Here we discuss some aspects which are not explicitly captured in our model.

The relationship between print and Protestantism. In the model, print is a technology of cultural transmission for practical and moral rules, and religion plays no explicit role. In fact, however, moral rules were justified by reference to the Christian belief system, which provided an overarching framework encompassing both ethical rules of behaviour, and truth claims about the nature of reality. Fifteenth-century Europe already had an extensive infrastructure for transmitting these beliefs – the Catholic church, which spread its beliefs by preaching, written works in manuscript, visual art such as that of the great cathedrals, and institutions like the monasteries and universities (in which the church played a major role). One possible interpretation of the Reformation is as follows. The Catholic church was an incumbent which extracted profit from belief transmission, not necessar-

ily directly, but by transmitting beliefs that favoured the incumbent, such as the doctrine of Purgatory which supported a profitable trade in indulgences (Ekelund et al., 1996). Print was a disruptive technology which threatened the incumbent by lowering the cost of cultural transmission, allowing consumers to "cut out the middleman". The reformed denominations provided a form of religion which was complementary to print, since they placed individual Bible-reading at the centre of religious practice. The Catholic church was initially handicapped by its traditional opposition to lay reading, especially of religious work in the vernacular. It was caught in an "innovator's dilemma" (Christensen, 1997), since the new techniques of enculturation threatened its existing infrastructure. Nevertheless, under the pressure of competition, Catholicism developed its own traditions of reading as cultural transmission. Not surprisingly, the competition between religious "firms" spilled over into political conflict and violence.

The role of culture in changing institutions. Relatedly, the printing press affected more than just individual behaviour and perhaps even preferences underlying labour market productivity. Print enabled institutional change by allowing the development of a "public sphere" in which government policy could be critiqued (Habermas, 1991; Zaret, 2000). Dittmar and Seabold (2017) show that Protestant output from printing presses predicted institutional change in European cities. Since political collective action is often enabled by norms (Ostrom, 2000), this perspective seems to fit our argument that printed material changed people's norms.

The failure of the printing press in the Ottoman empire. It is well known that the Ottomans banned the printing press initially, only allowing printed work among religious minorities. In 1729, the press was reintroduced, but throughout the 18th century, only 33 books were printed. Since eighteenth-century Ottoman Empire was considerably behind the technological frontier, in a conventional framework we would expect printed matter to be highly in demand. However, in our model, if productivity is sufficiently low, most people prefer to work in the traditional sector and there is no demand for technology. Indeed, after the printing of religious works was allowed in 1802, the rate of publication increased, with a substantial minority of books being on religious subjects (Coşgel, Miceli and Rubin, 2012).

12 Conclusion

The "Great Divergence" of Western economies is usually thought of in terms of economic growth and technical innovation, not change of behaviour. But a strand of the literature has always emphasized changes in human values, from Weber's (1904) "spirit of capitalism" to Mokyr's (2009; 2016) "enlightened economy" and "culture of growth". Indeed, there is evidence that "WEIRD" people – those in Western, Educated, Industrialized Rich Democracies – are different from others (Henrich, Heine and Norenzayan, 2010). We suggest that a specific technology, the printing press, may have contributed to shaping human values by lowering the cost of the written word.

In this paper we show how interaction between culture and individuals can account for the change from traditional production to modern production. Our modelling of interaction between culture and individuals involves two elements: splitting efficiency of labour into productivity and human capital; and, splitting culture into industriousness and knowledge. One prediction of our theory is that increasing the efficiency of the transformations of industriousness, respectively knowledge, into productivity, respectively human capital can change production from traditional to modern.

A key prediction of our theory is that book reading is associated with behavioural changes. Testing this in the early modern context is a challenge. While evidence on the effects of Protestantism could be compatible with our story, we really want more direct empirical tests. New techniques for quantitative text analysis could help. A first step in this direction is the recent evidence that cooperation-related content in plays increased before the English civil war and the Glorious Revolution (Martins and Baumard, 2020).

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