

Mining liquid gold: The lively, contested terrain of human milk valuations

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journals.sagepub.com/home/epn**Carolyn Prouse**

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Abstract

As global health organizations and national governments tout “breast is best,” the value of human milk is being calculated – and profited from – in increasingly diverse forms. In this paper I chart three of the major ways in which human milk is being economically valued: calculating breastfeeding as a contribution to a country’s GDP; buying and selling human milk to hospitals for profit; and manufacturing key components of human milk and the infant gut. In exploring these bioeconomies, I draw together two approaches to biocapital not often put into conversation with one another: a focus on the micrological generative capacities of biological material, and attention to the macrological biopolitical governance of populations. I argue that juxtaposing these bioeconomies demonstrates key features of human milk biocapital: the multi-scalar workings of reproductive biopolitical valuation and governance; the human and more-than-human ecologies (and labours) on which biocapital depends; and the feminist geographical contestations that shape, and sometimes undermine, these valuations.

Keywords

Biocapital, economization, bioeconomies, breastfeeding, reproductive labour

Emerging bioeconomies of human milk

In early 2017 Cambodia’s Cabinet ordered the Health Ministry to “take actions to immediately prevent the purchasing and exporting of breast milk from mothers from Cambodia” (AFP in Phnom Penh, 2017, para 5). Their target? Ambrosia Milk, an American start-up that was buying milk from women living in a so-called slum in Phnom Penh, fortifying it with nutrients, and selling it online at profit. The company maintained that they were offering “these women work where they are earning two to three times what they would

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be making elsewhere” (Cheang, 2017, para 13). The Cambodian government countered “Although Cambodia is poor and [life is] difficult here, it is not at the level that it will sell breast milk from mothers” (AFP in Phnom Penh, 2017, para 6). This event represents just one of the myriad ways in which human milk feeding is currently being monetarily valued and brought into circuits of exchange. As global health organizations and national governments tout “breast is best,” my purpose in this paper is to understand how the value of human milk is being calculated – and profited from – in diverse forms.

This paper takes as its inspiration recent work in bioeconomies that traces the valuation of nature, living beings, and lively material. Geographers of political ecology and science and technology studies (STS) have documented how diverse natures and bodily substances are variously commodified for both capitalist accumulative and social reproductive ends (Barua, 2019; Castree, 2000; Collard and Dempsey, 2013, 2017; Parry and Gere, 2006). The concepts biocapital (Cooper, 2008; Rajan, 2006) and biovalue (Waldby, 2002) designate how life itself is a main source of value in bioeconomic markets: the concepts capture

the transformation of living-being (typically at micrological registers of life such as genes, molecules, viruses, algae, and cells, but also at the level of individuals, as experimental subjects in drug development, and even populations whose health is coupled to information banks) into generative forms of capital through which further commodities and value are created. (Murphy, 2017: 13)

Geographers Rosemary Collard and Jessica Dempsey (2013) in this journal have shown the multiple scales at which biological liveliness can generate value, from the individual encounter of the trafficked monkey to the aggregated, social reproductive work of the mangrove forest. They follow Bronwyn Parry in thinking through how “lively commodities . . . retain their ‘vital and generative qualities’ – qualities that can produce capitalist value *as long as they remain alive and/or promise future life*” (Collard and Dempsey, 2013: 2684 emphasis in original). These scholars do not fetishize the biological; they argue that political economic forces are central to understanding bioeconomic value generation, including market structures, firm behaviour, and legal and regulatory regimes (see Rajan, 2006). STS influenced scholars, in particular, use the term “coproduction” to designate how the lively, generative qualities of biological materials articulate with both the technologies used to produce them and the political economic forces that help generate, isolate, produce, and calculate this value (Collard and Dempsey, 2013; Rajan, 2006).

In this paper I think through economic valuations within three bioeconomies of human milk feeding. I focus on: breastfeeding’s economization as part of a country’s GDP calculation; private corporations buying and selling human milk for profit; and biotech firms developing key components of human milk and the infant gut. Inspired by Collard and Dempsey (2013), I am particularly interested in how valuation in each of these bioeconomies depends upon: the liveliness of the material (i.e. the human milk tissue and the lively digestive ecosystems through which it circulates); the political economic processes that shape value accrual; and the biopolitical logics that shape the governance of macroeconomic life (see also Cooper, 2008; Cooper and Waldby, 2014; Guthman, 2015; Rajan, 2006). For each form of valuation I thus pay particular attention to: the means through which “value” is produced and calculated (i.e. as labour, asset, unpaid economic activity, speculative potential); and how the liveliness of milk – its understood biological properties – contribute to these diverse valuations at both micrological and macrological scales. Crucial to these processes is also the contested geographical terrain through which they play out – I thus pay attention to the frictions and contestations that shape milk biocapital in each market.

Juxtaposing different forms of human milk biocapital, as I do below, contributes to existing bioeconomies literature by demonstrating the multi-scalar workings of reproductive biopolitical valuation and governance; the more-than-human ecologies (and labours) on which biocapital depends; and the feminist geographical contestations that shape, and sometimes undermine, these valuations.

In what follows I briefly outline the shifting norms of breastfeeding that have fostered human milk as a new frontier of biocapital economization and valorization. I then discuss the rise of biocapital as a political economic regime that has coincided with the global promotion of breastfeeding. I draw together two approaches to biocapital not often put into conversation with one another: a focus on the micrological generative capacities of biological material, and attention to the macrological biopolitical governance of populations. While much work has been done to situate the biological in macrological structural capitalist processes (see Cooper, 2008; Cooper and Waldby, 2014; Rajan, 2006), there is less on how the micrological and structural relate to biopolitical investment logics at the scale of human populations. I analyze these relationships through three main examples of human milk valuation: the calculation of breastfeeding contributions to GDP, the commodification of milk by for-profit companies, and the manufacture and sale of the microcomponents of milk and the human gut by biotech firms. In so doing, I document how microscopic lively and chemical entities, such as bacteria, fatty acids, and immunofactors, are corralled to provide cost savings and the economization of life at a macrological scale. Each case has been fleshed out with data from human milk trade publications, biotech industry reports, breastfeeding conference presentations, market analyses, and interviews I conducted with breastfeeding NGOs and leaders of biotech firms. I close the paper by reflecting on what this juxtaposing of human milk valuations can elucidate for the geographies of reproductive bioeconomies.

Conjunctures of human milk and biocapital

Human milk sharing, commodification, and exchange have long histories and extensive geographies. In Europe in the 1600s, for instance, lactating women of lower classes breastfed infants of higher income families for low pay (de Almeida, 1999). Wet nursing was forced onto enslaved Black women in the Americas as a non-waged activity, with Black women feeding white slaveowners' children and, in places like Brazil, rented out to other families as a direct source of plantation income (de Almeida and Novak, 2004; Langland, 2019). But milk feeding is much more than just an economic exchange relation. Many different communities have long shared milk as a relational and familial activity. For instance, in Islamic societies the non-waged feeding of someone else's child is a way of establishing kinship (Ghaly, 2012). And in places that economically depend on parents and caregivers migrating for labour, such as in South Africa, infants have oftentimes been breastfed by neighbours and family members.¹ Milk sharing and exchange are thus practices shaped by political economic formations, but also exceed simple monetary valuations.

Breastfeeding norms at a global scale have also shifted significantly over time. During the 20th century human milk feeding was undermined by the development of the dairy and infant formula industries (the latter commonly called breast milk substitutes – BMS) and the promotion of dairy-based formula by pediatric societies (Swanson, 2014). But high profile stories about Nestle's nefarious practices (see Muller, 1974), and scientific evidence mounting about the “superiority” of breastmilk to formula feeding, has led the global biomedical establishment to promote “breast is best” since the 1980s. UNICEF and the World

Health Organization have issued a number of milk feeding policies and regulations over the last several decades, including the *Innocenti Declaration on the Protection, Promotion, and Support of Breastfeeding* (1990) and the *Global Strategy for Infant and Young Child Feeding* (2003). They have also established *The Code of Marketing Breast-Milk Substitutes* (commonly referred to as The Code) (1981) which constrains the marketing activities of infant formula corporations, and the *Baby Friendly Hospital Initiative* (2018), which promotes human milk feeding in hospitals immediately after birth. Many countries across the world have now adopted “breast is best” as public health policy, including India, Brazil and the United States. These countries’ breastfeeding recommendations, based on WHO and UNICEF guidelines, are for exclusive breastfeeding of infants up to six months of age and mixed feeding to one year and beyond.

At the same time, technological development has facilitated the separation of milk from the human body and the separation of the microcomponents of human milk. As Kara Swanson (2014) notes, refrigeration technologies have long been crucial to allowing milk to move, disembodied, between people; and the growing industry in breast pumps, alongside lack of parental leave in some countries, has normalized (and even monetized) this separation of milk from breast (see Fraser, 2016). Moreover, the biotech and genomic revolutions have created technologies that allow for the production and reproduction of microscopic entities in the lab (Cooper, 2008; Rajan, 2006), which, as I explore below, has facilitated the further separation (and indeed creation) of the microcomponents of human milk. In her popular bestseller *Lacktivism*, scholar Courtney Jung (2015) argues that these technologies (and lack of parental leave) have given rise to the notion that human milk feeding – not just breastfeeding – is best. In other words, public health messaging is now often focused on feeding infants human milk, not necessarily through the act of holding infant to breast.

The expansion of “breast is best” public health messaging beyond the breast has coincided with the rise of biocapital and new modes of biopolitical governance of life – political economic regimes that have facilitated the commodification of human biological substances such as milk. Work on biocapital, epitomized by STS scholars Kaushik Sunder Rajan and Melinda Cooper, draws together Foucauldian biopolitics and Marxist political economy to interrogate how life itself has become central to both governance and the accrual of capitalist value. Melinda Cooper (2008) charts the emergence of biocapitalist regimes from the political economic crises of the 1970s, in which industrial capitalism was forced to deal with the ecological limits to capitalist growth. The Reagan administration in the US, for instance, invested significant sums of money into the life sciences as an industry that could potentially internalize these ecological crises: using life itself as a way to generate surplus value (rather than depleting this life through industrial capitalist processes) via post-industrial innovation economies and emerging technologies in the biosciences. With the rise of genomic technology and the mapping of the genome, life at the level of the gene has become increasingly adaptable and speculative (Cooper, 2008; Cooper and Waldby, 2014; Guthman and Mansfield, 2012; Parry, 2008; Rajan, 2006). As Cooper (2008: 19) succinctly explains, the biotech revolution was “designed to relocate economic production at the genetic, microbial, and cellular level, so that life [would] become, literally, annexed within capitalist processes of accumulation.” This annexation has formed the core of new biotechnology sectors in multiple countries, such as the US, India, and China, in which firms, funded by risk-taking venture capitalists and sometimes the state, invest in the potentials to corral life.

Processes of neoliberalization have occurred hand-in-hand with the speculative potential of (genomic) life. As social welfarist reforms were rolled back throughout much of the Western world, and as social reproduction was downloaded onto the family and the individual, biological and reproductive life has increasingly been opened up to

commercialization (Fraser, 2016; Katz, 2001; Pratt, 2004). The rise of biocapital has also been facilitated by stark neoliberal changes in the regulatory environment in the United States, in particular: in the 1980s, a series of patent cases allowed for the protection of intellectual property in genetically modified organisms and life itself, which has been increasingly internationalized through TRIPS – The Agreement on Trade-Related Aspects of Intellectual Property Rights – effectively extending America’s hegemonic patent laws globally; and biotech firms were able to list themselves on the NASDAQ without having a product, with their intellectual property (i.e. patents) now counted as part of their firms’ assets (Cooper, 2008; Rajan, 2017, 2006). Here, the financialized logics of neoliberal capitalism resonate closely with the speculative potential of research into biotechnologies: Cooper (2008) and Rajan (2006) argue that the two have arisen partly as a function of one another, with the micrological potentials and capacities of lively material central to financialized value accrual.

Biopolitical governance has simultaneously been transformed at the macrological scale, in which a population’s life is targeted and managed to facilitate the economic growth of a nation. Feminist STS historian Michelle Murphy (2017) argues that this is another phase, or aspect, of biocapital. Hand-in-hand with the management of the cell, the gene, and the microbe, has occurred the “economization of life,” a

historically specific regime of valuation hinged to the macrological figure of national “economy.” It names the practices that differentially value and govern life in terms of their ability to foster the macroeconomy of the nation-state, such as life’s ability to contribute to the gross domestic product (GDP) of the nation. (Murphy, 2017: 5–6)

The Chicago School’s formulation of human capital has been central to this macropolitical economization. Human capital is “the embodied capacities of a person that can produce future economic benefits for that person, her employer, and even her national economy” (Murphy, 2017: 115). In other words, in this regime of valuation, people and populations are understood and treated as investable objects with potentials for economic return. Pivoting from population control techniques (i.e. “family planning”) of the 80s and 90s, international financial institutions and corporations now view investments in youth education, for instance, as a way to increase potential future productivity, thus fostering GDP for a nation (Murphy, 2017). This biopolitical governance at the level of the population resonates with investment logics of financialized capital (see also Roy, 2010) that have targeted the potentials of the cell, microbe, and gene discussed above. However, these investments are premised on the lively, productive capabilities and contributions of people at the scale of the national population to macroeconomic indicators like GDP.

Murphy argues that these regimes of investment operating at the macrological scale are not about human capital-as-labour per se. Rather, they are about the biopolitical management of human capital – of life itself – to control the economy. Drawing on STS approaches to markets (see Birch, 2017; MacKenzie, 2004), Murphy (2017) argues that a whole regime, or infrastructure, of calculatory logics, scientific institutes, big data, anticipatory affects, and spreadsheets help create the “value” of these population-level investments through, for instance, calculating future contributions to GDP. While different in technique and scale from the accrual of surplus value through micrological life, this macrological form of governance shares with the former a financialized investment logic and a commitment to capitalist economic growth through governing particular (gendered, racialized) forms of life.

Human milk feeding and new circuits of milk exchange highlight both the macrological and micrological workings of biocapital, and the commodification and biopolitical logics

that shape reproductive markets. I explore these articulations through three types of milk valuation below. In each section I chart the different way value is produced, understood, and calculated, paying attention to the liveliness of the milk, the labours involved in producing value, the biopolitical logics that inhere in each, and how each type of valuation has been developed through what Rajan (2006: 4) calls “frictioned terrain,” or contested, negotiated geographies.

Breastfeeding as investment in human capital and GDP futures

In 2016 the World Bank’s then-Vice President for Human Development, Keith Hansen (2016), wrote in the prestigious science journal *The Lancet* that breastfeeding is “excellent economics.” He continues,

Breastfeeding is a child’s first inoculation against death, disease, and poverty, but also their most enduring investment in physical, cognitive, and social capacity. When we nourish a child, we drive future economic growth . . . Breastfeeding reduces infant morbidity and mortality, increases Intelligence Quotient (IQ) score, improves school achievement, and boosts adult earnings – all essential for reducing poverty. (Hansen, 2016: 416)

Even before 2016, prominent economists promoted breastfeeding as a key contributor to national economies, one that was neglected by national measures of economic prosperity. For instance, Joseph Stiglitz and Amartya Sen, in their report of the 2009 French Presidential Commission on the Measurement of Economic Performance and Social Progress, argued the inadequacy of GDP to capture unpaid production: “There is a serious omission in the valuation of home-produced goods – the value of breastmilk” (Stiglitz et al., 2009: 39; see also Smith and Folbre, 2018).

These prominent economists echo feminist economists, such as Marilyn Waring, who have long been calculating the economic contributions of human milk to national economies. The prolific economist Julie Smith, for example, argues that the UN System of National Accounts (whose central element is the GDP) is “applied patriarchy” (Smith, 2018: 3; see also Waring, 1988) because it does not account for unpaid “productive” care-work in the home, such as breastfeeding. In a move that Smith & colleague Nancy Folbre (2018) call perverse, industrial infant formula production is seen as increasing GDP, while breastfeeding remains under-valued and unaccounted. Smith argues that human milk feeding is a particular kind of domestic labour that should be counted within GDP because it is both an unpaid household service (therefore a “satellite account”) (Smith and Ingham, 2001); and a commodity, with breastmilk able to be produced, stored, and sold, thus meeting “the official criteria for inclusion in GDP” (Smith, 2018: 11). The feminist economists’ overall goal in making these arguments is to use the value of human milk production to pressure nation-states to invest in maternity and parental leave and protections.

One of Smith’s research agendas is to calculate the national productive value of breastfeeding for various countries. She does so using a “market value of output” approach (Smith, 2018: 11). Smith draws on the already-existing price of donor human milk in the Norwegian health system (priced at \$100/L in 2018) and available UNICEF, WHO and/or country-specific data on birth rates and breastfeeding rates in various countries. Using this calculation, Smith argues that the global value of human milk production (at current breastfeeding rates and the aforementioned “market” price) is US\$2,331 billion.

Other economists and development practitioners are conducting cost-benefit analyses to assess specifically the *return on investment* that national governments would realize if they

spent public funds on breastfeeding support (see WHO, 2016). Their starting point is that infant and child morbidity and mortality are economic losses on two fronts: costs to the health care system in disease management, and costs in future economic production of the lives lost. Economists in Canada, in collaboration with economists and development practitioners in Indonesia, Thailand, and Vietnam, published a landmark study in 2016 comparing the “benefits of a health programme in terms of monetary units (e.g. health cost savings, economic productivity benefits)” with the “costs” of implementing and scaling up already-existing breastfeeding promotion programs (Walters et al., 2016: 1109).² Their results show a large return on investment:

The primary monetary benefits in the form of health systems savings due to reduced treatment of child illnesses and cognitive losses averted totaled US\$72.14 million. Overall, this scenario would generate human benefits of 200 child deaths averted and a BCR [benefit-cost ratio] of \$2.38 for every \$1 invested, or a 139% return on investment. (Walters et al., 2016: 1114; see also Holla-Bhar et al., 2015)

Breastfeeding is thus here calculated as an investable activity that has significant economic returns in the future. Such a calculation resonates with the economic logic of ecosystem services (ES), in which “nature itself” – including women’s work assumed to be natural – “must no longer be treated as a free amenity to be taken for granted, but priced and integrated into economic functions so that it might be valued” (Battistoni, 2017: 6; Collard and Dempsey, 2013; although see Dempsey and Robertson, 2012 for the heterogeneity of value calculation in ES). The specific mechanisms through which breastfeeding returns are calculated and priced are by averting death and cognitive loss.

Indeed, one of the key “returns” on investment that economists increasingly cite is heightened IQ (Intelligent Quotient) and its contributions to future Gross National Income (GNI). As Walters et al. (2016) argue above, human milk is thought to contribute to intelligence and thus future earning potential. Economists who make this case often cite the influential studies of breastfeeding scientists Cesar Victora, Bernardo Horta, Nigel Rollins, and their colleagues. One of these studies, a meta-analysis of breastfeeding research for the WHO, “suggests that breastfeeding is associated with increased performance in intelligence tests in childhood and adolescence” (Horta and Victora, 2013: 61) – an increase of 2.19 IQ points with maternal IQ and socio-economic status variables controlled. The authors of this report, Horta and Victora (2013), postulate that it is breastmilk’s fatty acids (specifically docosahexanoic acid (DHA) and arachidonic acid (AA)) that facilitate cortical development in infants’ brains, thus contributing to IQ development and future earnings. Economists have drawn on this data to calculate the future earning potential – and contributions to GNI – associated with higher IQ (see Hanushek and Woessmann, 2008); and IQ and future earning losses associated with present-day lack of breastfeeding (see Rollins et al., 2016). The latter, a highly-cited study published in *The Lancet* in 2016, estimates a current global loss of \$302 billion in GNI due to low breastfeeding rates. Julie Smith (2018: 15) uses this data in her own influential work to argue that these cognitive losses are losses in “Human capital... harming educational achievement, and ultimately a nation’s productivity.”

There are a number of ways that the “value” of breastfeeding is being calculated by these macroeconomists. The first, following Julie Smith, is as productive activity, the value of which is calculated using the already-existing price of donor human milk. The second way value is understood is through breastfeeding as an investment that decreases national health-care costs of infant morbidity and mortality. Finally, the value of milk is calculated as contributing to future GNI and GDP through a series of future-oriented dependent

steps: current breastfeeding is thought to facilitate IQ development, which translates into future educational attainment followed by future high-waged employment.

All of these calculatory logics take the population and GDP as a site of biopolitical management. In other words, they represent what Murphy calls the economization of life. The latter two, in particular, epitomize the human capital, investment logics of macrological biocapital: they value breastfeeding as averting losses (of life and of IQ/GNI) at an agglomerated scale, with return on investment being realized in the future. Here women (or lactaters) are investable in economic terms – as bits of human capital – who will produce lively and productive children, costing the healthcare system less and contributing to future GNI. The mechanism for this “return” on investment is understood as the lively, biological material within human milk: breastmilk’s fatty acids. The biological material itself is not turned into a commodity that accumulates surplus value; rather, value is calculated through numerous metrics and cost-benefit equations. This infrastructure of calculatory knowledge includes economists’ papers, online costing tools, and conference presentations. The economists’ mode of valuation – their calculations – agglomerates the effects of this lively biological material at the scale of GDP.

Labour, however, is a central yet often unacknowledged source of value in this economization. Indeed, it is women’s unpaid reproductive labour of lactating and feeding infants that underpins these calculations and realizes the return on investment in the future. While Murphy’s (2017) STS perspective privileges the calculatory infrastructures that economize life, this case demonstrates that macrological biocapital can depend quite significantly on material reproductive labour: breastfeeding one’s child. In other words, GDP and GNI values, potentially realized in the future, are subsidized by reproductive labour in the present, particularly when that labour is not remunerated or supported by maternity and parental benefits.

Many feminist economists do indeed make these macroeconomic calculations to compel governments to financially support breastfeeding, and their calculations have arisen out of struggles against the “patriarchal nature” of GDP. However, there is a risk that the calculatory infrastructure – and the technocratic, economic figures of GDP and GNI – will make these lives investable only insofar as they are useful as future productive units within a national population. In other words, if for reasons of disability, sexuality, race, or caste someone is not deemed potentially productive of future value then they might not be supported. Moreover, these efforts could amount to a calculatory “fix” that merely counts breastfeeding as economic value, thus disrupting the patriarchal character of GDP, without remunerating or economically supporting those who breastfeed. This becomes a reproductive labour “fix” when larger structural conditions (such as lack of maternity leave) are not taken into account.

Commodification of disembodied milk

The most obvious way in which milk is valued is when it is turned into a commodity, such as through the activities of Ambrosia Milk described at the beginning of this paper. There are many different ways in which human milk is being bought and sold, from large multi-million corporations selling “highly innovative” human-milk derived formula, to peer-to-peer online platform economies that sell milk at US\$2 per ounce. In this section I focus specifically on how private, for-profit human milk corporations commodify milk. I pay particular attention to how specific forms of labour and processes of assetization create value in this bioeconomic market. My geographic focus here is chiefly the United States: it is in this

country that the largest private milk corporations are located, due to the supportive bio-capital regulatory environment described at the beginning of this paper.

Prolacta Bioscience is the largest corporation trading in human milk. Prolacta is a private, California-based company that creates specialty products derived from breastmilk. The firm buys milk from lactating people (called donors) and creates multiple products, including “donor milk,” a full milk feeding product, and “human milk fortifiers,” a supplement of human proteins and carbohydrates that can be added to one’s own milk or infant formula (see Prolacta Bioscience, 2020). Prolacta buys milk from donors at a rate of US\$30/L in their affiliated milk banks, and sells their products for almost US\$300/L to American hospital neonatal intensive care units (NICUs) (Lopez, 2013) and through website sales direct to consumers. In late 2018 Prolacta claimed that its fortifier was in almost 40% of Level III and IV American NICUs (those caring for infants most seriously ill) (Prolacta Bioscience, 2018). Prolacta is thus financed partly through the direct manufacture and monetization of the human milk products that they sell. They are also, however, financed by venture capital and private equity firms, recently receiving \$35 million in Series E Preferred funding from Health Evolution Partners Fund and Aisling Capital IV, L.P (Prolacta Bioscience, 2016). Indeed, private fundraising has become so important to its economic model that venture capitalists and economists of private healthcare systems now comprise the majority of the company’s Board of Directors.

Prolacta Bioscience markets its milk to hospitals through a cost savings logic. Their promotional materials advocate the “cost effectiveness” of Prolacta fortified human milk: they compare the costs of the fortifier against NICU care for “prematurity-related morbidities and interventions” that human milk can help combat, such as medical necrotizing enterocolitis (NEC) (\$74,004/baby) and surgical NEC (\$198,040/baby) (Prolacta Bioscience, 2017: 2). Prolacta Bioscience (2017: 7) argues that, according to their calculations, an “exclusive human milk diet” (including the use of their human donor milk-based fortifiers instead of cow-based formula) results in 4.5 fewer days of hospitalization and a \$27,388 cost savings per Very Low Birth Weight infant. Here, human milk is posited as an investment in the future life of infants and the future savings of hospitals, justified through a cost-benefit analysis.

Prolacta protects its market share through extensive patenting. The company’s intellectual property includes both the *processes* for creating fortifiers, and the *actual composition* of the fortifiers and donated milk. One patent, for instance, is for “methods of making compositions that include a human lipid” such as “separating the milk into a cream portion and a skim portion” (US Patent No. 8,377,445 B2), while another is for “methods and systems for diagnosing or screening human milk samples to confirm that the milk is from a defined source” (i.e. using genetic information as identity markers – US Patent No. 8,628,921). Prolacta holds a patent for a logistical method to identify human milk with a number, a patent protecting the composition of permeate (milk components derived from pooling donor milk), and a patent for the methods used to isolate this permeate and add it to formula. Most of this intellectual property has been “invented” by founders and employees of the company.

As a result of these patents, Prolacta has held a virtual monopoly in the American market of human milk, and has filed lawsuits against companies they deem to be stealing trade secrets. Prolacta recently lost its lawsuit against the newer American human milk company Ni-Q (see Simon, 2019), but has engaged in a five-year battle with Elena Medo (one of the founders of Prolacta) and her company, Medolac, over manufacturing knowledge. (Medo counters that this is publicly known information in the industry – see Anderson, 2020). The lawsuits have impacted Medolac’s finances to the extent that this company – the second

largest milk corporation in the US – is not currently paying its donors for milk until the case is resolved.

The favourable biocapital regulatory environment in the United States has made it one of the few nations in which milk companies can legally buy milk from donors, but it is not the only place in which emerging biotech firms are looking to capitalize on milk-derived biological material. And these for-profit models of milk selling have been extremely controversial where they have been rolled out. For example, the new for-profit company Neolacta Lifesciences in Bangalore, India has sparked outrage in that country for not paying its donors (Yasmeen, 2016). Controversies also haunt the buying and selling of milk in the US: for example, Medolac initiated a campaign in Detroit that offered to buy milk from African American women for low sums of money, but was quickly quashed when Black breastfeeding advocates such as Kiddada Green (2015) called this practice hyper exploitative. And Cambodia outlawed the buying and selling of milk in their country due to the exploitative practices of Ambrosia Milk buying milk from impoverished women. Turning milk into a commodity is thus fraught, with both judicial and feminist contestations over milk commodification active in shaping the legal regimes that allow for milk to be bought and sold.

A number of processes are central to the valuation of milk-as-commodity within the private American company. In the example of Prolacta, money is often directly exchanged for the milk: the company pays lactators, and sells the microcomponents of their milk to hospitals. The lively capacities that make this milk valuable, according to Prolacta and Medolac, are immunofactors that prevent costly diseases such as gastrointestinal issues (like NEC) and respiratory infections, especially in low birthweight babies. For-profit companies like Prolacta are also funded in part through venture capital firms that are hoping for a future return on investment, which is increasingly protected by monopolistic patent protections, themselves a function of the current conjuncture of biocapital in the United States (see Cooper, 2008; Rajan, 2006).

Two forms of labour are central to producing the value of the human milk commodity in these firms' activities. The first is the reproductive labour of the milk donors: it is their internal metabolic labour that produces the milk (and the social reproductive care that goes into maintaining a body that can lactate), and the actual labours of pumping and sending milk to the corporation (the latter remunerated in a low waged way). This type of reproductive labour resonates with what Cooper and Waldby (2014: 8) call clinical labour within post-Fordist life science industries: it is an "activity . . . intrinsic to the process of valorization of a particular bioeconomic sector . . . when therapeutic benefits to the participants and their communities are absent or incidental." Selling human milk is a form of clinical labour in that the activity is highly valorized elsewhere (in the firm) and the people who sell it are often not paid well and they, and their children, do not receive therapeutic benefits.

Much of the value that Prolacta accrues, however, is through "innovative" labour and intellectual patent protections. As Cooper and Waldby (2014: 9) explain, "the life science business model is organized around a classical (Lockean) labour theory of value which identifies the cognitive labor of the scientist as the technical element necessary to the establishment of intellectual property in living matter" (see also Parry, 2008). In the Prolacta case, the scientists use their intellectual labour to collect, supplement, and package the donated human milk, and the firm protects these processes through intellectual property patents. Indeed, the patents are so important to facilitating the manufacture and exchange of life science products – often through monopolistic control – that Kean Birch (2017) argues they are the most important valorization step in life science commodity chains. Although creation of the patent depends on intellectual labour of the scientist, as described above, once in

existence the patent becomes a form of asset or property that the company holds, and which can accrue value in the future (Birch, 2017, 2019). Birch (2017: 469) continues, “Rather than commodification, the creation of knowledge (or other) assets is more appropriately conceptualized as a process of assetization... [T]hat is, the transformation of something (eg. Knowledge) into a revenue-generating and tradeable resource.” The patent, to Birch, is both a resource that helps produce the commodity (eg. the milk fortifier), and generates an income stream when that patent is licensed to other companies that can manufacture the product. Venture capitalists trade on the future promissory values of corporations’ patents when they invest in companies like Prolacta (see also Cooper, 2008; Rajan, 2006). However, as exemplified by Prolacta’s patent battles, monopoly control takes place on contested terrain, with intellectual property laws, legal precedent, and courts being vital to value accrual.

The buying and selling of human milk and human milk fortifiers exemplify the articulation of multiple characteristics of biocapital. For instance, the micrological lively, generative aspects of the substance – milk’s immunological factors – are central to valorizing the commodity (particularly through a cost-savings investment logic); much of the firm’s value is in its assets (i.e. intellectual property rights in patents); and multiple forms of labour, most importantly clinical/social reproductive and innovative labour, are central to the commodification process. Moreover, a focus on human milk commodification reveals a highly contested terrain of struggle through which profits are realized (or not): concerns over exploiting women (especially racialized women in lower-income communities) have defeated commodification efforts and have inspired new legal regimes that outlaw the buying and selling of milk in some parts of the world, such as in Cambodia. Finally, this case shows the articulation of commodifying reproduction with biopolitical governance at the macro scale: while large milk corporations are not concerned about infants contributing to a nation’s future earnings, they are focused on investment that can realize value and return at the agglomerated scale of the hospital population through protecting (some) life.

Manufacture and commodification of human milk ecosystems

The above two cases have explored how human milk and breastfeeding are being valued and commodified. My focus in this final section is on another group of high-value industries that significantly overlap with the milk commodification sector, one that is increasingly oriented to the very composition of milk itself. These are industries trading in the components of human milk ecosystems – the micrological relational entities that comprise human milk itself and the microorganisms that digest it. These industries include: the infant formula (breast milk substitute – BMS) industry, which has long created products trying to mimic milk’s nutritional composition; new firms manufacturing micro-components of breastmilk to be added to infant formula; and biotech companies creating microorganisms for the infant gut (eg. probiotics) that interact with key components of human milk. The latter two industries capitalize on the microbiome, “the diverse and sizable community of microbes contained within (and on) the human body” (Leiper, 2017: 2). While their products are not the same, I group the three industries here, loosely, as they represent scientific efforts to separate milk from the human and to understand the biology of human milk and its interactions with the infant gut – the human milk ecosystem.

The BMS industry has long been vested in trying to mimic human milk for infants. It has historically used bovine (i.e. cow’s) milk because it was seen as containing nutrients similar to those found in human milk. The industry has refined its bovine-based products over time to make them more human-like. Despite declining consumption of infant formula in the

Global North, investors expect the BMS industry to continue growing significantly due to emerging formula markets in Asia – China is now the fastest-growing BMS market in the world (Moreau, 2018). The largest global BMS industry players are recognizable names, including Abbott Laboratories, Nestle SA, Kraft Heinz Food Company, Group Danone, and Mead Johnson Nutrition, with firms in Asia, such as Yili Industrial Group (China's largest dairy producer and infant formula manufacturer), gaining a sizable market foothold (Coherent Market Insights, 2018). BMS companies currently invest significant time and money into research and development (R&D) to develop premium, closer-to-human products, and are partnering with smaller firms that study and help manufacture human milk microcomponents.

Academics and scientists studying mammalian nutrition have driven much of the research into the composition of human milk. University of California-Davis has emerged as a hub in this endeavour, spearheading the International Milk Genomics Consortium, with the goal to identify through genomics and bioinformatics techniques the mammalian genes involved in lactation (see German et al., 2006). They also aim to identify what the components of milk actually do for the infant and mother. Their research has found milk to be a substance that provides nourishment, transfers immunofactors to prevent disease, stimulates infant development, regulates mammary tissue development (and potentially prevents reproductive diseases like breast cancer), and, crucially, assists in the “inoculation, colonization, nourishment, regulation and elimination of infant microflora” (German et al., 2006: 658). They, alongside other scientists investigating human milk, have been particularly interested in the presence of more than 150 types of human milk oligosaccharides (HMOs) – a macronutrient hugely abundant in human milk (third in mass after fats and lactose, excluding water) but one that is not digested by infants. Scientists and nutritionists have long been perplexed by the function of HMOs, until recent research has suggested they provide multiple functions in the infant's digestive tract: they might act as a decoy for pathogens (thus conferring immunological benefits), and as a crucial prebiotic (i.e. food) for healthy bacteria in the infant gut (Smilowitz et al., 2014). In other words, research into human milk has increasingly focused on its relational geography with the more-than-human biological functioning of the infant: HMOs are not food for babies, but are food for the microorganisms found in “healthy” babies. They represent a specific, lively relation between milk and an infant's GI tract.

HMOs have now become a new frontier of research and development, manufacture, and profit. Biotech R&D in HMOs has become, according to milk chemist Steven Townsend, “an arms race to see how many compounds they can make and get into products” (Wetsman, 2019, para 5). Companies are trying to isolate and produce HMOs in a variety of ways. Medolac is at the forefront of trying to isolate HMOs from donated human milk, but this approach has limited profitability insofar as it depends on milk supply (i.e. the amount of milk donated by lactating people). Cow's milk has many carbohydrates structurally similar to HMOs, thus researchers at UC-Davis are attempting to extract these oligosaccharides from bovine fluid. However, most of the excitement around HMO development is through manufacturing them in the lab, where growth is not limited by the amount “naturally” produced by lactating people and cows. Lab manufacture is occurring through two main mechanisms: chemical synthesis (performed by Danish biotech firm Glycom - Wetsman, 2019); and synthesis through using genetically engineered microbes such as yeast (by Bay Area start-up Sugarlogix - Farr, 2019) and the bacteria *E. coli* (by German company Jennewein Biotechnologie).

These HMOs are being added to infant formula products largely through new partnerships between HMO biotech firms (which have designed and hold patent rights in HMO synthesis) and BMS and chemical manufacturers (which have the capacity to scale

production and inject HMOs into infant formula). For instance, in 2011 Nestle acquired a large stake in Glycom and has since released numerous products containing Glycom's HMOs (2'FL and LNnT, specifically) (Wetsman, 2019). Another HMO biotech firm, Glycosyn, that has significant intellectual property and patent rights in HMOs, has teamed up with the German chemical manufacturing giant BASF to produce HMOs for infant formula and other possible products, such as pharmaceuticals and cosmetics (Mahmoud, 2019). This partnership involves exclusive licensing of Glycosyn's patents to BASF. Jennewein, widely recognized as a world leader in HMO production and the first company in Europe to patent a recombinant bacterial process for food production, has its HMOs in Abbott's Similac, and has recently entered into a formal partnership with China's Yili (Tay, 2019).

The research, development, and marketing of HMOs has also fostered a related market in those organisms that digest HMOs: infant gut bacteria, commonly known as infant probiotics. Scientists at UC-Davis (some of those involved in the aforementioned International Milk Consortium) found, through genetic sequencing, that a key infant gut bacteria that digests HMOs, called *B. infantis*, is missing from many infants in the Western world, although appears to be more common in infant guts in the Global South (Frese et al., 2017).³ The scientists have hypothesized that this bacteria has decreased dramatically in hyper-sanitized, antibiotic-rich Northern countries, in places where formula feeding instead of breastfeeding is the norm, and in countries and hospitals that have high Caesarean section rates (where infants are not exposed to maternal fecal matter) (Evolve Biosystems Inc., 2019; Frese et al., 2017). This group of researchers has, in response, developed and patented the activated form of *B. infantis* and its effect on the infant gut. In 2012 they created a UC-Davis "spin-out" biotech firm called Evolve BioSystems (EB) that produces the activated bacteria under the trade name Evivo: "a probiotic powder that is mixed with breast milk and fed to babies each day to help release nutrients in breast milk and create a protective internal environment in baby's gut" (Evolve, 2019, para 1). They have done so, according to Evolve's scientists, to create products for a group of people generally not prioritized in biomedical science – women and children. Evolve sells Evivo primarily to hospitals in the United States to relieve infant gut dysbiosis, a microbial imbalance associated with inflammatory bowel disorders. After significant advocacy work, this biotech firm has caught the eye of philanthropic organizations, recently becoming a portfolio company of the two largest private foundations in the world, the Bill & Melinda Gates Foundation and the Li Ka Shing Foundation (Evolve, 2018).

The geography of *B. infantis* (and biomedical practices like antibiotic treatment) is, according to EB, a key factor in why the Gates Foundation has invested in the company: as Gates looks to roll out antibiotics throughout much of the Global South (thus potentially killing *B. infantis* elsewhere), and as the global health establishment promotes breastfeeding instead of formula feeding, they will open up new markets to sell this bacteria: "they want antibiotics to save babies, so we're going to have to put this [bacteria] back [into infants]."⁴ The Foundation's investment in Evolve Biosciences is part of Gates' goal to "Promot[e] a healthy microbiome [as] a key element of addressing infant and neonatal health in regions that face a high burden of enteric infections and malnutrition"; they are "excited by the potential of Evolve's activated strain of *B. infantis* to address these challenges and create a healthy infant microbiome for the world's most vulnerable children" (Webster, 2018, para 14). Gates' decision to invest in *B. infantis* is part of the Foundation's purpose to realize savings on investments in health: economists at the foundation calculate the "relative cost-effectiveness of products in our pipeline" (Walker, n.d., para 3) and support those products that have beneficial cost-benefit ratios. One major benefit of *B. infantis* that they calculate is

reducing infant morbidity and mortality, thus fostering GDP, the life of the population, and savings in healthcare costs. Investments in this micrological bacteria are thus being calculated and justified through macrological calculations and return-on-investment logics operating at the biopolitical scale of the population, again bringing into intimate relation the multiple scales of biocapital.

The value accrued and costs saved in these new human milk ecosystem markets depends on the liveliness of micrological entities beyond the direct commodification of the HMO or bacteria. Indeed it is, in part, the “natural,” cost-savings work done by microorganisms and other micrological entities in human milk and infant guts that helps accrue value. For instance, in its everyday functioning, *B. infantis* is believed to help prevent infant gut dysbiosis; its presence and “normal” behaviour is thus said to provide financial savings to hospitals and countries as it helps reduce costly infant diseases. Here, *B. infantis*, and the broader human milk ecosystem (including the bacteria’s food, HMOs), is engaging in what Barua (2019) calls ecological labour: the bacteria help regenerate (human) ecosystems that are themselves valued and costed in diverse ways (such as through hospital budgets), without always being totally subsumed by capitalist processes themselves. This labour involves the “quotidian rhythms and ethological propensities [of non-human life that] in their demise or absence . . . are felt” (Barua, 2019: 655) and ultimately very costly to replace (Battistoni, 2017). The framing of these rhythms and propensities as *labour* – as opposed to *natural capital* common to the ecosystem services literature – points to the centrality of eco-social reproduction, regeneration, and living work constituting this capital (Barua, 2019; Battistoni, 2017). In other words, the regenerative and living ecological labour of microbes is constitutive of the living biosphere (including infant gut ecologies) that, when absent, cost national economies and hospitals. Understanding this ecological regeneration as labour, rather than natural capital, politicizes this more-than-human work, de-instrumentalizes the category of natural capital, and foregrounds the subjectivity and collectivity central to nonhumans’ activities within the capitalist economy (Battistoni, 2017).

In all three cases discussed in this paper, a “properly functioning” human milk ecosystem (comprised of fats, HMOs, lipids, immunofactors, and gut bacteria) is performing ecological labour that produces a cost savings to GDP through averting the loss of future productive lives; saving costs to individual hospitals by averting expensive infant disease; and potentially averting future disease/death in parts of the world where malnutrition is high and antibiotics are becoming more prevalent. Thus, while human milk biocapital produces and commodifies the more-than-human components of human milk ecosystems (i.e. HMOs, probiotics), it also relies on the ecological labour of these ecosystems to realize a cost savings, labours which are thus central to the national scale, biopolitical investment logics that shape these bioeconomies.

Multi-scalar reproductive formations of biocapital

The above cases have demonstrated the vastly different scales at which human milk feeding is being economized and valued. I have explored valuations of human milk as part of a regime of biocapital – the biopolitical governance and surplus generation of life itself. I close here with a brief discussion about what juxtaposing these different forms of valuation reveals about biocapital: specifically, how it operates across micrological and macrological forms of life through contested geographical terrain.

While each of the cases focuses on a different scale of valuation – from a nation-state’s economy to the microscopic microbe – each points to the interscalar character of biocapital accumulation. In other words, each represents the confluence of micrological and

macrological governance of life. Macroeconomists' calls to invest in breastfeeding operate most obviously at the macro, biopolitical scale of the GDP, yet also draw on science about the micrological functioning of fatty acids that promote cognitive development, fostering arguments about future earning potential and contributions to GNI and GDP. The commodification of human milk by Prolacta and the company's appeals to saving hospitals' costs (and infants' lives), depend on the micrological functioning of immunofactors found in the milk itself. Finally, the commodification of microscopic bacteria and HMOs are increasingly being supported by global health foundations, such as the Bill and Melinda Gates Foundation, to decrease morbidity in lower-income countries and, in so doing, facilitating GDP growth and life. This paper has thus shown that micrological and macrological, political economic and biopolitical forms of biocapital articulate and uphold one another, particularly in reproductive bioeconomies focused on infants' futures.

Each case also demonstrates how the biopolitical goals of managing life are underpinned by labour, both social reproductive and ecological. Cost savings are realized through a more-than-human ecosystem – specifically the components of a human milk ecosystem – that serves as both a frontier of accumulation and a form of ecological labour. Components of the human milk ecosystem (including the milk tissue, HMOs, gut bacteria) are directly commodified, exchanged, and licensed as intellectual property and products. More subtle are the less direct forms of valuation and labour that make milk biocapital profitable and worthy of investing in. The normal functioning of the ecosystem, said to be “restored” through human milk feeding, reduces costly infant disease and death, therefore saving countries, hospitals, and families money. More-than-human ecosystem functioning is thus a key component of investment logics and monetary accrual shaping these bioeconomies. This milk ecosystem represents, too, the overlapping of biological and social reproduction, in which lactaters' labour, in sustaining themselves and caring for their bodies, is both directly and indirectly undervalued, from paying donors low wages for milk, to realizing cost savings through one's non- or low-remunerated breast-feeding and milk pumping activity.

Finally, these markets and valuations have not arisen simply or directly as a result of capitalist profit imperatives. Instead, they have taken shape through what STS scholars call frictioned terrain – in human milk bioeconomies, a frictioned terrain informed in part by different kinds of feminist fights against patriarchal regimes. Feminist economists calculate milk as a form of GDP, for instance, because they view standard GDP measures of productivity as “patriarchal”; they use the tools of their discipline to calculate (and thus valorize) domestic, household activity like breastfeeding so that it “counts.” Moreover, efforts to directly commodify (i.e. buy and sell) human milk have proven extremely contentious, and have inspired many countries to outlaw the sale of milk. Even in the United States, in which much of the legal buying and selling takes place, efforts to exploit marginalized populations (such as Medolac buying milk from Black mothers in Detroit) have met with swift and successful opposition. And the patenting of milk and microbes sets the stage for numerous legal battles and patent law precedents that shape a firm's ability to operate. While these contestations exceed feminist struggles, the examples also demonstrate how feminist responses can be at odds with one another: some focused on economizing life to make women's work “count”; others promoting new markets for under-valued demographics (such as women and infants); and others, especially those led by racialized women, attempting to ensure Black women and people of colour are not further exploited. Ultimately the examples show that there is nothing “natural” about human milk feeding, and nothing direct or simple about human milk feeding valorization. Rather, these processes

have taken shape through uneven and multiscalar geographical terrain that continues to be reconfigured through bioeconomic market contestation.

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Notes

1. Interview with NGO worker in Durban, South Africa, November 2018.
2. The authors identify six areas in which supporting breastfeeding could improve financial costs: the cost of infant formula (as share of per capita income); child mortality (due to diarrhea and pneumonia); health systems costs in treating these diseases; maternal mortality (slightly increased risk of breast cancer when not breastfeeding); indirect costs (travel and caregiver time); and cognitive losses and associated future income losses for children not breastfed up to 6 months (the latter citing Horta and Victora, 2013; Rollins et al., 2016).
3. Interview with researcher at UC-Davis 4 June 2019.
4. Interview with researcher at UC-Davis 4 June 2019.

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