Conflicting Threads

Technological Innovation and the Socio-Technical Ensemble of Weaving

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Abstract

This paper refers to two new approaches to conceive the relationship between technological innovation and society as one of anchoring: The TASC concept (Technologies as Anchors for Societal Conflicts) aims to show how societal conflicts are anchored in technologies that, as such, are not responsible for the conflict. The 'Anchoring Innovation' research program of the Dutch Research School in Classical Studies (OIKOS) aims to explain how technological innovations were anchored in ancient society. Our paper trials these concepts along the threads that connect the social and the technical in the weaving of contemporary India and archaic Greece. The first part of the paper examines the Indian government's efforts to provide technological upgradation to a community of weavers who insist on their loin loom that is embedded in their local ecology, making them appear backward and ignorant of innovation. In the second part, we examine how innovation in ancient Greece was anchored in the socially ubiquitous technology of weaving. In both cases, the social turns out to be an essential part of (the technology of) weaving. Conflicts arise where technology claims to be ahead of a society that must constantly adapt to it.

Keywords: History of Loom Technology, Industrial Revolution, Textile Production, Weaving in Ancient Greece, Weaving in India, Nagaland

Überblick

Dieser Beitrag bezieht sich auf zwei neue Ansätze, das Verhältnis von technischer Innovation und Gesellschaft als eines der Verankerung aufzufassen: Das TASC-Konzept (*Technologies as Anchors for Societal Conflicts*) will aufzeigen, wie gesellschaftliche Konflikte in Technologien verankert werden, die als solche nicht für den Konflikt verantwortlich sind. Das ‚Anchoring Innovation' Forschungsprogramm der niederländischen Research School in

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Classical Studies (OIKOS) will erklären, wie technologische Innovationen in der antiken Gesellschaft verankert wurden. Unser Beitrag erprobt diese Konzepte entlang der Fäden, die in der Weberei des zeitgenössischen Indien und des archaischen Griechenland das Soziale und das Technische verbinden. Der erste Teil des Beitrags untersucht die Bemühungen der indischen Regierung eine Gemeinschaft von Weberinnen technisch aufzurüsten, die auf ihrem eigenen, scheinbar primitiven Gurtwebstuhl und der Einbettung in ihre lokale Ökologie beharren, wodurch sie als rückständig und ignorant gegenüber Innovationen erscheinen. Im zweiten Teil untersuchen wir, wie Innovationen im antiken Griechenland in der sozial allgegenwärtigen Technologie der Weberei verankert wurden. In beiden Fälle erweist sich das Soziale als wesentlicher Bestandteil der (Technologie der) Weberei. Konflikte entstehen dort, wo Technologie beansprucht, einer Gesellschaft voraus zu sein, die sich ständig an sie anpassen muss.

Schlüsselbegriffe: Geschichte der Textiltechnik, Industrielle Revolution, Textilproduktion, Weberei im antiken Griechenland, Weberei in Indien, Nagaland

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Edward P. Thompson, in his study of the English working class, rejects the suggestion that the miserable conditions of workers in the textile industries were a result of old-fashioned traditions or of a decline of crafts, and that these conditions could "somehow be segregated in our minds from the true improving impulse of the Industrial Revolution."[2] Until the final agonies in the 1830s and 1840s "the older weaving communities offered a way of life which their members greatly preferred to the higher material standards of the factory town."[3] Although such communities clung to their dialect traditions, regional customs and medical ignorance, the opposition of progress and backwardness appears inadequate as "there was certainly a leaven amongst the northern weavers of self-educated and articulate men of considerable attainments. Every weaving district had its weaver-poets, biologists, mathematicians, musicians, geologists, botanists".[4]

By referring to the Luddites, textile workers smashing the new looms in the textile mills of the Industrial Revolution, Christian Götter presents the concept of TASC (Technologies as Anchors for Societal Conflicts) as a heuristic to approach a specific type of behavior of societal groups facing a new technology where "the technology of the mill became the anchor to which various wider developments were connected, one object into which a number of topics were merged, thereby turning complex processes into something that

2 Edward P. Thompson, The Making of the English Working Class (London 1963), 261.
3 Ibid., 290–291.
4 Ibid., 291.

was more clearly visible (and audible) – and way more easy to talk about."[5] The fight against textile innovation would be a "temporally restricted, though repeated, act of anchoring of a far-reaching and secular conflict between societal groups to core technologies of the Industrial Revolution […] without strictly being *about* those technologies as such."[6]

The authors of this contribution subscribe to the strong entanglement of technology and society. However, we want to underscore the fact that technologies always have a social dimension that needs to be accounted for. Technology only develops against the social grain when it anchors the idea of technological purity. To make our point clear, we extend the frame of historical reference far beyond the Industrial Revolution for looking at the connection of textile technology and social order forward into contemporary India as well as back into archaic Greece. Our examples will demonstrate that conflicts will arise precisely because technological innovations carry their own social order from outside the weaver community that clashes with the established ones, and because responsible negotiations of this fundamental change do not take place.[7]

The examples we discuss in this contribution are:

(1) Attempts of the Indian government to establish technical innovation in a community resiliently practicing traditional weaving that continues to order their society (introducing technology by ignoring the expertise coming with the traditional craft of weaving).
(2) New scientific concepts in early classical Greece anchoring in a socially accepted technology, namely weaving (successful anchoring building upon a widespread technical expertise).

In the first part we examine the situation of the Naga loin loom weaver and the attempts by the Indian state to improve her technology. Understanding this situation requires us to not only learn about the social and technical circumstances of the weaver, but also about the unstated assumptions and socio-technological imaginaries of the Indian policy maker. While the Indian government tries to develop its weaving technology and serve global markets, the Nagas seem to be historically resilient in the use of their own technology, and its meaning to their community. In juxtaposing their weaving technology with the upgradation plans, we can compare the two socio-technical systems and their modes of ordering, and try to understand where the lines of conflict are.

5 Christian Götter, Technologies as Anchors for Societal Conflicts. An Outline of the Concept, (in this issue).
6 Ibid.
7 This is not a new topic as the story of the weavers smashing machines as a sign of technology rejection has been investigated from different angles. See for example David F. Noble, "Present Tense Technology", Democracy 3, No. 2 (1983), 8–24.

We aim at demonstrating that the social is no arbitrary component of the technology of weaving and thus needs no anchor in it. To us, it appears to be the other way round: there is a constant attempt to dis-anchor weaving as technology from the social (and even natural) ecology in which it is embedded and which actually co-evolves with the technology itself. The un-anchored introduction of loom upgradations in Nagaland that attempt to cast weaving only as economic activity, results in conflicts coming up repeatedly.

We initially pursued the investigation of weaving in Nagaland as a comparative study in order to validate results from our enquiry of ancient weaving as a mode of existence that includes social and political organization, procedures of ordering elements into bigger systems, that symbolizes order and unification, and is hence a huge reservoir of technical terms for describing complexities. For archaic Greece, we can see that science and society are anchored in weaving technology. This investigation will form the second of our two weaving cases. Together they will demonstrate how the social and political ecology of textile technology is ignored, overturned not only by the distinction of backward-traditional and innovative technology, but also by a separation of the categories of social and technical, that then need to be forcibly anchored. As a result, we see that efforts claiming to respect the value of such ecologies seem to anchor societal problems in a technological paradigm that is first imagined independently of the social.

Part I: The Powerloom as Technological Paradigm Meets Handloom Weaving in India

For "the industrial bourgeoisie and their associates", as Maxine Berg demonstrated, "it became axiomatic that mechanical change was natural and evolutionary, the very motor of progress itself."[8] And one main achievement of this evolutionary development was the power loom, an achievement whose influence, as Berg says, could be disputed.

> "It was profitable only for certain fabrics and required a very large investment in fixed capital. It was quite clear to many that the productivity of the power loom was not its greatest asset. Consistent production time, and control and supervision over manufacturing processes in the factory were rather its most powerful attractions to the manufacturer."[9]

Still, we will find the same lines of arguments in favour of the power loom in contemporary India brought forward by the government in its program of technological upgradation. Where Indian handloom weavers insist on their handlooms and their rural settings, they appear to be backwards and ignorant of innovation. Where the Indian government seems to have a template to

8 Maxine Berg, The Machinery Question and the Making of Political Economy 1815–1848 (Cambridge 1982), 2.

9 Ibid., 241–242.

refer to, a technology to anchor their policy, the handloom weavers appear as a poor and uninformed late Luddite movement. The argument is as old as the Industrial Revolution itself. Following on a description of the most common looms in England that were still not mechanized in 1822 (and actually preferred by artisan weavers), George Richardson Porter described Indian looms as primitive tools for luxurious fabrics:

> "With this rude apparatus the patient Indian succeeds in weaving fabrics, which, for delicacy of texture, cannot be surpassed, and can hardly be rivalled by the European weaver, even when his labors are aided by the most elaborate machinery. But it is only in climates where the absolute natural wants of man are few, and under systems of government where the oppressions of the dominant caste deprive the unhappy bulk of the people of all means for attaining more than suffices for the barest supply of those wants, that such labors can be so performed."[10]

This argument claims that the oppression under which weavers suffer is the reason for the unrivalled quality of their products so that, even if the quality of the result cannot be surpassed by elaborate machinery, the substitution of the handlooms (which are preferred by artisans) by mechanical power looms is still "among the splendid offerings made by genius at the shrine of utility". And he concludes: "The injury to the deprived artisan is probably but temporary, while the benefit to society is lasting and progressive."[11]

Where do we stand today when looking back at the promise of the lasting and progressive benefit of mechanized looms? Measured along economic success alone, its contemporary result, namely Fast Fashion, is the biggest innovation in the textile sector and the dominating one because it allows for the biggest profits even though the average unit costs of garments have fallen considerably. However, at the same time, textile industry today is characterized by oppressive working conditions and a devastating climate footprint. The fashion industry produced 10% of global greenhouse gas emissions in 2017, which was more than all international flights and maritime shipping together.[12] It became the dirtiest branch of economy behind the oil industry. As Nikolai Anguelov, Professor for economics at the University of Massachusetts, resumes, "the diffusion of fashion to the masses creates more toxic chemical pollution per item than any other industrial product."[13] The oceanic

10 George Richardson Porter, A Treatise on the Origin, Progressive Improvement and Present State of the Silk Manufacture (Philadelphia 1832), 179–180.

11 Ibid., 215.

12 See https://www.europarl.europa.eu/news/en/headlines/society/20201208STO93327/the-impact-of-textile-production-and-waste-on-the-environment-infographic, accessed February 24, 2022. Meanwhile figures even increased.

13 Nikolay Anguelov, The Dirty Side of the Garment Industry. Fast Fashion and Its Negative Impact on Environment and Society (Boca Raton et al. 2016), x.

microplastic pollution for which fashion is responsible, amounts to 35%[14] and it takes 200 tons of water to produce one ton of fabric. Such data brings into question the whole idea of sustainable fashion.[15] Thus it might make sense to ask why weavers in India still insist on using handlooms.

The Socio-Technical Ensemble of Weaving in the Northeast of India

When Sonnie Kath[16] explains why weaving is so important to the Naga people in the Northeast of India, she says:

> "Women weave at home in the course of their daily routine even as they cook, clean, farm and rear children. It is very important to our culture and identity, and all women are expected to know how to weave. Weaving, spinning, dyeing, carding is taught to young girls at home. The loin loom occupies a central place in the everyday life of our households. I learned to weave from my elders almost while playing."

These home woven textiles, woven on simple back strap loin looms, are everyday as well as treasured objects and play an important sacramental role in various rites and rituals. Tribal and clan patterns are authorized for use with an elaborate set of rules that are negotiated via the age, gender, and social status of the wearer. The loom itself is portable, and made of wood and bamboo. One end is fixed to a wall, and the other is held in tension by means of a strap worn around the waist of the weaver, feet stretched as she weaves. Weaving on a loin loom is an activity that makes great mental and physical demands of the weaver. The weaver not only has to take decisions in the course of forming the pattern and performing complex algorithms,[17] but also provides the tautness to the loom by means of her bodily strength.

Recognizing the simplicity of the loom, we might feel compelled to address this type of weaving as being technologically primitive. The trajectory of technological development suggests that complex fabrics afford complex looms. However, the opposite is true: especially for skilled weavers, simple looms offer more possibilities than mechanized looms. The heddles and the shuttle have many more degrees of freedom as compared to other kinds of looms. In

14 Partha Dasgupta, The Economics of Biodiversity. The Dasgupta Review (London 2021): www.gov.uk/official-documents, accessed February 24, 2022, 116, box 4.4.

15 Documentary film *Fast Fashion. Die dunkle Welt der Billigmode*, arte, 9.3.2021. Available at https://www.arte.tv/de/videos/089135-000-A/fast-fashion-die-dunkle-welt-der-billigmode/ until 6.6.2021.

16 Weaver, textile designer, and activist Sonnie Kath (1974–2020) was the co-founder of Exotic Echo, Nagaland and of the International loin loom Festival. She worked to organize weaving collectives, and revived lost techniques and material practices.

17 For a discussion of the algorithmic nature of weaving with a loin loom, see Carrie Brezine, "Algorithms and Automation. The Production of Mathematics and Textiles", in The Oxford Handbook of the History of Mathematics, ed. Eleanor Robson and Jacqueline Stedall (Oxford 2009), 468–492.

a contribution to the history of mathematics, Carrie Brezine describes how the Andean weavers, who also use the backstrap or loin loom, build complex patterns by reacting to already woven parts with shifts or reflections in the following weft row, in this way combining algorithms to create patterns of high complexity.[18]

In weaving on the loin loom the weaver's body serves many functions: as the intelligence that shapes and animates the textile, as the motive power that methodically builds up the textile, and as the structural element which provides the force necessary to hold the warp threads in tension and thus weave. The weaver exhibits her technical virtuosity in how she can adapt the loom and its location via adjusting tension and placement through bodily movement. This also allows her to combine fibres from cotton of different staple lengths – to adjust sizing ingredients, patterns, dyes and loom tension to account for it, and thus to weave fibres of completely different origin, either via blended yarns or via mixed warp-weft fabrics. This is impossible in any mechanized system where yarn standardization is crucial to huge production runs.

That is why for all its simplicity the loin loom produces extremely complex fabric, recognisable as such by most other weavers, when weaving knowledge is at stake, rather than productivity. One such example is from an international weaver's conference attended by 300 weavers with their looms from all over India, in the weaver's town of Chirala, India in 2018. Standing in front of their looms, freed from the ideal of knowledge as expressed through language, product or through a technological trajectory of advancement, women weavers of the Northeast confidently presented their weaving knowledge. The coordinator in charge of setting up the weaving section writes in his field notes "what was surprising was that the weavers from all over were most interested in what the women with the most basic looms, the loin looms from the Northeast, who also spun their own yarn, wove, rather than the so called advanced Jacquard looms".

There was most interest where the loom itself was most flexible, without elaborate arrangements and mechanisms, where the demand for expertise from the weaver was the highest. The coordinator records further in his notes, with some humour "the officials from the Weavers' Service Centre, used to being the center of attention, and expected to convince and impress with their Jacquard looms as their technological innovation, were most offended to be displaced in this manner by women with such basic loin looms who did not even speak, while demonstrating their knowledge".[19]

In Naga households the act of weaving is the exclusive right of women, and largely observed through social custom and rigid taboos. Women in the

18 Ibid.

19 The Weavers' Service Centre is a department under the Ministry of Textiles, government of India that was established to provide handloom weavers with technology assistance, access to raw material inputs and marketing functions.

tribal societies of the Northeast hold a distinct position from that seen in normative caste Indian society. Moreover, the act of weaving (and spinning) is inseparable from their role as providers and caregivers to the family, and it is an activity that is intimately embedded and woven into the interstices of their daily life, that is consonant with diurnal and seasonal rhythms.

Substantively, loin loom weaving elaborates how building portable, resilient, and diversity-welcoming systems is crucial to the lives of the tribal people of the North East. The hills of the northeast have seen migrations from all directions, and crucial to this mobility is people's ability to use technology developed in one place to accommodate themselves in ecologies very different from the ones they were created in (the region spans ecologies ranging from Himalayan settlements to tropical rainforest). Living in a region carved by the mightiest rivers, bounded by the tallest mountains on earth, and with the highest annual rainfall, demands a certain measure of adaptability and resilience of the people who inhabit it.

Is the Loin Loom Weaver Technologically Ignorant?

Textile production as we describe it in modern culture today bifurcates (and privileges) the stages of production – of design (done by a designer) and implementation (a weaver's or weaving machine's job). A textile designer forms a new design as an abstraction (pattern) that is conceived and developed outside the loom (usually on computer, or less frequently, on paper). This is a process that always involves abstracting material properties, and thus naturally leads to standardized and homogenous materials that are more amenable to modelled abstraction. It also leads to the creation of hierarchy between creative work (that is deemed intelligent, innovative and thus better paid), and labour (tedious, repetitive and condemned to alienation).

What the loin loom weaver does, however, never subscribes to these categories. She has several modes of working – and she performs them directly on the loom with no intermediation required. It is this feature that gives the loin loom so much technological resilience. Since the material properties are always negotiated in the design, she is able to accommodate a variety of material forms. Drawing upon her memory, using complex forms of repetition and mimesis, synchronized with corporeal rhythms, she engages in a direct dialogue with a huge diversity of natural materials. She performs this even as she is mindful of the symbolic value of her design and its relation to the possible meanings of the textile that is being produced.

We see evidence of the recurring recognition of this quality in several ethnographic studies written by colonial administrators, in the latter part of the British Raj from 1890s to 1940s, of the technical excellence of Naga textiles, in comparison to other kinds of cloth. "The cloths made by the Na-

gas are remarkably strong", HF Samman writes in 1897.[20] Further, he says "Among the products of the loin loom, perhaps the best fabrics are those of the Nagas […] carefully woven and excellent of their kind […] which compare not unfavourably with many woven in the plains upon the four-poster loom."[21] Commenting on their longevity, he notes "The sheets of the Nagas are unequalled for durability and careful weaving."[22]

Sonnie Kath's life demonstrates how the loin loom helped her negotiate vitiated modernity on her own terms. Her story is that of a Naga woman with a modern education, who moved to New Delhi in search of a career. A nagging sense of alienation and anomie prompted her to abandon that life and move back to the family home and farm. "It is women's work that runs the Northeast", she said. Identifying strongly with issues of women's labour and socio-economic roles, she organized various kinds of women working in the informal economy (as street vendors, pedlars, etc.), and in addressing issues of human trafficking. It was eventually in the loin loom and her own weaving practice that she found her calling. In building an enterprise that catered to contemporary and traditional needs, she explored new productive relations with the market that were more equitable and creative for the community of weavers. She also discovered her own expertise in mediating between her culture and the world outside through the loom. In helping the shawl find new users, in designing patterns that were culturally appropriate and finally in enabling the creation of fairer engagements between the weaver and the market.[23]

These stories convey a link between productive and reproductive labour that cyclically link work, living and relationships which help the weaver negotiate varying circumstances. And it is precisely this cyclicality that ensures the reproduction of skill, culture and material practice, whether in a new generation, a new place, or in a new technological, material, or ecological niche. Loin loom weaving is a performance of heightened awareness that celebrates radical presence and contributes to a production of not only functional but also semiotic value. It is due to the richness and skill of such a performance that the loin loom weaver is able to reproduce society at the loom, and thus encode in its possibilities much of the material diversity, genealogy and memory, that constitute Naga culture and ecology.

The Claim for Technological Upgradation and the Societal Conflict

Nagaland occupies a mountainous, heavily forested region in the north east of India sharing a border with Myanmar. The Naga tribes who inhabit a region divided among four Indian states and two nations have had a fraught

20 HF Samman, Monograph on Cotton Fabrics of Assam, Office of the Superintendent of Government Printing (Calcutta 1897), 13.

21 Ibid., 72.

22 Ibid., 70.

23 Interview with Sonnie Kath, conducted by Vivek Oak on July 7, 2018.

relationship with the Indian state since inception. Born out of a plebiscite that overwhelmingly demanded a sovereign Nagaland, the people of the state have waged a long struggle for self-determination. Under the Indian constitution the state has special status that limits the role of the union government in several domains such as customary law, land and resource ownership and rights of movement. The signing of the Naga Peace Accord in 2015 brought a tenuous peace to the region after a nearly two-decade long interregnum.[24]

The Indian state amongst its many interventions in policy in the Northeast counts handloom weaving as an important one, as the region accounts for 58% percent of the total handlooms in India. The primary vectors of Indian handloom policy are planned at the central level via the 'Development Commissioner, Handlooms', a division in the Ministry of Textiles, and implemented via various state and regional agencies. The Technology Upgradation Fund (TUF) is a scheme run by the Ministry of Textiles. The overwhelming portion (more than 90%) of the TUF's budgeted outlay goes to the mill and powerloom sectors,[25] where the fund operates in the form of providing interest subsidy and reduced collateral on loans taken to invest in capital expansion. Many entrepreneurs use these funds to invest in importing discarded, second-hand[26] textile machinery from the West to improve production capacity. These funds then come in handy for textile businesses to periodically upgrade their machines with state support. Stated reasons for this support include livelihood creation, increase of production efficiency, and to make the sector globally competitive.

For the handloom sector, the government outright provisions for capital goods via the implementation agency, which are usually the state handloom departments. Very often this is provided as part of development plans for handloom weavers to 'upgrade' their production process, with a view to increasing policy-driven metrics. Applying productivity metrics derived from large scale manufacturing in the capitalist mode, this program aims to replace the primitive loin loom with modern improved frame looms and Jacquard looms.

It is important to examine the rhetoric and assumptions that underlie the TUF. At the foundation of the ideal of technological progress is that the technical domain can and should be separated from social conditions. Technological progress can then be accelerated, for the good of society, and it is society's responsibility to catch up. This argument of technological progress is linked to the economy in terms of introducing new innovations in the market, and is further developed along twin parallel trajectories at the production and the

24 Kedilezo Kikhi, "The Naga Homeland Movement. Historical Trajectory and Contemporary Relevance", in Economic and Political Weekly 55, No. 23 (2020): https://www.epw.in/journal/2020/23/special-articles/naga-homeland-movement.html, accessed February 24, 2022.

25 https://timesofindia.indiatimes.com/city/surat/textile-sector-upgradation-hits-a-roadblock/articleshow/72230673.cms, accessed February 24, 2022.

26 Notably markets in Nagaland are also flooded with cheap, second-hand clothing from Europe, America and Korea, thus contributing to a massive loss of market for local producers.

consumption end. At the production end, they are largely based on efficiency arguments. These assume the possibility of quantifying all the desirable properties of a production system that can then be maximised. Any other factors such as loss of bio-diversity or sustainability to labour and local ecologies, are seen as externalities which can be ignored. Inherent to such analyses is also a drive to standardization and the idea of labour or livelihood as fungible entities.

On the consumption end is the rhetoric of an insatiable 'global' market that demands endless novelty. This allows politicians and bureaucrats to exhort weavers to cater to this market, and frequently refer to globalization as a precondition that can either offer immense benefits to, or if not catered to, guarantee annihilation of, the artisan's way of life. Demanding that the artisans upgrade or evolve with the demands of the global market results in forcing the producer onto a treadmill of technological development that runs at a pace that is not determined by the weavers themselves. This demand also assumes that the creation of variety requires newer tools, and that new technology has to always precede the development of new textiles. Finally the idea of accelerated production to cater to hyper-consumption – an unsustainable tautological exercise as we show below – seems to obviate the necessity for the policymaker to justify their perspectives in any other terms to the public.

Fast fashion brands hold billions of dollars of unsold inventory and the average American discards 37 kg of clothing annually, most of it non-recyclable.[27] That which is not dumped into landfills or incinerated ends up in markets like the central market of Dimapur, one of the largest of such markets in the Northeast. Among the stalls selling local wares, mounds of discarded clothing from the US, EU, and Korea are seen in abundance, often with their labels cut off.[28] These are imported by weight and eventually reach consumers through a complex chain of intermediaries. The used clothing trade has been documented elsewhere as being instrumental in de-industrialization and large scale destruction of local production.[29] The government thus expects the Naga weaver to serve a distant market for niche handcrafted, "ethnic" goods even as her own local markets are being deluged by the detritus of industrial overproduction generated by affluent nations of the global north.

The TUF was introduced by the Indian State to increase the productivity, skill and wages of the handloom weaver:

> "Loin looms […] have low productivity and less durability […] so as to start up the commercialisation of the activity the looms need to be upgraded to fly

27 https://www.bbc.com/future/article/20200710-why-clothes-are-so-hard-to-recycle, accessed February 24, 2022.

28 https://www.newindianexpress.com/nation/2016/dec/05/nagaland-wears-used-korean-clothes-1545907.html, accessed February 24, 2022.

29 Andrew Brooks and David Simon, "Unravelling the Relationships between Used-Clothing Imports and the Decline of African Clothing Industries", Development and Change 43, No. 6 (2012), 1265–1290.

> shuttle loom. […] Technical support needs to be given on loin looms to increase their efficiency".[30]

It was also framed as a way for the handloom weaver to explore market niches after their primary markets had been captured by the mill and powerloom sector. This was seen as part of the broader development narrative to increase rural incomes, and to make north-eastern textiles an export product to build forex reserves, as well find a larger market within the rest of the country.

The encounter of supposedly innovative looms and traditional ones, and the conflicts emerging from that encounter have a long history in India that repeats instead of being resolved. The 1951 government census reports with reference to the Naga Hills:

> "The industries practiced in the hills are small and unimportant. Nearly all the clothes worn by the Nagas are made at home by the women. The Naga waist-loom is of the simplest character and consists of little more than a few sticks on which the warp is supported."[31]

Again, the fifth five-year plan of the Government of Nagaland, in 1974, refers to the population of Nagaland as having very little development, even of small scale industries, recommending a shift to fly shuttle looms:

> "the production by this method is very slow and time consuming. To improve this old method of production and to enable people to produce larger quantities within comparatively short time, fly shuttle looms [have] to be introduced in the state".[32]

Addressing the handloom weavers of Banaras in 2014 the Indian Prime minister had said,

> "You must embrace technological development, and scientific training. Technology will help you improve both in quality and quantity of production. If you do not enthusiastically adopt it, you will be left behind as anachronisms even as the world marches ahead."[33]

From the Prime minister's address, it becomes clear that the aim that accompanies the public policy of Technology Upgradation, is the valorisation of productivity metrics. Within this framing, the loin loom is an inefficient, crude relic of a backward culture. Further, since it is labour that is performed at home, it suffers from a double form of invisibility. Just as other forms of women's labour such as childcare are systematically diminished and pauper-

30 Unpublished report of All India Artisans and Craftworkers Welfare Association (AIACA) on Bodo weavers, 18.

31 Census of the Naga Hills, Government of India, 1951.

32 5th Five Year Plan, Government of Nagaland, 1974, 5.

33 Modi's address to handloom weavers of Banaras, 7.11.2014: https://www.youtube.com/watch?v=kL5VxEJzNpM, accessed February 24, 2022.

ized by state policy and labour laws, weaving also falls into the same gap. The Naga weaver thus holds a position of double illegibility to the state as a woman weaver. In the grand project of modernity the weaver is seen as clinging to outmoded tradition owing to her lack of 'technology'. She is seen as a subject to be skilled into a higher-wage production form in order to deserve the occupation of a skilled specialist weaver, and thus be made visible into GDP, wage and employment data.

In constructing the handloom weaver only as a rational economic actor (homo oeconomicus), who needs to individually meet the criteria defined by global capitalism in order to be seen as a viable enterprise, policy makers in the Indian state posit certain key metrics which must be aspired for in order to avail of government programs. These include productivity metrics which are quantitative (measured in total production, loom idle times, and daily averages), qualitative (defined statistically via defect frequency), and finally economic (return on capital, market share, penetration into new markets). A common feature to all of these metrics is the desire to move the trajectory of the weaver from the traditional strengths of diverse, small scale, decentralized, artisanal production toward a standardized, high growth, large-scale, profitable business. Given the well-known centralizing tendencies and enforced homogeneity that is current in capitalist technological development, these metrics mark an important point of departure for the artisanal weaver. In deciding the extent to which she is able to construct her work in these terms, she deals with the attendant alienation (from local markets, ecology and the household economy) that accompanies it.

As evidenced in the Prime Minister's terms it is clear that such claims constantly evaluate the weaver and her production, and sorts artisans into two classes – those who are 'progressive' and therefore worthy of support, and those who are not, and thus condemned to oblivion. "Today's consumer is very demanding. You must be able to expand your variety of production and cater to all their demands. If not, your place will be taken over by those who can."

Misunderstanding Technological Innovation?

In the discursive policy framing on productivity and efficiency the inefficient loin loom technology could be seamlessly interchanged through 'technological upgradation' with the productive frame loom. However, it is important to analyse the conditions of production of this new form. The frames of the fly shuttle looms are typically constructed in distant places and assembled on site, and it is a permanent structure that occupies much more space than the former loom. The fact that this is largely incompatible with the architecture of the typical Naga home was not considered. New sheds are thus built to accommodate these new looms, but that also necessitated that weavers would have to leave their home, and commute to the site of production. The frame loom when taken up uproot the weaver from her home and way of life,

and demand a wholesale restructuring of not only her mode of production but rather force a wholesale change in social relations. It sets into motion a twofold process of alienation – from her community in becoming a specialist weaver and hence being unable to sustain the reproduction of the household, and from her local market in producing new designs, in much wider forms, and with designs that are often externally imposed.

Finally, the natural outcome of the above would be implicit concord with the myth of creative destruction and technological determinism, namely that there can be no co-existence of the old and the new in the narrative of progressive technology. New forms can only be developed by the erasure of the old. This is underscored by the tech-billionaire Mantra "move fast and break things".[34] The outcome of this kind of mythologizing and valorisation of technology continues to be borne out in the series of 'forward-looking, comprehensive, holistic' policies that are periodically put out by the government of India over the last century, whether colonial or Indian. Remarkably, they have been largely undisturbed by political shifts, and bear a distinct technocratic continuity. The Indian government's policy making environment is significantly constrained and conditioned by the neo-liberal consensus forged in the WTO era. The TUF and other such production-oriented policies are eventual outcomes of complex trade deals negotiated via international institutions. They may only share a tenuous relationship with the needs and aspirations of the lives that are affected by them.

The Nagas sticking to their loin looms seem to provide a perfect example of a social group misunderstanding the impact of a new technology. As Alan Irwin and Brian Wynne point out in their introduction to several case studies of conflicts around the introduction of technology,[35] the manner in which scientific boundaries are established and maintained is particularly relevant for such conflicts. The model assuming that new technology needs to be disseminated to traditional craft communities informs the way "in which scientific knowledge frequently embodies tacit commitments about audiences or user-situations which may then serve as un-negotiated social prescriptions."[36]

In a field study of conversations of local sheep farmers and nuclear scientists around the Sellafield nuclear power plant, Wynne concludes:

> "It is not […] that scientific knowledge merely omits social dimensions that ordinary people incorporate in their evaluations and assessments. It is that scientific knowledge tacitly imports and imposes particular and problematic

34 The full quote is "Move fast and break things. Unless you are breaking stuff, you are not moving fast enough." Mark Zuckerberg, https://www.businessinsider.com/mark-zuckerberg-2010-10?IR=T, accessed February 24, 2022.

35 Alan Irwin and Brian Wynne (eds.), Misunderstanding Science? The Public Reconstruction of Science and Technology (Cambridge 1996).

36 Alan Irwin and Brian Wynne, "Introduction", in Misunderstanding Science, ed. A. Irwin and B. Wynne, 1–17, here 9.

> versions of social relationships and identities. This seems a major factor in the sometimes negative public response to technical pronouncements, especially ones which, in their lack of self-awareness or reflexivity, impose these social prescriptions without negotiation."[37]

This ability to reflect on their own social position and assumptions is what Wynne finds on the side of the lay people who in fact are traditional experts: "Indeed it is interesting that those who would be regarded as the representatives of traditional society showed this reflexive capability, whilst the representatives of enlightened society, namely the scientists, did not."[38] In the conclusion of their book, Irvin and Wynne state that the dominant view on public understanding of science assumes ignorance on the public side as a function of incapacity, and

> "deflects attention away from critical debate about science and scientific institutions, about the ownership and control of science and its products, and about the implicit social visions these carry. It is an important finding from our research that, since public experiences of science can never be detached from imputed institutional interests and agendas of whatever kind, the manifest *lack of reflexivity* on the part of science in public only amplifies any existing tendency for public groups to mistrust it."[39]

The TASC concept seems to imply such a view on the public understanding of science and technology which, according to Irwin and Wynne, rests on the assumption that: "Public controversy over technical issues is created by inadequate public understandings rather than the operation of science itself."[40]

Part II: Science Anchoring in a Traditional Technology?

Before we now enter the discussion of our second example, we want to shift attention away from the idea of a misunderstanding of technology to a perspective that focuses on the necessity of innovation being anchored in the relevant social group. In an introductory chapter on the circumstances of invention, Maurice Daumas reminds of the fact that technical inventions need not only specific materials and tools, but also professional traditions and an interest in change by a large number of individuals in the change they initiate.[41] This is the condition that the Dutch research program 'Anchoring Innovation',

37 Brian Wynne, "Misunderstood Misunderstandings. Social Identities and Public Uptake of Science", in Misunderstanding Science, ed. A. Irwin and B. Wynne, 19–46, here 20–21.

38 Ibid., 43.

39 Alan Irwin and Brian Wynne, "Conclusions", in Misunderstanding Science, ed. A. Irwin and B. Wynne, 213–221, here 215–216.

40 See Irwin/Wynne, Introduction, 6.

41 Maurice Daumas, "General Preface", in A History of Technology & Invention. Progress Through the Ages. Vol II: The Origin of Technological Civilization, ed. Maurice Daumas (New York 1969), 1–9, here 2–3.

conducted by OIKOS, investigates for innovations in Classical times.[42] The Classicists claim that new possibilities need to be realized and embedded in societal practices, that new ideas need to 'land' in the intended target-group. The societal conflicts discussed in the TASC concept would then signal a failure of anchoring the technology in question.

While the metaphor of anchoring in the TASC concepts suggests a floating societal element looking out to connect to a stable and ever evolving ground of technology, the Anchoring Innovation agenda assumes that there is necessarily a disruption being the result of a technological innovation which is new and thus un-anchored by definition. For both agendas, technology and the social are two entities in need of connection. However, from our investigations of weaving in archaic Greece and from investigations of several handloom weaving communities around the world, we see that the split is a historical phenomenon. However, the conditions for this split, the difference of everyday and scientific knowledge, and the idea that weaving knowledge can be fully implemented in machines by applying pure knowledge to textile production, have not only a long history, but also a very specific genesis.

The PENELOPE project investigates weaving technology as site of knowledge in archaic and early classical Greece. A central claim of our argument is that weaving *as* technology provided a distinctive, yet pervasive, mode of knowledge-through-order that grounds a significant sample of innovations in several domains, from the performance of instrumental music in lyric poetry, through cosmological models in pre-Platonic Greek thought, down to the establishment of a branch of number theory that Plato, and later Euclid, inherit from Pythagorean thinkers.[43] Along our investigations, we identified three main modes of how these innovations anchor in the technology of weaving *as* knowledge:

(1) the logic of generating patterns on the loom, with its distinctive co-extensiveness of structure and form, informs concepts of ordered structures in nature (*poikilos*, atomic conglomerates)
(2) technological features and the terminology of weaving 'travel' by imagery (especially metaphors) to other domains and ground technical and conceptual novelty

42 OIKOS is the National Research School in Classical Studies in the Netherlands and 'Anchoring Innovation' is an OIKOS Research Agenda from 2017 to 2027. See www.anchoring-innovation.nl, accessed February 24, 2022. For an introduction to the concept see Ineke Sluiter, "Anchoring Innovation. A Classical Research Agenda", European Review 25, No. 1 (2016), 20–38.

43 We can only give a short summary of the results here. For the extended argument see Giovanni Fanfani, Ellen Harlizius-Klück and Annapurna Mamidipudi, "Anchoring Scientific Innovation in Ancient Weaving", in Anchoring Innovation, ed. Miko Flohr, Teun Tielemann and Suzanne van de Liefvoort (Leiden), forthcoming.

(3) the arithmetic of number manipulation on the loom, based on the dyadic distinction of even and odd which determines the possibilities of patterning, is detached from the practice and crystallized into a formal number theory.

In the following, we will discuss those three modes along several examples and begin with a description of the specific features of weaving in archaic and early Classical Greece and its embeddedness in the society and knowledge of the time.

Penelope and her 'Primitive' Loom

A piece of archaic Greek pottery on display in the National Museum of archaeology at Chiusi, Italy, shows a depiction of Telemachos and Penelope, son and wife of Odysseus, in front of a warp-weighted loom (see fig. 1). Staff and objects are known from the Odyssey, an epos ascribed to the poet Homer, telling the story of the Greek hero Odysseus and the circumstances of his long and difficult return from the war at Troy. Penelope is his wife, left in their home on Ithaca without any information on his fate. Telemachos is their son and both struggle with a group of suitors requesting Penelope to choose one of them meanwhile besieging the palace and consuming its goods. After seventeen years of waiting for Odysseus, the suitors force Penelope to take a decision, but she asks for a delay: she promises to decide on a groom as soon

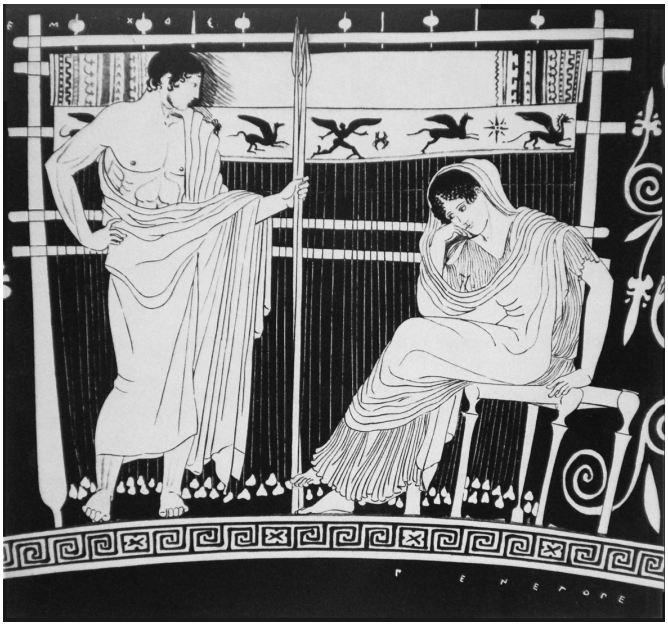

Fig. 1: Drawing after Skyphos Chiusi, red-figure, 450–400 BCE, National Museum of Archaelogy, Chiusi, Italy. In: Adolf Furtwängler and Karl Reichhold, Griechische Vasenmalerei. Auswahl hervorragender Vasenbilder, Series 1, Plates (Munich 1904), 142.

as she has finished a shroud for the funeral of Laertes, father of Odysseus.[44] This is the fabric we see behind Telemachos and Penelope as work-in-progress on the warp-weighted loom, the common weaving device of ancient times.

The historian of technology Hugo Blümner in 1875 claimed that the fabric depicted on Penelope's loom on the skyphos Chiusi could never have been woven with such a primitive device.[45] The combination of figured designs and geometric patterns indeed point to a complex technique that technologists connect to elaborate looms, but not to such an unspecific tool as the loom depicted. We already encountered this argument in the example of the loin loom of the Nagas, sharing the feature of simplicity with the warp-weighted loom of Penelope. From that example, we are also aware that the complexity of a weave is a result of knowledge on the side of the expert weaver.

The Powerful Social Role of the Ancient Weaver

In the *Odyssey*, the suitor Antinoos reports that Penelope puts up the loom in the *megaron*, which is the great hall where the guests are eating and drinking.[46] Still, several scholars imagine Penelope weaving in a remote female place. With regard to the depiction on the skyphos Chiusi, the ancient scholar Stansbury-O'Donnell writes: "It is easy to consider this space as another section of the house, well away from the entrance where Odysseus stands with his travelling pack, as well as the *andron* where the suitors eat and drink."[47] Yet, the word *andron*, denoting a male space (from *andros,* male), is a later term, indicating a change of the relation of space and gender. Erich Kistler points to the fact that there was a long development from a *megaron* culture that included women to an *andron*-culture that excluded women.[48] Still in the 7th century BCE, the ideal of the 'beautiful host' and 'skillful weaver' situated in the *megaron* that we find in the Homeric epics prevailed. And it has been attested as a real practice by archaeological finds. Kistler refers to several excavations of loom weights and spindle whorls in the *megaron* for example of a palace at Gordion in Asia Minor or in Prinias on Crete or Zagora on Andros.[49] It is only in the course of the 7th century that the culture

44 Penelope even extends the delay when she unravels by night what she achieved the day before.

45 Hugo Blümner, Technologie und Terminologie der Gewerbe und Künste bei Griechen und Römern (Hildesheim 1912), 158.

46 Further mentions of the loom by Penelope herself in book 19 (139–140) and by the soul of Amphimedon in the underworld in book 24 (128–146) confirm this narrative.

47 Mark Stansbury-O'Donnell, "Composition and Narrative on Skyphoi of the Penelope Painter", in Approaching the Ancient Artifact. Representation, Narrative, and Function, ed. Amalia Avramidou and Denise Demetriou (Berlin and Boston 2014), 373–383, here 379.

48 Erich Kistler, "Ehefrauen im Megaron, aber keine im Andron! Ranghohe Frauen beim Bankett im vor- und früharchaischen Griechenland", in Gender Studies in den Altertumswissenschaften. Räume und Geschlechter in der Antike, ed. Henriette Harich-Schwarzbauer and Thomas Späth (Trier 2005), 15–36, here 16.

49 Ibid., 25–26.

of feasts changed and the development of a citizen community with class structure finally led to the exclusion of the skillful women weaver from the social space of the banquet.[50]

This is not just a question of gendered spaces. In the context of the *megaron* culture, Kistler speaks of a demonstration of the production of particularly splendid cloth that is the task of the landlady and host, a demonstration of a technological practice without which networking by hospitality and gift exchange in the Homeric world would not have been sustained. "Inasmuch as a well-functioning hospitality is central to the royal dynasties, the landlady is an indispensable co-institution of royal 'power base politics'."[51]

Kistler's work refers to a comprehensive investigation of gift exchange in archaic Greece by Beate Wagner-Hasel, unfolding a world of social networks and models for rulership embedded in the exchange of metal objects and textiles. However, it is the textile gifts that clearly represent social cohesion. There are two terms in the Odyssey for the specific honor connected to such a ruler, namely *time* and *geras*, not only denoting esteem but also authority. As Wagner-Hasel explains, "in the Homeric world the reciprocal aspects of rulership are more important than elements such as obedience and command. *Time* and *geras* do not denote such one-sided dominance; instead they form the foundations of a reciprocal system for the provision of gifts and services". And this reciprocity, although not symmetrical, also applies "to the relationships between the *demos*, the people, as a whole and the high-ranking kings and queens who rule over it."[52] And exactly at this point, the power of weaving comes into play, because Penelope's weaving trick, namely that she unravels by night what she has woven by day, suspends the time of decision on the new marriage and marks an act of power.[53]

The Political Dimension of Ancient Weaving

Moreover, the social ordering and the enforcement of social ties that weaving facilitates are at the core of the most important political and social event in ancient Athens, the Panathenaic festival gathering citizens as well as visitors by means of a procession that carries a fabric to the Parthenon: a *peplos* for the city-goddess Athena showing the battle between Giants and Gods, woven within nine months by noble girls and women from the town, elected by the council members of Athens. In this festival, weaving unites the population of Athens, their fabrics, their battles, arms and armor, horses, poetics and

50 Ibid., 16–17, 30–31.

51 Ibid., 21. translation by Ellen Harlizius-Klück.

52 Beate Wagner-Hasel, The Fabric of Gifts. Culture and Politics of Giving and Exchange in Archaic Greece (Lincoln, Nebraska 2020), 188.

53 Wagner-Hasel includes an analysis of the situation of Penelope in the chapter on *time* and *geras* with relation to gifts of honour and structures of power. Ibid., 185–246.

gymnastics. In the context of this festival, the Homeric epics, the *Iliad* and *Odyssey*, were performed in a rhapsodic contest for centuries.

By weaving the *peplos* for the statue of Athena and ritually presenting it, the female citizens of Athens take part in the inner and outer representation of the city. Their work and products as well as their skill and knowledge, symbolically as well as materially expressed in the *peplos*, enter the contract of city and goddess. Therefore the fabric has to be renewed regularly, just as the contract is renewed by the repeated festival. The textiles and their production are constitutive of political action.[54]

Because of the fundamental value of the *peplos* dedication and what has been depicted by the weaving, the production of the *peplos* was subject to the rules of the political institutions of the city.[55] Although the details of this process are unknown, it shows that the *peplos* production and the story it presents as depiction were of great political relevance and demonstrate how the city-state wanted to be understood by the people inside as well as outside the city walls.

The foundational act of the weave, the preparation of the loom by weaving a starting border and distributing the odd and even threads of the loom (*diazesthai*), is paralleled to the foundation of the city, and executed by the *Arrhephoroi,* young girls, *parthenoi*, from noble families who begin the weaving by producing that ordering border.[56] In a passage from Aristophanes' *Lysistrata* (line 642) it is implied that being a former participant of the Arrhephoria rite was a predisposition to take over responsibility in the city-state. This founding border is a specific feature of warp-weighted-loom weaving that includes the distinction of threads of odd and even number and how they later combine into possibilities for pattern blocks.

When compared to the Nagas, we already recognize several features that ancient Weaving has in common with contemporary handweaving in India:

– Weaving is learned by almost everyone at home at a young age.
– The loom occupies a central place and role in the household.
– Patterns on fabrics are authorized and negotiated by social exchange.
– The primitive looms allow for complexity of design.
– Weaving is important for culture and identity.

The feature of ordering by textile patterns might even extend into the natural environment. Traditional Andean weaving can show how textiles work as a

54 Rosa Reuthner, Wer webte Athenes Gewänder? Die Arbeit von Frauen im antiken Griechenland (Frankfurt/Main 2006), 296–297.

55 Ibid., 299; Aristotle, *Ath. Pol*. 49,3 and 60,1.

56 See Wagner-Hasel, The Fabric of Gifts, 318. For a detailed analysis of the importance of the starting-border concept see Ellen Harlizius-Klück and Giovanni Fanfani, "(B)orders in Ancient Weaving and Archaic Greek Poetry", in Spinning Fates and the Song of the Loom. The Use of Textiles as Metaphor, Symbol and Narrative Device in Greek and Latin Literature, ed. Giovanni Fanfani, Mary Harlow and Marie-Louise Nosch (Oxford 2016), 61–99.

material science of order in sustainable farming. The planning of the textile design is directed towards visual expression of quantities of possible cultigen yields.[57] In finished mantles, patterns document each productive process, from land at rest to fields under cultivation as well as the harvested products. "This visual and conceptual design organization applies inductive and deductive reasoning combined with theoretical knowledge, and its transmission through woven forms of inscription."[58] Denise Arnold calls the Andean weaves "a woven morphology" that actually enables thinking connectively between and among things.

The Greeks also had a term referring to natural and artificial design (*techn*ē in Greek encompasses both nature and culture as well as art and technology) that shows a distinct order called *poikillos*. It does not just refer to what is visible at a surface but includes a specific underlying order, sometimes geometrical sometimes rhythmical and best represented by patterned textiles. For understanding this important feature of hand woven textiles, it is important to consider the basic concepts on which weaving builds.

From its very beginning, weaving is a technology that is rule-based and complex at the same time. It unites two systems of threads, namely warp and weft, and puts them in order by a reiterated binary decision: the weft goes either over or under the warp. Furthermore, a specific feature of weaving at the warp-weighted loom, namely the starting border, provides a system of binary classification at the very beginning of weaving: the threads are distributed for forming a shed by distinguishing the odd ones from the even ones. Pattern generation in weaving consists of the manipulation of a set of elements (the threads) that grounds on this distinction of odd and even numbers. Every geometric or figurative shape appearing on the fabric is the result of considerations of ratios between numbers and properties of integers (evenness, oddness, primality, and the respective combination).[59] Determining the odd- and evenness of groups of threads for arranging patterns implies mastering number composition and factorization, yet without the need to calculate the

57 Denise Y. Arnold and Elvira Espejo, "Andean Weaving Instruments for Textile Planning. The *Waraña* Coloured Thread-wrapped Rods and their Pendant Cords", Indiana 29 (2012), 173–200, here 116–121.

58 Denise Y. Arnold, "Comparative Reflections on Andean Weaving as Science", in HOMO TEXTOR. Weaving as (Technical) Mode of Existence, ed. Ellen Harlizius-Klück et al. (Munich 2022), forthcoming.

59 The logic of generating a woven pattern on the warp-weighted loom, and its relationship with early Greek mathematics are discussed in greater detail in Giovanni Fanfani and Ellen Harlizius-Klück, "Pattern Weaving as Knowledge in Early Greek thought", in Knowledge in Archaic Greece, ed. Robert Hahn and Alexander Herda (Cambridge, MA 2022) (dyadic arithmetic as formulated in Euclid's *Elements*), Giovanni Fanfani and Ellen Harlizius-Klück, "Weaving the Pythagorean Theorem. An (im-)material Contribution to Early Greek Mathematics", in Materia Philosophiae. The Material Dimension of Greek Tragedy, ed. Robert Hahn and William Wyans (Cambridge, MA 2022) (relationship between geometry and arithmetic, incommensurability).

total amount – features of numbers are more significant than the actual amount of threads. While weaving may appear to be applied geometry, it is in fact implementing arithmetic on the loom for generating geometrical patterns to the point that, for a weaver, the process of planning and patterning the fabric may be seen as thinking about forms in terms of numbers and thinking about numbers in terms of possibilities of form.

From Wagner-Hasel's investigations of textile gift exchange, it is clear that weaving provides a form of storing and commemorating knowledge.[60] Colourful or patterned cloth, in Greek called *poikillos*, inhere such a role for the establishment and care of social and family ties when they feature at special occasions such as funerals, sacrificial offerings, weddings, or when receiving guests. But the adjective *poikillos* is also used for the *peplos* dedicated to Athena by the women of Troy (*Iliad* 6.289), for the belt worn by Hera for the seduction of Zeus (*Iliad* 14.220), for the cosmic cloth featuring in the cosmogonic fragments of Pherecydes, where Zas (another name for Zeus) weaves a big fabric surrounded by the river *okeanos* and depicting the signs of the zodiac.[61] The verb *poikillo* can denote the creation of all sorts of colorful mixtures of countable or distinguishable elements. Especially in early cosmological texts, the term *poikillos* and the order that is included in any reference to weaving play an important role. [62]

Anchoring Cosmologies

The earliest Greek prose writer, Pherecydes of Syros, casts a patterned fabric as a template for the structure of the universe. [63] His book described in detail the preparation, performance, and ritual completion of the marriage of Zas and Chtoniê, two eternal deities. At the third day of the wedding "then Zas makes a robe, great and beautiful, and in it he patterns (*poikillei)* Earth, Ogênos, and the dwellings of Ogênos". Here, the notion of *poikillein* has the function of advertising the ordered structure of the physical world and of pointing to technological specificity, to patterns of discrete elements forming the multifarious appearance of *kosmos*.

Pherecydes' image of cosmic weaving employs the technological semantics of the term *poikillein* in 7th to 5th century BCE: it is a remarkable instance of weaving knowledge in that it projects on the macro-architecture of *kosmos* the logic of the woven pattern as an ordering device. At a time when other complex structures are conceived of, or conceptualized in terms of weaving,

60 See Wagner-Hasel, The Fabric of Gifts, 146.

61 See Hermann Sadun Schibli, Pherekydes of Syros (Oxford 1990), 50–77.

62 Adeline Grand-Clément, "Poikilia", in A Companion to Ancient Aesthetics, ed. Pierre Destrée and Penelope Murray (Oxford 2015), 406–421.

63 See Schibli, Pherekydes of Syros, 2–4. In terms of the chronology of Pherecydes and Anaximander, another early prose writer, the priority of the former's prose book is generally accepted by modern scholarship. See ibid., 4–9.

Pherecydes' project of rationalizing the tradition of Greek theo-cosmogonies through a prose book where weaving is the technology modelling the structure of the world can be considered a plausible endeavour of rational thought. In 5th century explanations of the structure of the *kosmos*, the notion of interlacement emerges as a mode of cosmic generation in the work of the atomists Leucippus and Democritus as a theory of atomic composition. Lucretius, writing his didactic epic on atomism in the first century BCE and himself a philosophical disciple of Greek atomists, still makes ample use of weaving terminology for describing the mechanics of atomic conglomerates. However, when he addresses the trajectory of technological progress in book five of *De Rerum Natura*, he characterizes weaving as a technology developed by men after the invention of iron.

> "Clothing made from materials tied together
> came before woven garments, woven chlothes
> came after iron, for cloth ist made with iron –
> that ist the only way men can turn out
> such fine, smooth heddles and spindles, shuttles,
> and rattling yard-beams. Nature forced the males
> to work with the wool before the females,
> for the male sex far excels in skill and is
> much more inventive, until tough farmers
> scorned weaving, and then the men were willing
> to let the women do that kind of work
> and to share equally among themselves
> in hard labour, strengthening hands and limbs
> with heavy tasks."[64]

Ubiquitousness in Decline: The Turn From Technological Term to Metaphor

Still strong in the 7th to 6th century BC, explanations of (cosmic, natural, social, aesthetic) order in textile terms become problematic around the beginning of the 4th century BCE. It seems that the weaving terms clash with a reality

64 Lucretius, *De Rerum Natura* / On the Nature of Things, Book V, 1350–1360. Even though carefully done when compared to other editions, the translation still shows several difficulties. The "yard-beams" are probably meant to be "yarn-beams", the original *insilia* are translated here as "heddles", which are the threads that select certain warp-threads when a heddle-rod is pulled. However, only the (production of the) heddle-rod might be in need of iron, but not the heddle. To select a different text would not help as all translations have problems understanding the Latin terms indicating parts of the loom. An older translation by William Ellery Leonard and E. P. Dutton available via perseus.tufts.edu renders the *insilia* as treadles, although such treadles do not exist on ancient looms. See http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.02.0131%3Abook%3D1%3Acard%3D1, accessed March 27, 2021). See Matthew Johncock, "Life Hanging by a Thread. The Weaving Metaphor in Lucretius", in Fanfani et al., Spinning Fates, 253–270, for a detailed discussion of the weaving 'metaphor'.

in which the reciprocity of male and female realms that we encountered in the home of Penelope and Odysseus disappeared, and the fact that weaving is mainly women's work gets into conflict with its fundamental role for the order of the society. Although for a long time there was no doubt among scholars that the *peplos* of the Panathenaic festival was woven by women, the end of the 20th century brought forward new studies claiming that the skills of the women were insufficient to weave such a complex fabric. Supposing an extraordinary size for the *peplos* carried on a ship model as sail, John Mansfield casts doubt into the technical skills of women and introduces male professionals who were contracted to do at least the *peplos* for the every-fourth-year festival procession with the ship.[65]

Weaving provides a type of order that rests on a balance of binary/primary elements: the threads which are ordered by the starting border and the weft that interchanges with the warp in discrete ways. This order is what atomists like Lucretius refer to. However the textile terms employed are no longer embedded in a community of readers that understands the practice or technology. As result, textile expressions are taken as mythical or metaphorical.

Already Plato, who extensively uses the comparison of the good political leader and the weaver to explain how to establish the fabric of society, feels obliged to diminish weaving as a minor and unintelligible subject at the same time.[66] However, as soon as the value of weaving for the relevant social group is lost and its power of order becomes unfamiliar, the act of cosmic weaving becomes a pale metaphorical image or myth. This change is obvious in a quote by John Scheid and Jesper Svenbro, two scholars of ancient history who disapprove of the association of weaving and social order as being grounded in the technology:

> "An expression such as 'the fabric of the city' (or 'the city is a fabric') summarizes this myth [that weaving unites and gives order to matter; EHK], which is merely a kind of commonly shared *idée fixe* by means of which the members of a culture constantly try to explore and organize reality."[67]

Weaving by hand does not figure as a technology but as a metaphor for the unification of opposites, a linguistic term without serious technological implications.

Scheid and Svenbro claim for Lucretius that the metaphor of cosmic weaving is anchored in the word *textus* with the meaning 'written text' and not 'weave' from the word *texere* meaning *to weave*. Furthermore, when referring to Pherecydes, they see the fragment as part of a cosmology, but the weaving

65 John Mansfield, The Robe of Athena and the Panathenaic 'Peplos'. Dissertation (Berkeley, CA 1985).

66 Plato, *Statesman*, 285d.

67 John Scheid and Jesper Svenbro, The Craft of Zeus. Myths of Weaving and Fabric (Cambridge, MA 1996), 3.

of the fabric with the order of the stars by Zas is only related to "the bonds of harmony and love necessary for the opposing elements of the entire cosmos. This is an interlacing that is essentially weaving."[68] As a consequence, the "metaphor of weaving" as it is employed by Lucretius as well as in the Greek atomistic philosophy by Leucippus and Democritus where physical reality is considered a *symplok*ē, a weave or plait, to Scheid and Svenbro, is related to alphabetic writing. "For the 'elements' that join together as if united into a fabric in the physical world are first and foremost, both in Greek and Latin, the 'elements' of writing."[69] The structure of the universe, by claiming weaving to be a male invention, clearly becomes an object of male observation and practice, and finally the value of weaving as ordering instrument comes to be successfully anchored in writing as technology.

Cast as a matter of writing and as metaphor, the textile terms are indeed easier to access for modern readers, but the value of weaving as ordering technology is lost. In a more recent investigation, Matthew Johncock revisited the extensive use of the weaving metaphor for explaining atomic compound structure by Lucretius,[70] and states that weaving is an appropriate term for this purpose because it is a widespread and well-known everyday task "while its complex technology provides a broad range of specific processes applicable to multiple scientific concepts."[71]

Anchoring Pure Knowledge

A further claim of our argument on innovations anchoring in weaving is that, in fact, the distinction of odd and even numbers and their mutual relations was not invented by philosophers (later understood as mathematicians), rather it can be shown to be a necessary tacit tool for ordering textile patterns in weaving. Based on this binary or dualistic distinction of numbers is the possibility to split knowledge into pure and applied.

The dialogue *Politikos*, where Plato extensively employs the weaving paradigm, begins with that split which is so fundamental to the whole history of science: the distinction of pure and applied knowledge is made here for the first time in history.[72] What Plato gives as best example for pure knowledge is dyadic arithmetic, a set of definitions and propositions handed down to us as part of Euclid's famous *Elements* and arguably introduced by the Pythagoreans. Historians of science see a true innovation, a disruptive jump of scientific reasoning, being documented in this number theory which, according

68 Ibid., 65.

69 Ibid., 166; Johncock in a deeper investigation of the weaving metaphor in Lucretius' De Rerum Natura opposes to the result of Scheid and Svenbro explicitly, see Johncock, "Life Hanging by a Thread", 257, note 27.

70 Ibid., 253.

71 Ibid., 254.

72 Plato, *Politikos* 258c.

to them, has no practical origin nor application.[73] However, weaving employs exactly the number properties that dyadic arithmetic defines: odd, even, even times even, even times odd, prime to each other, etc. All these definitions and propositions are important for fitting patterns and repeats into the system of warp-threads established on the warp-weighted loom.

Plato is both sustaining and disrupting, or anchoring and dis-anchoring in the *Statesman*: he is dismissive with regard to weaving in itself[74] but then suggests weaving as sharing features with the art of politics,[75] and indeed being the correct model, *paradeigma*, for the art of the statesman. Plato can thus be seen as extracting and removing the knowledge (i.e. the order-through-number) of weaving from the practice (and thus from the weaver) and reframing it as an instance of pure *episteme.* This operation has two consequences:

(1) by introducing the theory of odd and even as pure knowledge, Plato casts the technological knowledge of weaving into the darkness of mythology, and this makes – from Aristotle to modern scholarship – any sample of textile terminology that appears in early scientific texts a case of metaphorical speech.
(2) The 'mathematical' innovation of dyadic arithmetic is thus disrupted from textile technology and instead connected to a new rhetoric of pureness and universality to which we still subscribe today.

The 'familiarity' and universality that the language of ancient Greek mathematics and science gained throughout history has supplanted and replaced a previous paradigm of universality represented by weaving knowledge. As consequence of the split into pure and applied, scientific knowledge is situated outside material practice. A major implication of this process is a split of the unitary knowledge of weaving. Paradoxically, the successful anchoring of the new sciences in weaving renders this formerly familiar technology unfamiliar and modifies the perceived status of weaving technology and its epistemic import.

73 Wolfgang Lefèvre, "Rechensteine und Sprache. Zur Begründung der wissenschaftlichen Mathematik durch die Pythagoreer", in Rechenstein, Experiment, Sprache. Historische Fallstudien zur Entstehung der exakten Wissenschaften, ed. Peter Damerow and Wolfgang Lefèvre (Stuttgart 1981), 165.

74 Before embarking into the diairesis of weaving, the Visitor from Elea notes that (285d8-9) "no one in his right mind would be willing to chase the definition of the art of weaving for its own sake".

75 At 279a7-b2, the Visitor from Elea asks Young Socrates: "Which example (*paradeigma*) could we apply that, though extremely small, nonetheless shares the same kind of activity (*pragmateia*) with statesmanship and would enable us satisfactorily to discover what we are researching? What do you say, Socrates, if we have nothing else at hand, to taking the art of weaving?"

Conclusion

The first part of our contribution presented the conflict between the Indian Government and the weavers of Nagaland as a story where the technical and the social are intertwined in complex ways. One way to read the encounter between the TUF and the loin loom is to read it as an example of top-down policy making of the nation state, against a cultural way of life under threat. Another is to read it as an encounter between the narrative of modern textile technology as development through science, and the narrative of the loin loom as tribal culture. Both these readings create a kind of forced commensurability between the loin loom and the powerloom as technologies, where knowledge of science is universal and culture accounts for all incommensurability between technological societies. Instead, from our research on weaving in ancient Greece, we provide a reading of technology that accounts for its genesis – one where in essence technologies and societies are not separate actors. Not modern science encounters tribal culture, but the narrative of modern technology and its ordering of society encounters the Naga technology and its ordering of their society.

What then is at stake in the debate on upgrading the loin loom and developing the Naga society, is the negotiation of modern science and technology, and its economic imperatives of productivity metrics and growth with a society that does not distinguish living and weaving as separately social and technical. Yet, precisely because technical and social ordering is always ongoing, whether in the modern textile factory, or the traditional loin loom, this conflict comes from splitting them up – as work, and as life; as economically productive, and as social culture. This encounter becomes a negotiation of the mythologies and values each side holds. For the Naga weaver, for whom this separation does not exist, the conflict is perceivable only when the state attempts to change her material practices, in this case, to erase loin loom weaving.

It is precisely the absence of a platform for the negotiation of these two incommensurable narratives that keeps the issue unresolved. Thus we see a continuation of the same conflict, repeated over and over between each preceding modern textile technology proposed by the Indian State, and traditional loin looms. Rather than being silenced by the powerful Indian state's globalisation agenda, the Naga weaver persistently responds to the threat to her own technological ecology and myth. We could then conjecture that the connection of technology and society seems to be stronger and more stable in 'traditional' technologies like weaving, and even where conflicts appear, they have never been detached from the technology. Thus as sites of analysis by TASC, they mount a resistance to the separation of the domains of society and technology.

When, in the second part, we look at ancient Greece, we find similar modes of how weaving orders society. Thus, weaving as a technology, being rule based and binary in nature, plays a key role in determining the balance

of complex social relations and local ecologies. The fact that this is a central feature of hand weaving and not merely the outcome of specific 'cultural' factors is borne out by the vastly distinct examples that are presented here: of ancient Greece and modern Nagaland. By this we aimed to demonstrate that technology and society only became conflicting threads along history. In our reading, introducing technology as 'symbol' or 'anchor' or 'metaphor' used by societal groups in case of a conflict only produces an artificial divorce that it then tries to explain and remedy. Instead, we see the divorce as a historical result that goes hand in hand with the idea of technology being innovative and always ahead of a society in constant need of adaptation.

For Greece we also discussed a different mechanism of anchoring where new intellectual endeavours are in need of acceptance by a wider group in society. We make a case for the widespread and ubiquitous technology of weaving being able to contribute a common ground for new concepts of numbers, of political order, of cosmic generation and change, and even of philosophical classification (pure vs. applied knowledge). Some of these innovations sustain the textile tradition at least in metaphors, some appear to be neutral, but the most successful ones are clearly disruptive. Although Plato's introduction of dyadic arithmetic as pure science is interwoven with the paradigm of the *Statesman* as a weaver, he still casts them into the opposite modes of pure and applied knowledge. This innovation is familiar to us, while the details of textile technology in which the philosopher anchored those innovations for making them acceptable escape our understanding.

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