Global Electronic-Waste Recycling:

Constructing a new form of resource extraction for an old industry

By

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Abstract

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This dissertation focuses on the convergence of specialty metals production with global South e-waste recycling. My research, described in a series of three chapters in this dissertation, links two themes – the political economy of natural resources and the politics of representation – through the idea of sustainability. Sustainability represents economic goods such as efficiency, conservation of resources, and stability (Miller, 2013). In the case of e-waste, it has also come to represent solutions to e-waste problems that are driven by scientific authority, a new and improved identity for an old industry, and a gloss that masks neocolonial relations of extraction. Each of the three chapters traces aspects of these two themes and presents the different ways sustainability acts as a strategic representation for the political economy of end-of-life electronic goods and new waves of resource extraction.

The political economy of natural resources is first explored through an examination of the varying forms-of-production and relations between sites and actors conducting work on discarded modern electronics. I trace the global environmental history of mining the underground for mineral wealth and link the transformations in this industry with the global shifts in manufacturing and production through the opening up of foreign direct investment and the loosening of international trade restrictions that took place toward the end of the twentieth century. Next, I examine the environmental history of Umicore from 1960 through 2000, and its transformation from the colonial economic powerhouse in the Belgian Congo to global sustainability leader for green production of rare and specialty metals, providing a postcolonial analysis of our current conditions. Though this story of industrial transformation traces a number of technological and logistical changes for an extractive giant, I argue that Umicore retains its long-standing relationship with the global South, now cloaked in a green neo-colonial garb through its involvement in international e-waste development projects. Lastly, I unpack the creation of The Best of Two Worlds, the model co-produced by Umicore and other elites, in

India and China and trace how the calculated efficiencies and profitability of the so-called "developing country" recycling economies are taken up in international policy reports and conferences seeking to address environmental damages. The analysis reveals the false science and flawed assumptions built into the model. I argue that Northern corporate interests comprise the true problems the model is trying to solve. The model failed in the company's initial pilots. I explore some of the reasons for this failure, finding causality in cultural conflicts and intractable economics between large, capital-rich Northern firms and small recyclers in the South.

Through the process of exploring why, at first glance, strange actors were involved with strange science, I found a thriving global economy that was far more about competition and access to valuable resources than it was about either dumping or cleaning up wastes. Further and more surprisingly, I found that e-waste struggles proved to be the continuation of colonial traumas and re-enacted historical practices/patterns: Colonial and neocolonial forms of rule, revolutionary African independence, and massive expropriation of infrastructure. E-waste imagery and knowledge production still deploy tropes of helpless "informal" recyclers demanding the e-waste problem be solved using the Best Available Technology.

My research highlights how discourses of green recycling and circular economies hide the extractive and capitalist underpinnings of this industrial change, producing inequalities amongst actors not equipped to engage in high-stakes knowledge-making or policy. This dissertations supports further inquiries into addressing environmental harms such as toxic releases from e-wastes that consider the need to retain higher-value materials, production, and economic opportunity in the global South. These lines of inquiry may produce conclusions counter to the interests of global North elites or private entities engaged in development partnerships, but I argue the goal of this work is not to ensure a steady stream of profit for a few elite firms, but to address wicked socio-environmental problems with the least harm to local communities.

For Chloe, Jack, Lucy, Alex, and Loki

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List of Acronyms

BEF – Belgian Francs (currency)
BFr – Belgian Francs (currency)
Bo2W – The Best of Two Worlds
DRC – Democratic Republic of Congo
EMPA – The Swiss Federal Laboratories for Materials Science and Technology
EU – European Union
GIZ – The German Development Organization (Deutsche Gesellschaft für Internationale Zusammenarbeit)
NGO – Non-Governmental Organization
Öko-Institut – The German Institute for Applied Ecology (Institute for Angewandte Ökologie)
ONUC – Opération des Nations Unies au Congo
SGB – Société Générale de Belgique
StEP – Solving the E-Waste Problem Initative
TCL – Tanganyika Concessions Limited ("Tanks")
UM – Union Minière
UMHK – Union Minière du Haut-Katanga
UN – United Nations
UNEP – United Nations Environment Programme
UNU – United Nations University
US – United States

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My choice to embark on doctoral studies within ESPM was based on the interdisciplinary focus of the program, the flexibility to craft unique and impactful questions, and the professionalism and comradery that was made apparent both before I applied and throughout my tenure as student and candidate.

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I was fortunate to find rich intellectual engagement both within ESPM and in the broader Berkeley community. I cut my critical teeth in Nancy Peluso's Land Lab. Friends and colleagues spanning eight years shared their work, poked at my ideas, and supported my development over wine, Indonesian take-out, and occasional pasta-making. I thank Nancy, Dan, Woods, Alice, Matt, Juliet, Sebastian, Brian, Hekia, Annah, Jennie, Ashton, Lisa, Dan, Margot, Oji, and Mike. Workshops should always be accompanied by snacks and this group fed my soul and my belly.

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Chapter 1

1. Introduction

1.1. Finding the mine

Spring 2007. Dara O'Rourke delivered a lecture on environmental justice to a room of public health undergraduate students at the University of California, Berkeley. His lecture was illustrated by images of children sitting in smoky, blackened neighborhoods amongst burning cables and vats of overflowing toxic chemicals in Guiyu, China. At fault were wealthy countries, like my own, dumping their obsolete electronics on the world's poorest communities: Not in my back yard (NIMBY), but on a global scale. Electronic waste (e-waste) had become another example of transnational environmental harms, like the dumping of thousands of drums of toxic waste on African coastal towns in the 1980s, that inspired the United Nation's Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal[1].

I was hooked. The problem of e-waste cast light upon the dark underbelly of the sleek information technology manufactured by Apple, Microsoft, and Nokia. This enmeshing of toxic exposures with industrial work as a result of global consumption of shiny things, upended the promise of my iPhone. Greenpeace images of these communities, caught up in the grim "informal" e-waste sector, were reminiscent of gritty photographs of the working poor by Jacob Riis or Louis Hine. Good and bad were starkly defined: Victims who did not have the skills or power to compete on their own terms in the global economy were pitted against international profiteers externalizing the costly de-manufacturing of the digital revolution.

I began to seek out the places where e-waste recycling was occurring. Handfuls of news reports, activist exposés, and a few academic articles identified hot spots of injustice in China, India, and Ghana. Of the three, I found the most detailed information for the Indian cities of Delhi, Mumbai, and Bangalore: In the mid-2000s, a handful of academic articles were published analyzing data from field observations made in the three Indian cities' recycling sectors.

In 2009, I visited Bangalore to explore my initial research ideas, at the time, centered on which recycling practices may be the most toxic. Soon after, I participated in a workshop for junior e-waste researchers, organized by the network of scientists who had published the handful of articles I had found so useful in focusing my regional interest. The outcome of both these trips was a radical redirection of my research towards the political economy of international development projects focusing on the so-called "informal" e-waste recycling sector.

Key to this turning point was the peculiar involvement of a mining company in the projects I had read about in those Indian cities; a company which had sponsored the workshop and organized a

[1] The Basel Convention is a multilateral environmental agreement intended to control the movement of hazardous wastes across national borders and prevent "dumping" of toxic materials in places that are politically or economically less powerful. It has delivered mixed success. For more information see Clapp, 2001.

full-day tour of its smelter in Hoboken, Belgium for the nineteen workshop participants. This network of Northern elites were promoting a model of transnational division of labor, called "The Best of Two Worlds," that promised a "win-win" solution to "the e-waste problem." This dissertation is the result of unpacking that model.

My new research focused on the convergence of specialty metals production with global South e-waste recycling. I traced the production of The Best of Two Worlds and the strange and surprising actors central to its promotion in transnational networks. My questions asked: (1) Why was Umicore, a global producer of rare and specialty metals, so interested and involved with the "informal sector" in the global South, (2) how were the studies produced, and (3) what was the outcome of these studies?

My research, described in a series of three chapters in this dissertation, links two themes – the political economy of natural resources and the politics of representation – through the idea of sustainability. Sustainability represents economic goods such as efficiency, conservation of resources, and stability (Miller, 2013). In the case of e-waste, it has also come to represent solutions to e-waste problems that are driven by scientific authority, a new and improved identity for an old industry, and a gloss that masks neocolonial relations of extraction. Each of the three chapters traces aspects of these two themes and presents the different ways sustainability acts as a strategic representation for the political economy of end-of-life electronic goods and new waves of resource extraction.

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The politics of representation are described by Mehan as the "competition over the meaning of ambiguous events, people, and objects in the world" (Mehan 2000). The representations at work here can be considered an outcome of Doty's notion of *imperial encounters* in global North-South[2] relations: encounters defined by an imbalance of agency in which one entity constructs and acts upon a reality that the other entity was unable to co-construct (1996). My analysis grounds this abstract notion through a focus on representations of expertise and scientific authority, "informal" economic sectors[3] and poverty, and changing ideas of waste and resources. In the following three papers, the political economy of resource production underpins the ways representations are used and justified in global trade, scientific studies, and classifications of material goods. The emphasis on optimization of economic returns and material conservation (or efficiency) by global North elites constructs a reality in which e-waste labor practices are divided into two sets of representations. The first, loosely assigned to small, independent recyclers in the global South, mingles ideas of poverty, inefficiency, destructive polluting, and naïvité. The second, attributed to global North elites, integrates and conflates expertise, wealth, and global connections to produce a representation of sciences and "win-win" sustainability that is consumable by international policy makers and national leaders. In the next section, I describe the ways each of these is treated in my three dissertation chapters.

1.2. Chapter 1: The birth of the flexible mine: Changing geographies of mining and the e-waste commodity frontier

The first chapter, previously published in the journal *Environment and Planning A* in 2015, provides an analysis of global relations of production for both the e-waste recycling industry and for global mining companies. Since the end of the twentieth century, a subset of large multinational mining companies has pursued flexible mining as a multi-faceted strategy to reduce exposure to economic volatility and/or decline in mineral and commodity markets, to reduce dependence on mineral resources produced in mine-host countries, and to reframe their operations as means of establishing sustainability partners to address multiple environmental problems from resource scarcity to global climate change. Five mining companies that operate precious and rare metal integrated smelters have adopted a flexible mine approach to procuring feedstock for their operations. These five companies generally self-identify as industry equivalents with respect to e-waste recycling and are often identified as a group by other actors

[2] I use the terms global North and global South to distinguish between so-called "haves" and "have-nots" in terms of power, wealth, and ability to engage in flows of transnational capital. The discussion of binary terms in Chandra Talpade Mohanty's 2003 article is instructive for a deeper analysis of the implications of terms that rely on a false geography to denote these types of differences (Mohanty 2003).

[3] Barbara Harriss-White states that "[i]nformality is more a political process than a binary state existing in opposition to formality" (2016), which extends the notion that informality is a *mode* of formality (Roy 2005). Other scholars have used terms such as autconstructed or unregulated to illustrate the distinctions between forms of labor or landscapes that conform to state regulations and those that exist or were created by coloring outside the lines (Agarwala, 2008; Agarwala, 2009; Caldeira, 2000; McFarlane and Vasudevan, 2014; Medina, 2008; and Ranganathan, 2010).

working in e-waste markets or policy arenas. My analysis examines these transitions to flexible mining.

I show how the transition to e-waste flexible mining allows for a reframing of their operations to that of sustainability partner for future growth, while simultaneously providing a much sought-after solution to increasing challenges in their more "traditional" arms of the business: underground mining and/or refining of primary ore concentrates. I show this by exposing the proportional changes in feedstock materials for their operations. I also look at the increase in new technologies to process feedstocks heavy in plastics with more complex elemental profiles.. Lastly, I analyze their interests and involvement in environmental policy related to e-wastes and other discard streams; and their changing discourses about themselves and their industry. This attempt at a double-transformation – solving a material problem (e.g. resource scarcity, price volatility, or political uncertainty) and a legitimation problem (e.g. representation as a sustainability partner versus a resource exploiter) – is a theme that is further analyzed in the subsequent two chapters focusing on Umicore, Incorporated, a paragon of flexible mining. The spatial and temporal reconfiguration of extractive spaces and labor practices create what Nancy Peluso describes as resource territories without formal boundaries and independent of government imposition (Peluso 2018). What is unique to my analysis is that I am seeing this take place within the structures of industrial processes.

1.3. Chapter 2: Umicore: From the Heart of Darkness to the Vanguard of Flexible Mining

A central pillar of postcolonial theory is the serious consideration given to the relationship between current conditions and colonial histories. In this chapter, I examine the development of Umicore, a Belgian-based multinational corporation that has become a vanguard of recycling innovation amongst their peers within the copper-based precious, specialty, and rare metals industry. Once known as Union Minière du Haut-Katanga (UMHK), the company has a long and violent colonial history, epitomizing bloody extractive practices and dark geopolitical politics (Gibbs, 1991; Van Reybrouck, 2010). However, Umicore now represents itself as a firm with a "commitment to sustainable development" pursuing new commodity frontiers and markets. I trace the transformation of the company from Belgian colonial profiteer to sustainability expert through Umicore's late twentieth century pivot toward recycling the detritus of production and consumption. This is a story of constructing a flexible mine: a new source of mineral ore that offers the firm increased geospatial, temporal, and interpretational flexibility.

The chapter takes us from the Congo Crisis and nationalization of Congolese mining infrastructures through the global recession in the 1970s, to the birth of global sustainable development goals and corporate social responsibility. The nationalization of UMHK infrastructure, combined with the subsequent global economic crisis propelled the company into a decades-long and costly search for new mineral resource and corporate stability. Unlike those of its contemporary peers, Umicore's history seems to manifest the metaphorical problem of holding all of its colonial eggs in a single basket. UMHK's undiversified colonial portfolio created the conditions for a paragon of innovation into new forms of imperialism and neocolonial extraction. Two and a half decades after nationalization of the company's assests in the Congo, Umicore emerged an independent corporation (independent of the Belgian state and various holding or parent companies) and embarked on a radical reorganization and reorientation toward sustainable development and the environment through e-waste recycling.

Umicore, while not a household corporate name, has had enough standing to co-author United Nations Environment Programme reports on e-waste and sit at the table with Interpol discussing global environmental crime. This chapter explores how Umicore came to be the unlikely partner in global South development projects focused on e-waste. I argue Umicore's pervasive efforts to promote a particular form of a flexible mine, first attempted and studied in India and named "The Best of Two Worlds," mirror colonial forms of extraction: They treat the global South as a source of cheap raw materials (electronic scrap) to supply their value-adding refining operation and brokering services.

1.4. Chapter 3: How a model is made: The Best of Two Worlds and a new imperialism

Electronic waste has risen up the agenda of international environmental governance bodies as campaigns by activist organizations such as the Basel Action Network and Greenpeace have highlighted the horrific environmental pollution related to end of life electronics. Like many environmental problems, solutions are neither simple nor easy. Poverty, resource scarcity, manufacturing processes, and environmental regulation are just some of the intersecting issues related to e-waste. In this last chapter I demonstrate how knowledge about e-waste recycling in the global South is produced and circulated by global North elites, including individuals at Umicore, university students and faculty, and United Nations policy experts.

I analyze the politics of model-making in a transnational public-private partnership by examining the development and promotion of The Best of Two Worlds (Bo2W), a model justifying an international division of labor to solve multiple electronic waste "problems". At the nucleus of this model for transnational trade is a single number (25) – generated by a student and her guiding committee – that represents the calculated efficiency of the global South recycling sector. Put simply, one of the numerical results from a student project in India has come to define the productive abilities of the small-scale global South recycling sector.

I argue that Umicore, through their involvement with the United Nations "Solving the E-Waste Problem" Initiative and related institutes, was able to steer the design of the Bo2W, producing a model of environmental problem-solving that privileges its corporate interests, suppresses technology development in the global South, and distributes questionable facts about Southern expertise.

My analysis highlights the two mechanisms – a specific politics of representation and a privatization of science – that allowed Umicore to co-opt the partnership research agenda, gain privileged access to an expanding market for their services, and support Umicore's successful pivot from the dirty business of colonial and (subsequently) transnational mining to a sustainable development partner. This analysis addresses critical gaps in studies of public-private partnerships, namely the effectiveness and legitimacy of partnering with for-profit extractive industries, by tracing the influence of a private corporation on problem-definition, fact-finding, model design, and results dissemination. The Best of Two Worlds model reproduces the very inequity and environmental harms it is supposed to address. Further, my analysis shows how scientific authority was leveraged to construct a neocolonial model of capitalist production. The Bo2W, at its worst, is a continuation of the exploitation of the global South as a reservoir of raw natural resources and cheap labor.

1.5. Research methods

Questioning why strange actors like precious metals specialists do strange things like influence global waste politics (chapters 2 and 3) and unpacking the story of a powerful number and how it travels through networks (chapter 4) was made possible by a research orientation combining political ecology and science and technology studies. I used political ecology's "critical tools" (Robbins, 2012) including critical environmental history, postcolonial and development studies, and power/knowledge and critical discourse analysis (Hajer, 1995; Hall, 2007; Forsyth, 2003; Foucault, 1980; Goldman, 2005) to frame critical questions, engage critical discourse analysis, and examine what lay beneath "unbiased" science. The overlap of these tools with Science and Technology Studies approaches led me to examine the calculative practices and effects of measuring, classifying, and enumerating the world (Bowker and Starr, 1999; Dunn, 2005; Foucault, 1970; Porter, 1995; Scott, 1998). I collected data using a multi-sited, mixed qualitative methods approach (semi-structured interviews, textual analysis, observations and secondary literature review). Fieldwork locations, interview participants, and data resources were determined through a modified snowball sampling approach in which initial interviewees were asked to provide additional referrals or resources.

Tracing the creation and movement of a model through global networks of knowledge and actors is a method described by many scholars of "the global" (Biao, 2007; Latour, 1990; Li, 2007; Marcus, 1995; Riles, 2001; Rottenburg, 2009) Reflecting this emphasis on the network as the field site (rather than on discrete geographic locations), I visited Bangalore, India; Davos, Switzerland; Berlin, Germany; Hoboken, Belgium; Orlando, Florida; Middlebury, Vermont; and Burlingame, California. I conducted 40 interviews with subject-matter experts both in-person and by telephone or skype connection. Interviews were supplemented with participant-observer interactions and extensive review and analysis of archival materials, including historic news articles, scientific and policy literature and reports, historic annual financial reports, and historic chronicles. I used qualitative analysis software (Atlas.ti) to organize and systematically review texts. My approach was best characterized by a focused curiosity to follow the relations that appeared strange and to always question the things often taken-for-granted, particularly enumerated "facts" and statistics generated by allegedly trustworthy institutions.

For detail on protocols, funding, and Institutional Review Board approvals, refer to Appendix A.

Chapter 2

2. The birth of the flexible mine: Changing geographies of mining and the e-waste commodity frontier

2.1. Introduction

The mining industry has been facing mounting political-economic challenges over the last century. In particular, increasing public scrutiny of environmental and livelihood impacts of mining sites, commodity market volatility, and the transition from colonial forms of rule to independence for some of the host countries, have brought significant challenges for multinational mining interests (Acuña 2015, Bebbington and Bury 2009, Bridge 2004b, Emel et al. 2011, Himley 2010, Warhurst and Bridge 1997). Some mining companies are changing how they source and refine ores by seeking metal-bearing wastes, such as industrial slags, end-of-life-vehicles, and discarded electronics to supplement feedstock from mines. These "above-ground" ores are smelted alongside "below-ground" mining concentrates in large refineries. I propose the term flexible mine to describe this expansion of ore supply chains and associated relations of production, and I demonstrate how it operates through multiple registers of flexibility: spatial, temporal, and interpretational[4]. I highlight how these registers of flexibility address three problems in below-ground mining – geospatial fixity, resource scarcity, and environmental effects – and also create new governance challenges in regulating extractive industries.

The flexible mine is an increasingly plural set of spatially and temporally discrete sites, in which discarded materials are taken apart, sorted, and re-aggregated for recycling: the extraction and concentration of raw above-ground metal ores for resource recovery. These ore-concentrates are then shipped to integrated smelters, where they mix with concentrates from below-ground mines or other industrial wastes, to be transformed into purified copper, gold, silver, platinum, indium, gallium, and so forth.

The flexible mine is both a "widening" and a "deepening" commodity frontier (Moore, 2010) for the mining industry. The flexible mine promises a disarticulation from geophysical processes and, by extension, mining country geopolitics. This imagined disarticulation comes through the commodity-widening strategy of expanding production to above-ground mining sites and the commodity-deepening strategy of socio-technological changes to extract more types of metals from more types of concentrates. The technical and organizational changes associated with

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[4] Interpretive flexibility was proposed as a concept in the Social Construction of Technology (SCOT) approach (Pinch and Bijker 1984). It referred to the different ways groups consider and interact with an object, each consideration relating to a different problem. SCOT has been critiqued by many for its emphasis on social constructivism and its linear structure. Interpretive flexibility, however, is useful to highlight the various framings and strategic discourses leveraged in mining and e-waste.

flexible mining suggest a new phenomenon, wholly different than below-ground mining and refining. However, the flexible mine is equally as entangled in geopolitics and geophysics.

The mining of waste streams blurs the boundaries between extraction, production, manufacturing, consumption, and disposal. To wit, the newest smartphone generation is simultaneously the future mineral deposits for the flexible mine. The flexible mine is, thus, only a temporal and spatial distancing from geophysical processes and in fact depends on capitalist commodity production, consumption, and prior extraction to exist: a cyclical paradox. It is yet another production boom, created by the excesses of manufacturing and consumption of technology materials and premised on the imaginary of renewable resources and sustainability. Examining resource extraction in this way troubles the analytical categories commonly used in geographic scholarship on the flows and transformations of materials and goods, thus responding to and extending Bridge's (2008) call to extend global production network scholarship to extractive industries. Further, the flexible mine challenges the distinction between urban and non, arguing against the reliance on too-familiar binaries in geographic scholarship.

Using the case of electronic waste (e-waste) recycling, I explore how this flexible mining frontier comes into being. The challenges in negotiating public concerns over a historically dirty and exploitative mining industry, coming on the heels of decades of volatile metals markets and geo-political relations, have articulated with an e-waste "tsunami" (Biello, 2008; Johnson, 2008), producing the conditions for an e-waste flexible mine.

The move towards recycling e-waste is touted as a revolutionary and sustainable solution to multiple socio-environmental problems, ranging from crises of resource consumption and environmental degradation to economic development. Yet, sustainable development discourses can hide deep and pervasive inequalities arising from the production relations of capitalist expansion and resource extraction (Elgert, 2010). E-waste is not simply waste or resource: it is a loosely-defined collection of disparate ideas that each articulate with high-stakes problems and discourses, ranging from neo-colonial environmental injustices to a futuristic source of innovation materials. The interpretive nimbleness of e-waste and recycling technologies supports the expansion of the flexible mine into new spatial and temporal geographies, creating novel governance challenges for extractive industry relations because of the (temporally and spatially) nimble character of procurement contracts, and a sustainable gloss that renders socio-environmental effects invisible. It is this interpretive flexibility that sets the flexible mine apart from well-established resource recovery industries such as textile or steel recycling.

The structure of the paper proceeds as follows. After a brief description of methods, I discuss three challenges for below-ground mining that a flexible mine may address. I then introduce e-waste as a flexible mine and discuss some technological and structural changes associated with mining e-waste ores. I discuss so-called urban mining and how the flexible mine challenges ontologies of analytical categories. I then analyze how the flexible mine addresses the three challenges to mining highlighted earlier. I conclude with a discussion of challenges for mining e-waste and I highlight governance and socio-environmental concerns with flexible mining.

2.2. Methods and analysis

This multi-sited, mixed-method, qualitative study examines large integrated copper and precious metals refineries, historically associated with multinational mining, that recycle discarded electronics and that self-identify in documents and interviews as industry equivalents: Aurubis (Germany), Boliden (Sweden), Dowa (Japan), Glencore (facility in Canada, headquarters in Switzerland), and Umicore (Belgium). Some refineries are parts of corporate structures that include primary mining operations, while others are parts of corporations that no longer contain primary mine holdings. All are facilities that were originally developed decades before the growth of the flexible mine, and all have upgraded their facilities to improve their abilities to process e-waste materials. I focus on the mining of gold, copper, and other metals in e-wastes that are refined in copper-based facilities. Each facility has a different metal-product profile, but all analyzed here use copper as a base-metal.

Field work and data collection included participation in workshops and attendance at trade conferences between 2009 and 2012; review of materials collected between 2011 and 2015, including corporate reports; news articles; government and non-governmental (NGO) reports; peer-reviewed journal articles; conference proceedings; and 20 in-depth, semi-structured interviews with individuals from refineries, e-waste NGOs, development agencies/institutes, e-waste recycling businesses in India, and industry lobby groups. Interview participants were identified through snow-ball sampling, and connections made at conferences, workshops, and with authors of publications. A qualitative discourse analysis was conducted within the Atlas.ti (version 1.0 for MacOS) environment.

2.3. Three challenges for mining: Fixity, scarcity, and the environment

Mining has remained an industry fundamentally structured by three interrelated factors: geophysics (where ore is located), technology (how we extract and process the ore), and the surrounding political economy. Shifting to recycling materials containing already-mined-metals suggests an apparent neat partial solution to some of the key historical challenges in extractive industries: a spatially-flexible high-quality mine, freed from the territorial restrictions of geology, and thus the concomitant geo-political relations tied to specific geologies and socio-environmental struggles at mining sites. The mining of e-wastes is an attempt to address three interrelated problems for land-based mining: geospatial fixity, resource scarcity, and environmental sustainability.

2.3.1. The fixity of mining investment and infrastructure

The fixity of mines and refining infrastructure is a key challenge to profiting from ore and mineral concentrates. Indeed, as a *Financial Times* article stated in 1976: "Mines are where you find them and not where you would wish them to be: they cannot be sited in the most favourable environment" (Marston, 1976). Mining of below-ground copper and precious metals tends to take one of two forms: surface and underground extraction. Underground mining requires technology for digging and maintaining tunnels, ventilation, and transporting workers and ores in and out of the tunnels, increasing costs compared to surface mining. Both require installing infrastructure in place. Once extracted, the ore is often processed on-site to concentrate the metal content and decrease transportation costs by leaving behind most of the undesirable waste rock. Secondary refineries (including the integrated smelters in this study), another fixed asset in mining, are commonly located far from sites of extraction in "home" countries and are therefore less subject to the same geopolitical challenges.

Only geophysics determines where "natural" mineral resources are located and the sunk costs in mining infrastructure can be unrecoverable if located across national boundaries. A mining company that invests nearly a decade of time, money, and infrastructure developing a "greenfield" site for mining activity seeks long-term stability in the form of legal agreements defining property rights or access to the minerals, commonly in the form of a concession agreement promising up to decades of operational control (Emel et al., 2011). Decolonization, sometimes ushering in nationalization[5] of mining infrastructure, and increasing environmental protests over local effects of mine operations have destabilized trust in and public support for concession agreements. As industry analysts argue, the ability to develop a mine in the most favorable location, a "spatial fix" for capitalist extraction (Huber and Emel, 2009), would be a boon to the industry facing "quite draconian" environmental laws (Union Minière, 1973) and other "impediments foisted upon mining companies by government action" (*The Times*, 1975).

2.3.2. The politics of resource scarcity

Volatile and contingent socio-natural scarcity underwrites the exploration of new commodity frontiers. Whether an element is considered scarce is dependent on the interplay between geophysical abundance and access, and market and geopolitical relations (Bridge, 2004a). In general, for the mining industry, fluctuations such as the dramatic price of gold between 2011 and 2013 (Owens, 2013), is part and parcel of the capitalist mining endeavor. Further, mine owners or operators have limited ability to influence market prices for commodities.

A recent controversy over so-called "rare earth" metals illustrates this convergence of geopolitics, geophysics, and market volatility to produce scarcity. Rare earth elements (the lanthanide series in the periodic table of elements, plus scandium and yttrium), used in both military and consumer technologies, are primarily extracted in China.[6] The global trade in rare earths suddenly made headlines in 2010 when China abruptly restricted exports of rare earth ores to Japan as retaliation for an island dispute (Ting and Seaman, 2013). Subsequently, Japan, the United States, and the European Union filed a complaint against China with the World Trade Organization, which eventually ruled that China violated free-trade policies. In response to this scandal, many nations began pushing to develop rare-earth mines, reframing access to these metals as an issue of national security. The market value for rare earths also spiked dramatically

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[5] The process of independent nation-states claiming control over local mining infrastructure (see Kobrin 1984).
[6] This is due to China having developed and operating rare earth mines earlier, rather than the global distribution of rare earths in the earth's crust. There are rare earths found on many continents. See Klinger (2017) for a detailed account of rare earth metals.

due to the geopolitically-caused scarcity. Industry news was filled with reports of new exploration licenses and projects across multiple continents, including both foreign and domestic investments. Activity has since quieted in response to falling market prices for rare earths and a few of the once-hot projects have reportedly stalled (Hopkins, 2015).

2.3.3. The environment and sustainability

Below-ground ores are generally only about five percent metals-of-interest by volume, thus mining can leave a great deal of waste rock and waste materials near the sites of extraction after concentrating the minerals for shipment to refineries (Warhurst and Noronha, 2000). This is in addition to the significant environmental impacts of constructing and operating the mine: for example, landscape scarring from earth removal or tunnel construction, water pollution from acids or mercury produced or used in mining, and destruction of local resources for livelihoods. These local environmental impacts, in additional to well-established dangerous working conditions, have been the foundation for significant socio-environmental protests by local communities (see e.g. Bebbington, 2011). As a result, mining companies have had to adopt an approach to mine development and operation loosely labeled a “social-license to mine” (Govindan et al., 2014).

A social license is not a standard document or set of rules, but instead refers to a general approach that can include extensive stakeholder meetings, funds directed toward local community development projects, and funds and contractual promises for environmental controls and/or remediation of legacy landscapes of pollution (Hilson and Murck, 2000; Parsons et al., 2014). These socio-environmental concerns have combined with mounting criticisms of the vast amounts of energy needed to extract and process mineral resources from the earth. Not surprisingly, the mining industry is increasingly on the losing side of environmental sustainability calculations (Whitmore, 2006).

2.4. E-waste: A new ore

A new source of ore, seemingly different from below-ground mining, could provide a renewed social license to operate. E-waste is extremely materially diverse, which contributes to its interpretational flexibility: its meaning is constantly being renegotiated amongst interested stakeholders as the materiality of and the socio-technological contexts for e-waste change. E-waste is variously an opportunity, hazard, mine, pollutant, or resource (Kiddee et al., 2013; Kolias et al., 2014; Pickren, 2014; Robinson, 2009). E-wastes are also extremely mobile (Kirby and Lora-Wainwright, 2015b; Lepawsky and McNabb, 2010; Lepawsky, 2014), contributing to perceptions of geospatial flexibility. Their networked connections along the demanufacturing chain, or “global destruction network” (Herod et al., 2014; McGrath-Champ et al., 2015) are just as varied (Breivik et al., 2014). Further, the ways to recycle metals from electronics (Cui and Zhang, 2008) and the actors who engage in recycling are extremely diverse (Pérez-Belis et al., 2015) adding yet another layer of interpretational flexibility. Further, electronics as potential mine troubles common analytical categories of extraction, production, manufacturing, and disposal. Adjusting analyses to seriously consider interpretive flexibility, or embodied multiplicities, in conjunction with time and space blurs the divisions and the directional flow between these theoretical stages of socio-material transformations.

I focus on one part of end-of-life management for electronic discards: copper-based gold, precious, and specialty metals recovery (non-ferrous and non-aluminum). Processes of metals recovery from discarded electronics may range from so-called “wet chemical” gold recovery in either a small shop in India or a large refinery in Japan, to heat treatment (smelting) in a Canadian facility. The technologies of metals extraction from e-wastes are constantly in flux as new processes are developed; as electronics themselves change with design innovations; and as the problems associated with end-of-life treatment change in relation to both the material nature of electronics and the political economies of resources, production, and consumption.

Recycling metal-bearing ore from discarded electronics has been identified as a rapidly growing and profitable industry. In Japan, a recent estimated value for the recycling of small electrical appliances was close to 330 million dollars, the majority of value stemming from the amount of gold and silver content (Nakamura and Halada, 2015). An industry report projects that e-waste volumes will reach 93.5 million tons in 2016, and the e-waste “management market” will reach a monetary value of $20.25 billion (Tiwari, 2014). A recent United Nations University report on e-waste statistics estimated that 41.8 million metric tons were generated in 2014, of which 6.5 million metric tons were “documented and recycled with the highest standards.” The report further estimated the monetary value of the total global supply of e-waste to be 48 billion euros in 2014 (UNU, 2014:8). The economic value of mining end-of-life products is not lost on the industry players: “With a potential $1tn opportunity in transitioning to the circular economy, companies are recognising that preservation makes as much economic sense as it does environmental. In the words of Unilever CEO Paul Polman, ‘[a circular] economy can deliver growth. Innovative product designers and business leaders are already venturing into this space’” (Thimmiah, 2014).

The e-waste “management market” is challenging to compare to the “traditional” mining industry. To understand the scope of e-waste flexible mining, I turn to proxies and estimates. A recent United Nations Environment Programme (UNEP) report on global metal for example recycling rates estimated that most of the precious metals, plus cobalt and nickel, are produced with 25-50% recycled content. Copper and zinc commodities contain somewhere between 10-25% recycled content (UNEP, 2011: 20). These statistics do not specify the types of recyclables used. Comparing global estimates of metal commodities embedded in e-waste (as potential mine) to current metal commodity production, e-waste contains about one-tenth of both the gold and copper production from below-ground mines (UNU, 2014; USGS, 2013).

The flexible mine provides an additional strategy for the refineries, meant to diversify and protect against economic fluctuations in the traditional refining sector. However, the degree of substitution of below-ground ore concentrates with materials to be recycled varies across the sector. Refineries report that anywhere from 10-80% of their feedstock is from materials to be recycled, often highlighting e-waste specifically. Recycling is not yet a total replacement for below-ground ore processing. For now, however, interpretive flexibility creates the opportunity to completely replace the mining identity of industry actors to that of sustainable businesses.

2.4.1. Infrastructural changes for flexible mining of e-wastes

As Castree suggests, "the process of capitalist commodification (or its effects) might operate rather differently depending on which particular natures are being commodified" (2003: 275). The used gold, platinum, copper, germanium, silver, and palladium in e-waste are not fundamentally different than the same metals extracted from the ground. However, the conjoined materials of e-ore, that is, the plastic-housings, resin-matrices, and higher concentrations of metals embedded in printed circuit boards is vastly different than below-ground ores. As well, the mobile nature of e-waste and other secondary products means that the spatial and temporal pace of extraction is different in recycling networks than in below-ground extraction.

The expansion of precious metals mining from below-ground ores to e-wastes should not be confused with creating a new commodity market: electronics have been mined for their embedded copper and gold since they were first discarded, both in small-scale enterprises and in massive integrated smelters. For example, the Rönnskär smelter in Sweden (operated by New Boliden) incorporated early-generation telecommunications equipment since the middle of the last century and has been accepting e-wastes for decades (anon, 2013, personal communication). The Horne copper smelter, now owned by Glencore (previously by Noranda and then Xtrata), made public statements in 1997 about increasing the already-existing practice of refining electronic scrap because of the higher economic returns and the lower toxic emissions compared to below-ground concentrates (Worden 1997).

However, the infrastructural needs for refineries processing increasing amounts of e-waste differ from earlier periods. In the 1990s, with increases in volume of discarded electronics, refineries experienced technological limitations in how much they could process, primarily due to the plastics embedded in electronics. The hydrocarbon content (plastics and resins), which is readily combustible, created too much heat, leading to numerous expensive refinery shut-downs. Over time, the large refineries invested in new technology that could handle the heat generated in pyrolytic processing of e-wastes. They also invested in new environmental controls, such as scrubbers on emission towers, to address both the growth of more stringent environmental standards and the different byproducts created when recycling electronics.

2.4.2. Is a flexible mine urban?

Scholars have begun to draw specific parallels between the stages of below-ground and so-called "urban" mining. For example, both Oguchi et al. (2011) and Nakamura and Halada (2015) argue that the exploration phase of below-ground mining is analogous to a "material flow analysis" of e-waste — a calculative process by which scientists measure and then estimate volumes of discarded electronics in a particular geographic area. Ongondo et al. (2015) propose the concept of "distinct urban mines" arguing, for example, that some urban areas may be richer in copper than another urban mine, which may have a higher gold lode due to the specific consumption and disposal practices in each location. This differentiation between above-ground mining sites mirrors the different mineral extent, composition, and ease in accessing below-ground mines.

It is important to note that "urban mining" is not a new concept, phrase, or practice (Nakamura and Halada, 2015). Urban mining discourse has historically emerged in times of resource scarcity, notably during wars (Klinglmair and Fellner, 2010), as well as in response to environmental concerns. Discourses of recycling as mining describe a range of extractive processes from metabolizing and mining existing but underutilized urban infrastructure to recycling various discarded materials from the "technosphere" either from landfills or other discard streams (Binnemans et al., 2013; Krook and Baas, 2013). "Urban mining" rhetoric has, again, become a convenient discourse to signal a new and sustainable source of resources: "[W]ith the inevitable explosion of urban mining in the coming decade, traditional mines can be closed and returned to the Earth" (Urban Mining, 2015).

The specter of cities as mines presents an opportunity to disrupt binaries between urban and rural or dichotomous visions of urban metabolism, separating "natural" and "sociotechnical" worlds. However, the flexible mine is neither urban per se, nor more socio-technical than below-ground mining. It is different than below-ground mining: it has different spatial and temporal pacing (waste materials move rapidly along circuits of trade and disposal, and are mined via nimble short-term contracts for extraction); the materiality of wastes-as-ores can be very different (e.g. plastics and resins often dominate e-waste ores); and the discourse and interpretive flexibility of various wastes and recycling technologies conjure up vastly different narratives than those associated with below-ground mining. However, with all those differences, it is important not to fall into to what Angelo et al. call "methodological cityism" or the "naturalization" of the urban as a distinct object in analyses in which the non-city may also be relevant (2015).

Analyses arguing that the flexible mine, under the label "urban mining," is a specifically mobile urban policy (Reddy, 2015b) or an urban phenomenon (Oteng-Ababio et al., 2014), focus on the urban as if it were a necessary feature of flexible mining. Beyond the density of waste-generation in cities, mining wastes also helps converts rural areas to above-ground e-waste mines such as Guiyu, China, a former agricultural area and now a major e-waste mining site (Wong et al., 2007). Below-ground mines do the same: converting rural areas into highly-concentrated nodes of workers, their families, infrastructure, temporary or permanent homes, roads, and so forth. These "traditional" mining sites are not, however, typically considered urban. E-waste ore, for example, is also generated in rural electrified villages. Ore collection and concentration sites, and e-waste refineries are also located distally from city centers. Methodological cityism, in the case of e-waste mining, further supports a disarticulation from histories and processes of below-ground mining by analytically separating so-called urban mining from "traditional" extractive industries and thus reinforcing conceptual boundaries between stages of material transformation and flows.

There is no compelling reason, aside from discursive persuasion, that we should consider mining mineral-laden goods as distinctly urban. Further, what makes above-ground mining more constitutive of processes of urbanization than below-ground mining is not clear. As Labban (2014) argues, the practice of mining previously-manufactured goods for mineral wealth is an extension of below-ground mining in support of "planetary urbanization" (see e.g. Brenner, 2013). His "global extractive network" extends the planetary urbanization concept to a "planetary mine" producing a "global extractive network that is intimately bound up with and constitutive of processes of capitalist urbanization" (2014: 564).

The flexible mine concept avoids the trap of "methodological cityism" and adds important considerations to these analyses of global circuits of recycling: the explicit attention to interpretive flexibility and how that both enables the relations of production and elides exploitative relations. The flexible mine concept encompasses the spatial and temporal differences from below-ground mining, explains how this re-territorializing of mining from below-ground to above-ground happens, and highlights what is at stake in this shift to flexible mining.

More critically, the flexible mine disrupts the urban/rural (or nature/culture) binary by focusing on encounters between material flows and the multiple interpretations of their transformational processes, rather than on an ontology of place as a defining characteristic. If we wish to interrogate the condition of the urban, the flexible mine allows us to examine facets thereof. However, in contradistinction to the contemporary scholarship on "planetary urbanization," I suggest the flexible mine allows for an examination of what Derickson calls "urbanization 2." The disruption and decentering of analytical categories such as extraction and consumption, urban and rural allows us to ask "different questions in different ways" producing "counter topographies" that trouble "existing representations" (Derickson, 2014: 7). The flexible mine concept highlights, for example, how the sites of consumption are also sites of mine-formation. It also shows how traveling knowledges of efficiency, efficacy, or risk encounter different socio-material geographies, producing different forms of, or resistances to a flexible mine.

2.5. The promise of the flexible mine: Fixity, scarcity, and the environment revisited

2.5.1. Fixing fixity: Disarticulating the mine

Sourcing ore from highly-mobile flows of discarded material, un-fixes the mine and promises wealth for the already-existing, fixed refining infrastructure.

If no longer tethered to stationary geologic formations, mining companies are, in theory, freed from historically resistant local labor and "unfriendly" environmental regulations and controls commonly associated with below-ground mining. This de-coupling of ores from fixed territories means that refineries can establish business relations in more politically and economically friendly locations, and more importantly, choose only short term or single-service contracts. E-waste refineries typically use a "toll-refining," or service-based, contract model in which they sell their refining services to the owners of waste-ores, such as businesses that separate and aggregate printed circuit boards. Refineries either ship purified metals back to the owner or broker the metals in the marketplace on behalf of the owners (anon, 2013, personal communication; Nakamura and Halada, 2015). This commodity widening strategy extends the geographic scope of commodity production to these new spatially- and temporally- flexible territories of extraction.

The flexible e-waste mine is a mirror image of liberalized electronics manufacturing networks which dynamically link local manufacturing industry with global market strategies (Lüthje, 2002). Indeed, the nimbleness of service-based contract refining of some aspects of flexible manufacturing arrangements in which turn-key facilities bid on short-term contracts to manufacture a set of components, in a network of other manufacturing and assembly sites, all of which may be completely independent corporate entities, located across multiple national borders and regions (Sturgeon, 2002). Though there is variation across firms in their desire for long-term stable business partners versus multiple short-term contracts, once contracts are fulfilled, formal business relationships may be severed until the next contractual agreement is drawn up. In this way, the flexible mine is similar to some aspects of flexible manufacturing, flexible specialization, or more broadly, flexible accumulation (Cooke, 1988; Gereffi et al., 1994; Gough 1996b; Harvey 1989; Scott, 1988). Flexible accumulation theories describe a major structural change in commodity manufacturing networks, developed in the late 1960s and early 1970s, as a result of the liberalization of trade and foreign-direct investment restrictions. The "New International Division of Labor" described a change in which the global South shifted from being simply a source of raw natural resources for the global North to a site of value-added manufacturing (Fröbel et al., 1977; Sayer and Walker, 1992).

Some forms of the flexible mine, however, suggest a move towards the former: the global South as only a site of extraction with value-added refining only in the North. For example, one epistemic community explicitly proposes an "international division of labor" in which metal-bearing e-wastes are first disassembled by workers in the global South (where labor costs are low, thus allowing for high-quality disassembly by hand instead of mechanized shredding as is typical in the North) and then "efficiently" recycled in the global North (loosely referred to as the Best of Two Worlds) (Manhart, 2010; Reck and Graedel, 2012; Williams et al., 2013). This arrangement has been critiqued as a cherry-picking strategy and smacks of post-colonial relations of extraction, including the concomitant assumptions of "advanced" knowledge and infrastructure in the North by those promoting it. The flexible mine, thus, does not fit neatly into already existing models of international trade and production like close or loose subcontracting (Cooke, 1988) or Just-in-Time production (Boyd and Watts, 1997) and instead addresses the call by Bridge to extend global production network scholarship to the extractive industries (2008).

Inflexibilities are as much a part of e-waste mining arrangements. The technologies required to process diverse feedstock promises renewed economic development for the fixed geographies of refineries (for a discussion of development via mining see Graulau, 2008). Tabuchi (2010) writes of this promise: "Two decades after global competition drove the mines in this corner of Japan to extinction, Kosaka is again abuzz with talk of new riches…. This town's hopes for a mining comeback lie not underground, but in what Japan refers to as urban mining – recycling the valuable metals and minerals from the country's huge stockpiles of used electronics." Recycling secondary materials promises new life for fixed infrastructure, threatened with obsolescence without access to a new commodity source.

2.5.2. Solving scarcity through an abundance of waste?

Ever-increasing volumes of discarded materials provide the material foundation for the flexible mine, a sustainability paradox not captured in discourses of circular economy.

As stated earlier, scarcity is determined by the articulation of material abundance, access to that abundance, market influences, and geopolitics (Bridge, 2004a). Volatile metals markets, decreasing yields form below-ground mines, geopolitical challenges in purchasing or trading ores, and increasing challenges in constructing greenfield sites have led to another moment of mineral resource scarcity.

The growth of manufacturing and global consumption of goods has led to a sharp increase in metal-bearing wastes (UNEP, 2012), creating an "ecological surplus" (Campling, 2012) of rich ores, and setting the conditions for flexible mining. The promise of future metal riches from recycling end-of-life goods is reflected in the proliferation of government-sponsored endeavors such as ProSUM, an EU-funded project "aiming at collecting and standardizing data on critical raw materials to be extracted from e-waste" (European Commission, 2015). This is only one example of many efforts to construct a "circular economy" of discarded goods, mined for raw materials to re-enter the manufacturing cycle.

Strategies using flexible discourses reframe and broaden solutions to both waste management issues and below-ground resource scarcity, suggesting a win-win scenario. For example, one refinery representative is quoted in an article discussing the turn to recycling: "'Rather than looking at e-waste as a burden, we need to see it as an opportunity,'… He recommended replacing notions of 'waste management' with 'resource management'" (Collins, 2012). Substituting "waste" with "resource" is a discursive strategy aimed at replacing problematic below-ground ores with above-ground ores, while simultaneously eliding the production-consumption-wasting problems inherent in capitalist production cycles. It reunites what Gille (2010) calls a "waste regime," (regulating what is waste, who can get it, where and under what circumstances) with a resource regime, carrying valuations of "good" as opposed to "bad."

2.5.3. From environmental pariahs to saviors

Discursively "solving" the environmental problems of below-ground mining directly supports mining actors prospecting for new flexible mining contracts, by redefining them as sustainability experts and a facet of flexible mining that differentiates it from earlier forms of scrap recycling. Indeed, as Lawhon (2013) shows in her South African case study, national e-waste industry transitions are a site for discourses framing e-waste recycling (by particular actors) as a win-win solution to both the environment and development.

Governments, international institutions, and non-governmental organizations have looked to above-ground mining to address the environmental impacts of extraction. For example, UNEP states, "mining activities expand, potentially leading to growing environmental impacts.

Recycling is a way to mitigate these impacts. We can call this 'mining above ground' or 'urban mining', and these activities are of increasing importance in generating raw materials" (Graedel, 2010: 2). Most scientists agree that recycling scrap materials takes orders of magnitude less energy, produces fewer greenhouse gas releases (Navazo et al., 2013; Simoni et al., 2015; Wernick and Themelis 1998), and brings other environmental benefits (Bigum et al., 2012; Hischier et al., 2005) due to the relative "richness" of this ore. For example, Mueller et al. (2015) examined the potential to extract rare earth elements from end of life vehicles or electronics and concluded that the concentration of, thus potential for, neodymium recovery is greater from anthropogenic sources.

The reframing of recycling as environmentally-sound mining promises a disarticulation from mining legacies and a reframing of the industry as sustainable. This flexible interpretation and subsequent disarticulation from the past is exemplified by Umicore's transition: "'When we go out to new investors we have to explain who we are,' says Umicore's chief executive, Thomas Leysen. 'It's not a question of reneging on your past, but we don't have to be fixated on it'" (Fulford, 2004). That is, to investors, Umicore is no longer Union Minière de Haut Katanga, the polluting and violent colonial Belgian copper mining company. Instead, the multinational firm is a sustainability pioneer in metals science and management, winning multiple environmental awards over the past decade.

The sustainability frame engenders the legitimacy and trust the mining industry needs to engage new and diverse partners. A few companies have been invited to special meetings and projects focusing on environmental crime, resource scarcity, pollution prevention, and international trading in hazardous wastes. For example, Umicore was one of a couple of dozen organizations with representatives at the table for a meeting on international environmental crime, organized by Interpol. Similarly, the United Nation's international development work on e-waste recycling systems has opened calls for bids from multiple refineries now specializing in complex feedstocks. A project leader for international cooperation projects focusing on e-waste hazards made clear the pragmatic reasons for refineries to engage directly in these fora: "they simply do not have to visit all 53 [African] countries individually." That is, they can attend just one meeting with many local electronics dismantlers, rather than traveling to each location individually, making multiple strategic contacts for their refining services (anon, 2014, personal communication). This is in direct contrast to the mining of past: "It is a world away from the gritty African mines…" (Fulford, 2004)

2.6. Not so fast: Challenges in making a flexible mine

2.6.1. Changing expertise: Producing new knowledge in a zone of nascent science

Rendering resource management questions as strictly technical elides the politics and the economic struggles of the many and varied recyclers trying to succeed in this competitive marketplace, and creates a perception of objectivity, leading to "trust" in the numbers provided by refinery scientists (Porter, 1995).

The interpretational flexibility of e-wastes, recycling, and mining must be exploited for flexible mining to develop. The investment security for a large integrated smelter that is processing circuit boards is “uncertain” (UNEP, 2009), particularly given the territorializing efforts of diverse and competing e-waste recycling actors. The problem of access to ores, for multinational mining, rests on the ability to re-fashion the industry as experts in sustainability, building what Levy (2008: 955) calls “legitimating ideologies and governance structures” in support of their economic interests. This building of legitimacy is achieved through producing e-waste knowledge and discourses of greening production in epistemic communities (Haas, 1992). This strategy is made explicit in one corporate environmental report:

> Is UM contributing its views and knowhow to help shape the regulatory system of tomorrow?… Thanks to our close co-operation and excellent networking with worldwide metals associations and research institutes, we have been able to submit a wealth of scientific evidence and methods to the EU, so the new initiatives can be based on hard facts rather than allegations (Union Minière, 1999: 7).

Clapp (2001), in her analysis of the Basel Convention[7] politics, described a similar process through which recycling industry representatives, operating in the less-visible Technical Working Group, influenced the definitions of what counted as what type of hazardous waste in reports for the Conference of the Parties. Lawhon (2012) shows how multiple and varied stakeholders grapple with an emerging e-waste recycling industry and highlights the need to examine power and trust-relations in socio-technical transitions.

Flexible e-waste miners must engage with hazardous waste and chemicals policy, necessitating a radical change in expertise accompanied by a long-term strategy of credibility-building: “You cannot just hire overnight a number of scientists and engineers and instruct them to change the profile of the company…” change on this kind of scale takes "long-term effort" (Balch, 2013). Electronic discards often contain many chemical elements that are embedded in matrices, presenting significant challenges for de-manufacturing: separating the elements (Klatt, 2003); keeping up with changes in electronics manufacturing (Lam et al., 2012); and managing exposures to toxic materials, even in so-called “formal” facilities in the North (Julander et al., 2014). As one refinery informant explained, “E-Scrap is a mix of dozens of elements which normally would not appear in a single type of scrap or natural resource. On top, e-scrap contains elements which can generate toxic effects on the environment if not treated properly while the impact of a [below-ground ore] concentrate or a typical piece of copper-scrap is comparably low, if there is any. Because of this very nature, e-scrap is more regulated than other recycling materials, such as Al [aluminum], Copper or Fe [iron] Scraps. ...in that regard, it is a completely different business than, say, certain regular scrap materials.” (anon, 2014, personal communication). In other words, the interpretive flexibility of e-waste, arising from the interplay

[7] The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989) and Basel Ban Amendment (1995).

between material complexity and socio-politics, means that an e-waste mine is fundamentally different than circuits of "traditional" metal-bearing scrap: materially and politically.

Refinery representatives are no longer geologists prospecting greenfield sites. Instead, they are salespeople, chemical engineers and environmental scientists who specialize in persistent organic pollutants, as well as experts in regulation serving as liaisons with international development and environment agencies. This credibility and legitimacy is necessary for negotiating their services both as refiners to e-waste brokers and dismantlers, and as sustainable hazardous waste remediators to government agencies that grant permits to move these materials across national borders.

The science of how to process e-waste in the most efficient or safest way is uncertain. Therefore, producing new science in an emerging landscape of e-waste knowledge is critical for steering the regulatory world towards a particular set of "best practices." For example, a safer-than-thou competition in both the regulatory and market arenas can justify sanctioning one recycler over another: "A traditional miner and smelter has an advantage in dealing with electronic scrap: extreme heat that can make plastics vanish with a minimum of pollution using proprietary technology…. So that allows us to safely handle the plastics that come with electronics recycling" (Schaffer, 2004). Plastics are some of the more challenging materials in e-wastes as they form dioxins when processed at low temperatures and contain toxic materials such as brominated flame retardants (Nnorom and Osibanjo, 2009; Wang and Xu, 2014). Combining efficiency or yield calculations with scientific reports of toxic remediation (or releases) across competing recycling techniques discursively narrows the best-available approaches to recycling.

Indeed, solving problems of toxic byproducts and inefficient materials management is compelling for governments under pressure to address a multitude of environmental and resource problems. Refinery scientists, project managers, and salespeople often contribute to these discussions and are sometimes invited as experts to weigh in. For example, Aurubis, Boliden, Glencore, and Umicore worked with the European Electronics Recycling Association to craft standards for recycling processes for e-waste. The purpose was to "define normative requirements and governing principles…. [and gain] influence at the EU level for the recycling industry…." (*Recycling Today*, 2014). Hugo Morel, the executive vice president for Umicore stated that the standards should "'undermine inappropriate recycling operations that rely on environmentally unsound and unethical sourcing'" (*Recycling Today*, 2014), thus reducing competition from end-processors that cannot meet the specific technical requirements set out by these four refineries.

2.6.2. Territorializing regional flexible mines

Metal scarcity drives the development of the e-waste flexible mine, but the growth in and competition for the e-waste flexible mine has ushered in renewed scarcity concerns. This phenomenon represents a gap in recycling economy research highlighted by Gregson and Crang (2015): moving beyond the environmental question to examine the geopolitics of recycling. Public and private sector actors once called for restricting flows of discarded electronics and other metal-bearing wastes based on environmental pollution or dumping concerns. Now, however, they call on restricting flows for national security reasons of long-term access to specialty metals (Chancerel et al., 2013; Goe and Gaustad, 2014; Guyonnet et al., 2015; Rademaker et al., 2013), counterfeit components unknowingly recirculated into the economy, or discarded chips that facilitate intellectual property or identity theft (Shegerian and Hershkowitz, 2015).

Many governments are identifying a direct relationship between the (real or perceived) shipping of e-wastes and the ability to access the specialty metals necessary for manufacturing new electronics (particularly energy and military technologies). For example, a report for the European non-ferrous mining sector states that "[t]he EU is… dependent on the accessibility of EU 'urban mines' (recyclable materials) where it is currently facing fierce competition from abroad (China, India)" (ECORYS, 2011: 15). Further, a recent draft of a European Commission reference document for non-ferrous refining states that "[t]he importance of using indigenous secondary raw materials such as scrap metal and other residues cannot be emphasised [sic] enough." (European Commission, 2014: 1). The discourses of indigeneity and scarcity highlights the increasing competition and threat of further scarcity of above-ground ores.

Leveraging policy to restrict the movements of e-wastes or who may access e-wastes within a region is one way to territorialize the flexible mine. Humphreys (2013) describes the processes of securitization via territorial restrictions by nation-state actors as a "new mercantilism" and argues that this is a response to increasing uncertainty around resource access due to increasing plurality of actors in the marketplace.

For example, both Japan and the European Union (EU) are seeking to delimit the geography for flexible mining. The EU, through policies crafted in Brussels, seeks to close porous borders that leak discarded electronics, securing access to metal-bearing ores for European refineries to process and return to preferred regional-manufacturing cycles (Kama, 2015). In addition, the EU is funding novel research into improved methods for e-waste recycling, explicitly in support of EU-regional recycling industry (for example: EU's Seventh Framework Programme for Research and Technological Development Projects "Remanence" Ref. 310240 and "Reclaim" Ref. 309620). Japan seeks to create special regional zones of transnational trading that allows some movement of electronic detritus across political borders while simultaneously attempting tight control in order to secure Japanese access to the refined metals (Kirby and Lora-Wainwright, 2015a).

Corporate and other private actors also support various restrictive trade policies for e-scrap. For example, Glencore, with a Canadian facility, and itself a Swiss company, publicly supported domestic United States policy on e-waste trade restrictions at an industry conference in 2013. These efforts are supported by Environmental NGOs that, for reasons other than resource-security, also tend to hold a similar view: that end-of-life electronics should only be processed in state-of-the-art facilities, which are only located in the global North, thereby supporting territorializing regional flexible mines. A policy expert was more blunt: "They [refinery] want e-waste to be hazardous materials. Or more specifically, they want unprocessed material in the EU to be included under the Basel Convention because then it must remain in the EU to be processed there. Once the [printed circuit boards] are removed, they are not clearly hazardous waste, but they want them classified as such to keep them within the system…. These things are a workaround to trade treaties…. There is all this talk about 'eco-efficiency'. But eco-efficiency is crap. There are way too many variables to be able to say this [or that] is a more eco-efficient process. So this idea that they are more eco-efficient and thus contributing to reducing global climate change, et cetera, this is just to regulate others out of the market" (anon, 2013, personal communication). By restricting trade flows through constructing knowledge of risks and hazards in recycling and therefore defining the movement of discarded electronics to certain spaces or by certain actors as an environmental crime (CWIT, 2015; Ni and Zeng, 2009; UNEP, 2015) or fitting in to environmental-dumping narratives (Clapp, 2002; Cole and Elliott, 2005; Dam and Scholtens, 2012), access to the flexible mine can be controlled.

2.7. Conclusion

Mining companies could be thought to have "enhanced possibilities for accumulation" (Campling, 2012) from e-waste because of their ability to leverage capital and due to the perceived low-value of waste streams. However, simply building the technology is not enough to gain regular access to high quality ores to refine. This new frontier is, in fact, an already-existing commodity within numerous and diverse commodity networks, and the competition is keen for who will access it, either through legal structures such as property-based contracts or through extra-legal modes of access such as discourse, authority, and power (Ribot and Peluso, 2003). The organizational and geographical becoming (Coe et al., 2008) for a flexible mine is intimately linked to the dialectical relationship between the material and the social worlds.

The flexible mine concept elucidates how the interplay between interpretive flexibility and spatial and temporal flexibilities expands extractive relations of production into a new commodity frontier via e-waste recycling. This new commodity frontier is both a widening into new above-ground territories of extraction as well as a deepening of technological innovations to extract metals from new ores. Three challenges for below-ground mining have been highlighted, which the flexible mine seeks to solve: fixity, scarcity, and environmental effects. However, while there may be a disarticulation from the history and geographies of below-ground mining, the savior-like qualities of e-waste mining are ephemeral as competition for these ores increases, producing new scarcities and fixed geographies of flexible mining, and as environmental controversies continue over hazardous materials and recycling techniques. As one informant stated: "so to me, when I was in the business… it used to be a very lucrative business. I mean we made buckets of money, but now it's sort of like… it's more like a commodity now… I think, and in terms of the health of this e-scrap industry, we're in the process of a kind of a shake out. There's rationalization going on. Small players aren't going to survive…. but until that happens it's going to be a bit of a rough-go." (anon, 2013, personal communication).

Scholars have begun making the case for training a critical eye on the "circular economy" or global circuits of recycling (Hobson, 2015). What has not yet been considered is the socio-economic justice of mining actors' powerful positions in determining who are the "good and clean actors" when at the policy table. Mittleman (2011: 192) suggested that "[m]oving beyond economism, the key questions are: What conditions in respective zones of the world economy are propitious for entry into this division of labor, and on what and whose terms?" Mining actors, seen as experts in sustainable e-waste solutions are involved in projects, contributing knowledge about who should recycle. As an expert pointed out in the context of working with various refineries in global South projects, "they are a key driver… But also there are very specific industrial interests. That's for sure" (anon, 2014, personal communication). The discourse of sustainability serves as a gloss over the socio-environmental effects of what is clearly an extractive industry.

While it might be a good-enough choice, for now, to refine electronic parts in mining-industry refineries for material efficiency or environmental reasons, the question of how to regulate an industry that is transitioning to nimble and short-term service-contracts rises to the fore. What is not addressed in this new model of resource extraction is how labor and environmental health issues are being addressed along the demanufacturing network. If the flexible mine truly mirrors electronics manufacturing, exploitative practices and toxic environments will continue to grow due to the challenges in governing short term, independent contracts (Lüthje, 2002; Mulvaney, 2013). Further, and more concerning, is how discourses of green recycling and circular economies elide the extractive and capitalist underpinnings of this industrial change, producing inequalities amongst actors not equipped to engage in high-stakes knowledge-making or policy.

Transition to Chapter 3

In the next chapter, I take up the question of why Umicore is a vanguard of flexible mining by unpacking the historicity of our current moment. A political ecology approach often includes attention to the historical trajectories that lead to certain conjunctures. In this case, the growth of flexible mining is a conjuncture that brings together socio-environmental movements, externalities of global manufacturing and consumption, and histories of changing foreign investment in natural resource extraction. I will show that Umicore's uniquely un-diversified portfolio in the middle of the last century, created a unique vulnerability to geopolitical changes, namely decolonization and nationalization of foreign infrastructure. Umicore was faced with a significant disadvantage compared to other global mining giants, which typically had access to multiple mining locations that helped them weather disruptions in any particular locale. Umicore was forced to pivot early and the context of growing calls for sustainability science and green solutions to global environmental problems presented a fortuitous opportunity to change.

Chapter 3

3. From Heart of Darkness to Sustainability Leader: Umicore's Transformation to E-Waste Recycling

> *"Mines are where you find them and not where you would wish them to be. They cannot be sited in the most favourable environment" (Marston, 1976).*

3.1. Introduction

Umicore, once known as Union Minière de Haut Katanga (UMHK), has a long history as a mining company, epitomizing bloody colonial extractive practices in the Belgian Congo and dark geopolitical politics. In this chapter, I trace the company's self-styled transformation from Belgian colonial profiteer/extractor to sustainability expert through their focus on recycling the detritus of industry and consumption[8]. This process results in a dual "cleanup": both their image and the world's wasted electronics.

In Umicore's self-commissioned and self-published history, then-chief executive officer Thomas Leysen acknowledged the firm's colonial roots. He also called for recognition that Umicore was no longer the Union Minière de Haut Katanga.

> In a few months, we will also be able to mark the 100th anniversary of Union Minière du Haut-Katanga.... This books tells and illustrates the story of how, from these distant beginnings, a number of mainly Belgian-based mining and smelting companies gradually evolved into the dynamic, global specialty materials group that is Umicore today. In these two centuries, our group and its predecessor companies experienced periods of great success as well as profound upheaval. They demonstrated at times an entrepreneurial drive which still has the power to inspire us today. On the other hand, certain behaviours and attitudes of the past are

[8] This chapter is motivated by a puzzle that arose during my preliminary fieldwork. As I was exploring international development projects focused on urban environmental health, electronic waste (e-waste) recycling, and themes of international environmental injustice, I noticed an unusual partner: not the usual government agency, research institute, or non-profit advocacy organization. Umicore, a speciality metals and materials firm, always seemed to be present in discussions around global e-waste and hazards associated with dumping or crude processing. Further, when I participated in the inaugural StEP[8] (United Nations) workshop for young researchers working on e-waste, Umicore was a central player in our program: as a financial sponsor, represented by high-status executives and salespeople in the workshop; and as an exemplar of high-technology recycling, offering us an exclusive all-day tour of their facility in Belgium. Umicore, while not a household corporate name, has co-authored United Nations Environment Programme reports on e-waste and sat at the table with Interpol discussing global environmental crime. This paper explores what Umicore is, and how they came to be the unlikely partner in global South development projects.

> no longer consistent with our present values.... three themes emerge which are still shaping Umicore today: A passion for technology... A spirit of entrepreneurship... A desire to explore new frontiers... We have added a fourth driving force in recent years: A commitment to sustainable development...[and] a strong focus on recycling..." (Brion and Moreau, 2005)

Umicore is now to be regarded as a company with a "commitment to sustainable development," in its pursuit of new commodity frontiers and markets. It is this commitment to sustainable development that provides the key to their current success through the construction of the flexible mine: a new source of mineral ore that offers increased geospatial, temporal, and interpretational flexibility (Knapp, 2016 and chapter 2 of this dissertation). End-of-life materials recycling and disposal have developed into a recognized alternative to "traditional" below-ground mining activity. Leveraging the sustainability trope has been a successful strategy for Umicore to insert itself into non-traditional marketing fora for recyclable scrap: scientific meetings and development projects focused on e-waste hazards in the global South.

The current chief executive officer of Umicore, Marc Grynberg, in an interview on a Belgian sustainable business forum (LEAD-IN, 2015), narrated a story of a company radically shifting from a commodities-based mining and smelting giant to a firm that is no longer classified as a mining company, defining itself as a sustainability pioneer. He suggested two drivers for this change: volatile commodities markets coupled with high operating costs, and an increasingly burdensome environmental legacy on and around their primary facility in Hoboken, Belgium. The environmental impact of more than a century of industrial smelting on the fence-line community in Hoboken was public knowledge. Global commodity market volatility has also been well documented, particularly through the mid- to late- twentieth century. His story, however, omitted what I argue is the key driver of Umicore's transformation. UMHK was an exploitative colonial mining company in the Belgian Congo. The company has been tied to the assassinations of two major global leaders – Patrice Lumumba (the first democratically elected Prime Minister of the Congo) and Dag Hammarskjöld (the Secretary General of the United Nations). Their massive mining empire was expropriated in the course of nationalization. The loss of their assets led them to make desperate attempts at finding a foothold in the global non-ferrous metals markets. Finally they radical reorganized, a move that inspired this interview in front of other Belgian businesses seeking success through sustainability.

Umicore is a vanguard of flexible mining amongst industry peers within the copper-based, precious, specialty, and rare metals industry. However, I argue they have not abandoned all of their exploitative practices. In particular, Umicore's pervasive efforts to promote a particular form of flexible mine, known as The "Best of Two Worlds," mirror colonial forms of extraction: treating the global South as a source of cheap raw materials (electronic scrap) to supply their value-adding refining operation and brokering services.

In order to understand how Umicore underwent it transformation, we begin more than fifty years ago in the Belgian Congo, where Union Minière du Haute Katanga was the lead extractive company and the primary generator of economic value for the Belgian colony. This narrative, forged in mid-20th century anti-colonial African independence movements and the Cold War, is fundamentally a story of competition over strategic and valuable mineral resources. We begin with the struggle for independence and unity in the Belgian Congo, from the Declaration of Independence in 1960 by Patrice Lumumba, the first freely elected Prime Minister of the newly renamed Republic of the Congo (later renamed Zaire and then Democratic Republic of the Congo) and continuing through the expropriation of UMHK's vast mining infrastructure at the opening of 1967. It is this expropriation of assets that set in motion the development of what is now known as the Umicore corporation and the birth of a flexible mine.

3.2. Methods

I collected information by reviewing scholarly literature, historical research, news and other media articles, video media, annual corporate reports, and other corporate materials such as websites, self-published promotional materials. I collected and collated historic news articles using search terms such as UMHK, Union Miniere, Congo, UM, electronics, waste, and various names of individuals who appear in this narrative. I used these articles to corroborate and extend my interpretive textual and financial analysis of Umicore's historical documents combined with an in-depth review of secondary historical sources. The analysis was provided texture from videos, images, and promotional materials. My broader research project included on-site observation (twice at Umicore's Hoboken refinery) and semi-structured interviews. These data are not formerly presented in this chapter, but assisted with the textual analysis presented here.

3.3. Colonial Roots

The story starts in the Copper Belt, a rich ore region in the center of the African continent, covering areas that span the former Belgian Congo and British-controlled Northern Rhodesia. The mineral wealth in this region drew Albert Thys, the representative of the Belgian King Leopold II, and Cecil Rhodes, from Great Britain, to claim these areas and develop vast mining infrastructures to exploit both the minerals and the people. Within the Copper Belt, the richest and easiest-to-exploit copper, first reported in secret to King Leopold II in 1892 by Jules Cornet as described in Van Reybrook's history of the Congo (2010), was found in the southern Katanga region. This region grew to represent the majority of industrial wealth for the Belgian colonial economy, rising dramatically from the "red rubber" boom dominant at the turn of the century. The Compagnie du Katanga, a private company directed by Thys, began mineral extraction in the Katanga region after violent conflict between the local leader, King Msiri, and an armed expedition failed to achieve a treaty for land rights and instead ended in the assignation of King Msiri and the murder or evacuation of the people living there (Brion and Moreau, 2005; Gibbs, 1991, Van Reybrouck, 2010). Many decades of brutal exploitation followed, both of the land and of the people who were forcibly employed as laborers for the mines and related industries. Estimates of 10 to 15 million deaths urge consideration of the term genocide. Families were torn apart, limbs severed in punishment, whippings with the *chacotte* were standard, disease and starvation were common. In addition, vast infrastructure – well beyond the requirements necessary for ivory and rubber exploitation - was developed to maximize the profits from mineral extraction including rail-lines, electricity generation and transport lines, and eventually company towns with schools and health clinics (Van Reybrouck, 2010).[9]

Umicore was formed through a large collection of parent companies, of which the oldest, a mining operation on the Belgian-German border, dates from 1805. Union Minière du Haut-Katanga (UMHK), the most direct parent of Umicore (renamed Union Minière in 1967 and Umicore in 2001), was originally formed in 1906[10] through an association between the holders of the concession rights for the copper deposits in the Belgian Congo, i.e., King Leopold II[11] and Albert Thys (a military commander and industrial developer); the British holding company Tanganyika Concessions Limited (TCL or "Tanks"); the Belgian holding company and financial house Société Générale de Belgique (SGB); and a private subsidiary of SGB, the Comité Spécial du Katanga which was two-thirds owned by the Belgian-Congo colonial government, one-third by the Compagnie du Katanga, and directed by Albert Thys as mentioned above (Figure 3.1). The Comité Spécial du Katanga, though not formally authorized to tax or adjudicate, was charged with administrating the Katanga region (Brion and Moreau, 2005; Gibbs 1991; Peemans ,1975) including granting concessionary rights to UMHK. Van Reybrouck argues that the Comité Spécial du Katanga had a "very special legal structure... a state within the state" operating simultaneously as private business, government administrator, and law enforcement (Van Reybrouck, 2010).

[9] For an extensive history of the Congo, see David van Reybrouck's 2010 book, *Congo*. For a detailed examination of the Congo Free State and the extraction of ivory and rubber, see Arthur Hochschild's 1999 book, *King Leopold's Ghost*.

[10] Two additional companies were formed at the same time: Forminière (La Société Internationale Forestière et Minière du Congo) was created to exploit diamond resources in the Kasai region, and the Compagnie du Chemin de Fer du Bas Congo au Katanga was created to build and operate the rail system (Gibbs, 1991: 44).

[11] King Leopold II originally claimed the Congo as his personal state, but transferred control to Belgium in 1908 after mounting international and domestic pressure resulting from the atrocities and bloody personal profiteering documented during the time of the "Free State."

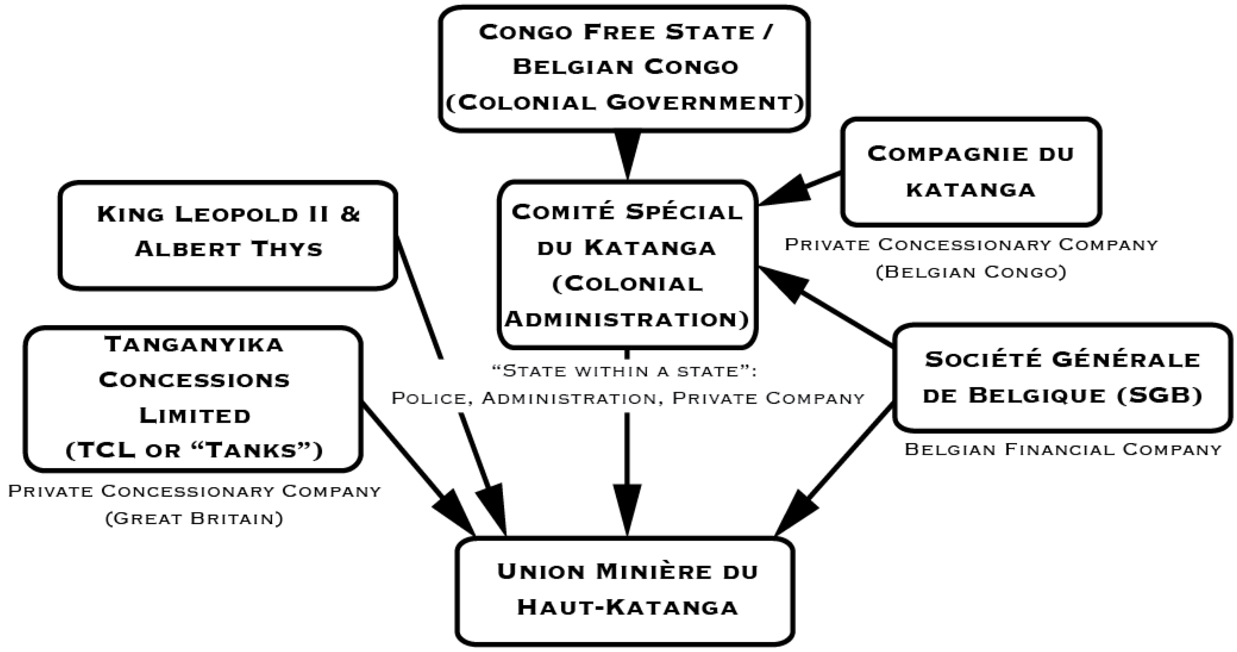

Figure 3.1: UMHK ownership structure in early 20th Century. Source: Author's calculations.

As is common with large multinational corporations spanning decades, the corporate structure, including controlling interests, board membership, subsidiaries, and other corporate investments and activities, was a complex web of circulating elites and creative corporate portfolios. Clear axes of state or private interests are difficult to identify as are sharp boundaries within the corporate structure that includes overlapping controlling interests, subsidiaries, and consultancies. For example, in 1961, the council of fifteen administrators of UMHK consisted of three men representing the British holding company, TCL, with interests in UMHK, two men also from the Belgian holding company, SGB, with controlling interests in UMHK, and three men from the former colonial Congo administration (Gilroy, 1961). There was similar overlapping administration in the British and Belgian holding companies and which continued for a number of years (Gilroy, 1962), extending also to other mining companies, such as British South Africa Company (Howe, 1962).

This chapter focuses primarily on the material and economic networks of the smelter in Hoboken, Belgium, the hub of UMHK's refining activities for over a century linking the colonial mining apparatus to their contemporary practices as Umicore. The smelter in Hoboken, Belgium, was constructed to process concentrates mined and processed in the Katanga region. It was financed and controlled by the Société Générale de Belgique in tandem with UMHK. In 1989, Union Minière absorbed the Hoboken smelter. This smelter is, arguably, the only remaining colonial artifact within the company and is a central facility now for Umicore.

3.4. Independence for the Congo: Cold War Politics, Mercenaries, and Profit

By the end of the 1950s with the Begian government still holding the Congo as a colonial extension of the state, copper, along with cobalt, zinc, uranium, radium, germanium, cadmium, and precious metals found in the Congo were mined and concentrated by UMHK for shipment to the smelter in Hoboken, Belgium. UMHK operated a vast empire of infrastructure: power plants, concentration plants, towns, hospitals, schools, and eight mines. It also employed approximately 20,000 Africans and 2,000 (white) Europeans, and was credited with supplying about 10% of the world's copper and 60% of the world's cobalt (Bart, 1960; *The Times*, 1958; Union Minière du Haut Katanga*,* 1960). A United States consulate report from 1948, as quoted in Gibbs, stated that the "governors of Katanga have tended to be 'yes men,' the strong power being the Union Minière du Haut Katanga" (1991: 60)[12], suggesting that the corporation wielded significant political influence in the region, continuing the tightly intertwined nature of politics and private interests in Katanga. In 1957, despite the bubbling up of public calls for independence[13] and growing unrest, the economic outlook for the Belgian colony was quite positive as described in the UMHK public statement to shareholders (The Times, 1958).

At the close of the 1950s, reports emerged of violent clashes within the Congo threatening production and, by 1959, Belgian troops based in Katanga were used in an attempt to quell revolt (Quelling riots, 1959), resulting in a massacre that created an international scandal and a rapid announcement by King Baudouin that independence would come soon (Gibbs, 1991: 74). Violent clashes at industrial production sites were not new. In 1941, for example, a massive strike at UMHK led the company to usher in the *Force Publique* (colonial police force) and many workers were killed (Gibbs, 1991: 58). However, a radical independence movement all over colonial Africa had been growing since the 1950s, starting with northern African countries gaining independence, followed by sub-Saharan African countries in the 1960s.

In the context of the anti-colonial nationalist movements both surrounding and growing within the Belgian colony, a plan for independence was quickly designed with a date of independence set at only six months later. On June 30, 1960, Congolese independence was declared. Despite being reported in the press, a less headline-grabbing set of politics were at play: The Belgian and British governments were strategizing to join the Katanga province with the UMHK infrastructure and Northern Rhodesia (still a British colony, see Figure 3.2) which was primarily mined by the Anglo-American mining corporation. The purpose of this linkage was to create a separate region allowing continued access to the full Copper Belt riches (The Times, 1960).

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[12] Department of State report November 5, 1948, Decimal File no. 855A.001/11-448, RG 59, National Archives. (Gibbs, 1991: 230)

[13] In 1956, the french translation of a report by A. A. J. van Bilson was published. The report, titled "A thirty year plan for the emancipation of Belgian Africa," inspired heated debates and a response by Alliance des Bakongo (Abako), publicly presented by Kasavubu at a rally. The Abako response was much more radical and called for immediate independence (Nzongola-Ntalaja, 2014)

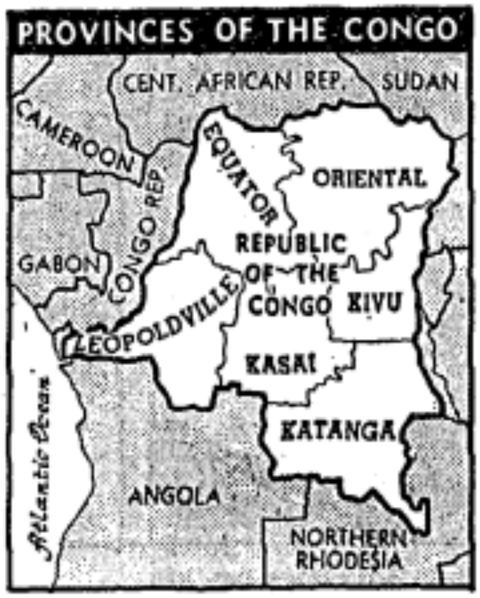

Figure 3.2: The Belgian Congo in 1960 (Krieger, 1960)

Only eleven days after Lumumba publicly declared the Congo a free nation, the local leader and perceived puppet of UMHK and their colonial allies, Moishe Tshombe attempted secession by declaring the Katanga Province independent from the new Republic of the Congo. For the Belgians and British, Katangan independence from Congo carried the promise of a friendlier trading partner in Tshombe, compared to the socialist- (and feared to be communist-) leaning Lumumba. Further, the United States and the United Nations also initially supported this "neocolonial" extension of Belgian control over the mineral-rich region because of their support of western, or Belgian-specific, industrial interests (Gibbs, 1991). The extension of Belgian control over the vast mining infrastructure in the region was also supported by the legacies of colonial extraction and control in the mining region: there were only a few dozen African university graduates, and only three of the five-thousand management-level civil servants were Africans (Hochschild, 1999: 301). In Katanga, these racial differences were even more apparent with the vast majority of both state and company management and specialist employees white (Gibbs, 1991).

Katanga was, by far, the richest and most industrially developed region in the new Republic, and the successful secession of Katanga would have meant economic devastation for the rest of the nation. An engineer, quoted in Wrong's historical narrative, suggested the Katangan mineral wealth was so rich, it was a "geologic scandal" (Wrong, 2000), which colorfully emphasizes the value and perhaps explains the jockeying for control. In order to maintain a unified Congo, Lumumba appealed to external leaders for help, reaching out to both western and Soviet nations: "Premier Lumumba ... asked the United Nations to intervene and force Belgium to leave. Unless the U.N. acted, he said, the Congo would turn to the Communist bloc for help" (Krieger, 1960). Lumumba's pleas, amplified by Cold War fears of losing control of critical natural resources, drew the rapid involvement of the United Nations, under the direction of Secretary General Dag Hammarskjöld, which approved U.N. Resolution 143 on July 14, beginning the operation, ONUC (Opération des Nations Unies au Congo) (Krieger, 2960; *The New York Times*, 1960b; Van Reybrouck, 2010). U.N. troops began arriving in the Congo only days after Independence. Tshombe, however, refused entry into Katanga to the U.N. and violence in the region escalated, leading to further shutdowns of mines and other installations (Bart, 1960; *The Wall Street Journal*, 1960). The United Nations adopted two subsequent resolutions, each expanding authorization of force in order to protect an independent and intact Congo, and to remove all mercenary forces and other military not under direct control of the U.N.[14]

In 1961, the first reports of mercenaries arriving in Katanga appeared, hired by Tshombe and financed by the profits at UMHK, which was paying taxes to Tshombe's secessionist government rather to than the Congo Republic (Gibbs, 1991; Lefever, 1965; Van Reybrouck, 2010). The hiring of mercenaries was no doubt related to the financial losses they were incurring: "The racial strife sweeping the newly independent Congo has begun to take a heavy toll on a company whose wealth is as awesome as its elaborate name - Union Miniere du Haut Katanga" (Bart, 1960). For more than two years, violent clashes erupted between various U.N. regiments and Katanga. It was clear, both then and now, that UMHK was providing both monetary support to finance these clashes (Figure 3.3), as well as the use of their facilities for manufacturing equipment and for providing bases for military action (Gibbs, 1991; Gilroy, 1961; *The New York Times,* 1961c; *The Wall Street Journal,* 1961a; Williams, 2011). Some mercenaries were found to be directly on the payroll of UMHK as "mechanics" as they transported weapons and munitions into the region (Williams, 2011).

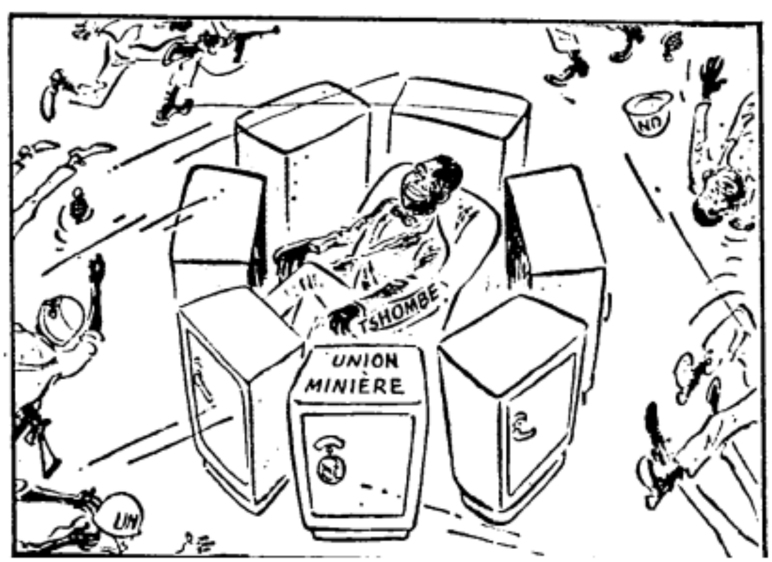

Figure 3.3: Illustration from New York Times article, "No News from Katanga" (1961a).

[14] U.N. Resolution 161 of 21 February 1961, and U.N. Resolution 169 of 24 November 1961

News articles from this period depict a complex collection of debates and controversies over why particular nations or agencies were acting in particular ways. For example, in France and Switzerland, a report suggested that Hammarskjöld's brother, Bo Hammarskjöld, along with two other Swedes, Sven Schwartz[15] and Sture Linner[16] were plotting to take over Katanga's mines. This fear stemmed from Linner's request to have the Swedish Institute of Cultural Relations send Schwartz to conduct a four-month assessment of mining in the Congo. Ironically, Schwartz recommended nationalizing the Katanga mines (Howe, 1961). Gibbs provides a more nuanced interpretation. The Swedish consultants, with ties to competitors in the non-ferrous mining industry, in recommending nationalization for the Katanga mines would likely have reduced copper output from Katanga and thus benefitted the various mining interests in which they had ties (primarily Boliden in Sweden and the Liberian-American Swedish Minerals Company) (Gibbs, 1991: 105-107).

Western powers appeared continually concerned about a Soviet-backed Congo: "Mr. Chester Bowles, President Kennedy's special advisor on Africa, Asia, and Latin America, said today that the United States might be forced to act unilaterally in the Congo if the country went communist as the result of a successful breakaway by Katanga" (*The Times*, 1961). Meanwhile some Belgians balked at the involvement by the U.S. Kennedy administration: "Jules Cousin, administrative director of the Union Minière du Haut-Katanga, sent a message to President Kennedy today saying he [Cousin] had returned the Medal of Freedom awarded to him by the United States (US) in 1946 for Katanga's vital contribution of uranium for the atomic bomb" (*The New York Times*, 1961a). Gibbs argues that ties to specific business interests in the Congo determined United States intervention policy (covert or otherwise) as well as French, Belgian, and British approaches. For example, Gibbs suggests that the Eisenhower's administration's connections to various Belgian Congo investments influenced the sluggish response by the U.S. during the beginning of the Congo Crisis (1991: 99-101). This was in contrast to the Kennedy's administration's ties to the Swedish mining industry, an American industrial diamond interest, and the Rockefeller family (they provided credit to the central Congo government), pushing the US and the UN to take a more aggressive role in suppressing the Katanga secession (1991: 113-114).[17]

In 1961, two important figures had been killed. Patrice Lumumba was assassinated on January 17,1961 after having been captured on his way to Stanleyville in the east, escaping house-arrest in Leopoldville in a coup led by his military secretary, Mobutu. On September 18, 1961, Dag Hammarskjöld was found dead near the wreckage of his plane just outside Ndola airport in northern Rhodesia. He was *en route* to meet with Tshombe in continuing efforts to end the civil war and secession of Katanga. The role of UMHK in these deaths, if any, is still murky.

[15] President of Boliden-Gruv, a precursor to New Boliden, one of four current industry-equivalents for Umicore.
[16] The temporary head of the UN's Congo operations and former African personnel supervisor for a mining company with Bo Hammarskjöld as a board member
[17] The politics and interests were far more complicated that this and for a more extensive and nuanced discussion of private corporate ties across NATO nations, including conflicting interests within the U.S. Kennedy administration see Gibbs (1991) chapter four: "The Anticolonial Bloc and the Congo" (pp 103-144).

However, new evidence was brought to light indicating that UMHK and Tshombe's military were directly involved in Hammarskjöld's death (Williams, 2011) and that UMHK, along with the United States Central Intelligence Agency and dissenting Congolese military were directly involved in Lumumba's assassination (*The Wall Street Journal*, 1961b). This is supported by the admission of the Belgian government of their direct involvement in Lumumba's death (Riding, 2002), interviews with former CIA officers, and statements made by former UMHK employees, Belgian police officers, and local Congolese officers who disposed of Lumumba's body using particularly gruesome methods and supplies provided by Union Minière[18] (Akerman, 2000; De Witte, 2001; Gerard and Kuklick, 2015).

Many scholars, in addition to the popular press, have made the case that UMHK was deeply intertwined in Tshombe's Katangan government and backed the secession attempt (Gibbs, 1991; Williams, 2011). In the wake of the deaths of Lumumba and Hammarskjöld, UMHK came under increasing fire to cease its support of the Katangan government and instead to pay taxes and dividends to the central Congolese government. Despite the lack of international recognition of Katanga as a legitimate nation-state, UMHK directed its Congolese portion of dividends to Tshombe's coffers (Gibbs, 1991; Van Reybrouck, 2010). UMHK made public statements defending their actions against accusations of being "political." "'They [critics of Union Minière] cannot have it both ways. Either Union Minière is in politics or it is not. We take this opportunity to re-emphasize that the only safe and correct course of action open to a private company in ex-colonial areas is indeed complete and consistent non-interference.'" – Terwagne, Managing Director (The New York Times, 1962).

At the close of 1962, Tshombe and Premier Adoula (the second Premier after Lumumba) signed an agreement, formally ending the secession and reunifying Katanga with the rest of the Congo. Fighting continued for a number of months into 1963, but by mid-year, it was clear the secession was truly over. Various installations had sustained damage over the course of the civil war and continued to be occasionally targeted by small attacks aimed at the Belgians, UMHK, or different groups in the region.

3.5. Nationalization, Exclusive Contracts, Severance, and Final Payments

One of the last regions subjected to large-scale colonial extraction was sub-Saharan Africa, and in the mid-twentieth century many of the remaining colonial-controlled regions fought and won

[18] On January 17, 1961, Patrice Lumumba, Maurice Mpolo, and Joseph Okito were killed by firing squad, attended by Belgian officers and Katangan officials and commanded by the Belgian, Captain Julien Gat. The next day, a team, led by Belgian police officer Gerard Soete, moved the bodies from the shallow pit where they fell to a burial site 150 miles away, close to the British-controlled Rhodesian border. Ten days later, in order to prevent feared inquiries, the Katangese Ministry of Interior, Godefroid Munungo ordered Gerard Soete to make the bodies disappear. Soete and Belgian Police Commissioner Verscheure dug up the bodies and spent two days keeping themselves drunk while using a hacksaw to dismember the bodies and dissolve the limbs in acid, which was supplied by UMHK. Multiple accounts state that Soete kept keepsakes such as teeth from the gruesome event. See Gerard and Kuklick (2015) for a detailed account. Numerous news outlets have also published accounts and updates as new information emerges.

their independence. Independence was often followed by the nation-state's expropriation[19] of the mining assets owned by the corporations operating with old colonial concession agreements (Kobrin, 1984; Minor, 1994). Compensation was often demanded by the corporations, but varyingly granted (Kobrin, 1984). Former colonial mining interests found themselves scrambling to secure regular access to mineral ores and concentrates[20] in a world increasingly difficult to control from Northern centers of administration and business. A *Financial Times* article summarized some of the anxiety in the global mining sector during this time: "Why go mining? The soaring costs of new operations and the even greater task of financing them – in view of the potentially unreliable agreements made by the miners' host countries, especially those in the developing world – are now overshadowing the traditional problems of the industry, which anyway has never been an easy business" (Marston, 1976). I argue that the expropriation of Union Minière's entire infrastructure in one blow is the event that set in motion their eventual transition to sustainability leader.

The years following Independence and the civil war were interrupted by threats of nationalization by Tshombe[21] and by transportation restrictions for the mineral commodities from the Katanga region. In November 1964, Tshombe rescinded all concession rights to foreign firms operating in the Congo, including forest and land rights previously granted by the Belgian government while Congo was a colony (*The Times*, 1964a). Half a century earlier, UMHK had purchased mining concessions from these original concessionary organizations that had just lost their rights to the Independent state (The Times, 1964b). In 1965, the shares of UMHK previously held by the Comité Special du Katanga, the private company (despite a name suggesting a governmental department) in charge of administering and policing the colony, were transferred to the new Congolese government. This change joined together the remaining majority shareholders, Tanganyika Concessions Limited, Societé Génerale de Belgique, and the Compagnie du Katanga; and which effectively dissolved the Comité Spécial du Katanga (*The Economist,* 1965) (see Figure 3.4). That year, UMHK began paying 24% of the dividends to the

[19] There is no standard definition of expropriation. I use the term expropriation in this paper to indicate the forced divestment of UMHK assets regardless of the parallel actions towards other multinationals operating in the Congo. Often, it is used synonymously with nationalization, and may indicate more or less extreme measures taken by host countries in their taking of private corporate assets and placing them under state control. Jodice defines expropriation as "a general descriptive term for governmental action to transfer the ownership of private (in this case, foreign) assets to the state, with or without compensation" (1980: 177). Truitt draws a distinction between these terms on the basis of discrimination: expropriation is used when a particular firm or firms are targeted for divestment and nationalization is used when an entire sector is brought under state control (1970: 23). Kobrin uses the term expropriation as a general term that can describe many forms of forced divestment. Though he does not draw the same distinction as Truitt, he uses the term nationalization to help define "mass expropriation" when entire sectors are divested by a state. The alternative for Kobrin is "selective" expropriation in which firms are specifically targeted for divestment (1984).

[20] A concentrate is a secondary form of mineral ores after they have been first concentrated at or near the extraction site. A concentrate therefore has proportionally more metal content than the ore that comes out of the ground, but it has not yet been purified enough to sell or use as the metal or mineral itself. Concentrates are typically then shipped to.refineries for further processing and purification.

[21] According to Van Reybrouck (2010), Tshombe rose to become Premier of the Congo through alliances with Kasavubu and Mobutu, resulting in a landslide election in 1965.

national government of the Democratic Republic of Congo. The first payment of 92 million Belgian francs was delivered on February 7, 1965 (*The Times*, 1965).

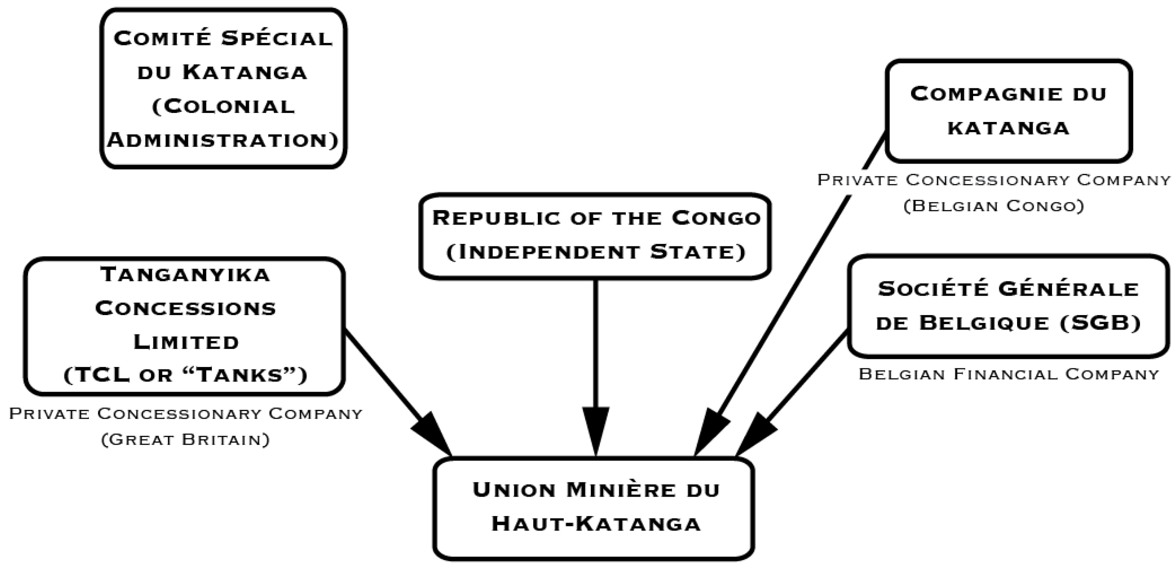

Figure 3.4: UMHK shareholder structure in 1965 with quarter of total shares transferred to the Republic of the Congo from the Comité Spécial du Katanga. Source: Author's calculations.

The term nationalization used in conjunction with the status of a private company could affect its valuation or at least its standing within the industry. UMHK and its investors were in a tenuous position. In 1966, President Tshombe was removed from office, General Mobutu positioned himself as leader of the DRC, and the "Bakajika Law" was passed, which stated that the Congolese government would re-evaluate any concession claim granted prior to June 30, 1960. International press suggested that this was not nationalization because it did not represent a takeover of assets, rather a re-evaluation of the terms of previously granted concession rights (*The Times*, 1966b). However, international politics scholars argue that nationalization is a term that can include many forms of forced divestment of foreign direct investment assets or rights by host nations, including renegotiation of concessionary rights. For example, Kobrin defines four types of forced divestment in his analysis of trends in state-initiated divestments during the latter half of the twentieth century: formal expropriation (taking foreign property under local law), intervention (extra-legal forced transfer of ownership), forced sale (involuntary divestment through sale, regardless of price), and contract negotiation (state coercion forcing renegotiations of contractual arrangements, typically concession agreements in the extractive sector) (1980: 68).

Continuing negotiations between the DRC and UMHK broke down over whether UMHK would relocate their corporate headquarters to the Congo (The Times, 1966; The Times, 1966b). UMHK insisted on remaining in Brussels and subsequently the Mobutu government, in December 1966, banned all exports of copper concentrates or other products mined by UMHK after increasingly hostile accusations towards UMHK of "neocolonial actions" (*Los Angeles*

Times, 1966; *The New York Times*, 1966; *The Wall Street Journal*, 1966). Shortly thereafter, on January 1, 1967, the Democratic Republic of Congo expropriated and claimed as property of the new state company, Gécomin, all mining and related assets (*Chicago Tribune* 1967; *The Times*, 1967a). The mines continued to operate and produce copper concentrates, which were stockpiled as negotiations opened up to the international marketplace for refining services (*The New York Times*, 1967a).

The final ownership ties between UMHK and DRC assets were severed when the Congolese-owned shares in UMHK were cancelled in May 1967. On February 15, 1968 UMHK changed its name to Union Minière, reflecting the finality of this moment and stated that they would thereafter pursue new international investments and projects: "Union Minière's first aim will be the search for and development of mineral substances, more particularly non-ferrous metals, both abroad and in Belgium" (Union Miniere, 1968: 5). Further signaling Union Minière's intent to diversify beyond their former French-speaking colonial investments and modest holdings in industries outside of the Congo, their 1967 annual report is also produced in English.

The value of Union Minière's losses to the DRC were reported as approximately $800 million US dollars (The Wall Street Journal, 1967; The New York Times, 1967) and though they claimed that they could write this loss off of their books due to the favorable cost of copper as they sold their reserves, Robert MacNamara (then head of the World Bank) helped them negotiate compensation from the DRC government (*The Times*, 1968). As reported in the press, compensation was finally set to be $8 million US dollars, first to be paid over 15 years via a 6.5% interest in Gécomin (*The New York Times*, 1969) and an additional 10 years at 1% for continued technical assistance with an unclear timeline (*The Wall Street Journal*, 1970a). Later, compensation was renegotiated to be completed by 1975, sooner by 19 years, in order to reduce long-term risk related to national instability within DRC/Zaire (*The Economist*, 1974; Union Minière*,* 1974).

The relationship between Union Minière and the Democratic Republic of the Congo was not limited to simply settling financial compensation for their expropriated assets. Union Minière engaged in negotiations, in 1970, to develop new mines outside of the already-developed areas within Katanga, competing with an international consortium led by American Standard Oil and Anglo-American Corporation. Union Minière lost the bid, arguably because they refused to consider building a secondary refinery in the Congo (*The New York Times*, 1970a; *The Washington Post*, 1970). Such a facility would have been in direct competition with the Hoboken facility, in which Union Minière held a 50% stake. DRC authorities allocated another concession to a largely-Japanese multi-national investment group for a greenfield[22] in Katanga (*The New York Times*, 1970b). At this point, Union Minière no longer held assets in DRC despite attempts to regain concessionary rights.

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[22] Greenfield refers to a location that has never been developed as a mine.

Although rival multinational mining interests had begun preparing bids to step in as middlemen/marketers for Katangese copper products, an agreement was settled between Gécomin, the DRC state-owned mining company, and the marketing subsidiary[23] of UMHK's parent firm[24] to have the Belgian company handle the sale of concentrates to the UMHK Hoboken facility for refining (*The Times*, 1967b). Further, the deal included a sub-contract to UMHK for staffing the mining operations owned by the DRC (*The Wall Street Journal*, 1969), resulting in a 25 year contract for technical co-operation (Union Minière, 1970: 5). One business analysis argued that this agreement came about partially because of the global scarcity of refining capacity (a boon to the Hoboken facility), forcing Mobutu to contract with the Belgian company despite market competitors (*The Economist*, 1967).

UM continued to refine Congolese copper through an ongoing contract between Gécomin and Société Genérale de Minerais, but the Belgian company also frequently claimed that instability in the Democratic Republic of the Congo affected profits. In 1974, an *Economist* article linked volatility in Union Minière stock with instability in central Africa, despite their efforts to diversity and develop other business endeavors outside of their former colony. In 1977-78, civil war conflicts around the Kolwezi mines led to major production interruptions in what was then Zaire[25] which dramatically affected the Hoboken smelter operations still receiving much of their copper concentrates from Gécomin (Buchan, 1978). Union Minière offered technical assistance to Zaire in efforts to return the mines in the Shaba[26] (formerly Kantanga) province to operating levels: "... the company also needs the earnings it derives from this continuing relationship with Zaire. It is having difficulty finding its feet as an international mining company after the nationalization of its Shaba mines.... Today Union Minière, once so deeply involved in Belgium's dubious African policy, is seeking to reduce its links with Zaire, but it is finding the task difficult" (Lewis, 1978). Despite independence and nationalization of Union Minière's Congo infrastructure, their economic relationship persisted for decades.

3.6. Prospecting and Investments

The year 1968 witnessed a critical moment in Umicore's history. Union Minière publicly announced the shift in their corporate mission to the pursuit of new commodity frontiers i.e., beyond DRC. The following decades were marked by heavy investment in prospecting and greenfield development, and diversification of their corporate portfolio and mission. These experiments with seeking new profitable mines and sectors were pursued in a context of volatile commodities markets in the global economic crisis of the 1970s. In sum, the late 1960s initiated a period of financial strain and hopeful, but largely unsuccessful attempts at pivoting after

[23] The Société Genérale de Minerais.
[24] The Societé Générale de Belgique.
[25] Democratic Republic of Congo was renamed, Zaire, by President Mobutu Sese Seko as a gesture of nationalist pride.
[26] The Katanga region was renamed Shaba by President Mobutu Sese Seko.

expropriation, taking form first in demanding shares and profits, and second in full eviction of the Belgian staff and owners and cancellation of concessionary rights.

Union Minière was not alone in trying to meet the growing challenges for mineral extraction in a post-colonial world. A 1976 article detailed a number of obstacles for international mining firms, highlighting that the "traditional problems" of high costs associated with exploring "remote" areas and developing infrastructure were being overshadowed by post-colonial problems of "unreliable agreements" with host-countries. Put succinctly: "Mines are where you find them and not where you would wish them to be. They cannot be sited in the most favourable environment" (Marston, 1976). The mid-1970s was another peak period of massive expropriations across a number of sectors (Kobrin, 1980, 1984; Minor, 1994). Kobrin's study of expropriation between 1960 and 1979 summarized 559 acts of divestment from 1705 companies by 79 countries. The highest concentration, sixty percent, fell between 1970 and 1975 (1984: 332-333). In this volatile context, Union Minière was notably absent from meetings in which European multinationals discussed the geopolitical scarcity of ores. *The Economist* suggested their absence was due to Union Minière's sensitive position negotiating final expropriation compensation from Zaire (*The Economist*, 1975). Given the well-documented flurry of renegotiated agreements across multiple sectors, coupled with the loss of sunk costs associated with foreign direct investment, it is no surprise that Union Minière would decline to participate in public critique of countries in which they had materials interests.

Union Minière, in the late 1960s, had already begun aggressive exploration in Australia and Canada, as well as developing additional arms of their business such as technical consulting to other mining firms (Union Minière, 1968). With an eye to new markets and uses for mineral commodities, their annual reports in the late 1960s held the first mention of specialty metals in the nascent electronics and semi-conductor manufacturing industries (Union Minière, 1969; Union Minière, 1970). As well, the first mention of rare earths suggested the future growth direction into non-ferrous rare and specialty metals (Union Minière, 1970). Despite the lackluster results of exploration and prospecting by 1970 Union Minière continued to emphasize that they did not want to be "only a holding company" (*The Wall Street Journal*, 1970b): a new mine must be just under the surface. Over the next decade or so, they used cash reserves, stockpiled metals, and expropriation compensation to develop mining-related businesses and explore for new mines in Latin America, Belgium, the United States, Spain, Greenland, and Oceania (Brion and Moreau, 2005; Union Minière, 1974).

Gerard Van Schedel, the general secretary for Union Minière, suggested that the company would never replicate their earlier mining largess: "'We still hope to get mines -- and we will get them, I am sure... But I wouldn't dare say that mining will become [sic] as big for us as before'" (*The Wall Street Journal*, 1970a). In efforts to diversify away from mining, Union Minière began investing widely, and developing expertise in chemical industries, computer applications, nuclear engineering, and domestic non-ferrous metals industry (*The Times*, 1971; *The Wall Street Journal*, 1970a)

Perhaps the most radical prospecting endeavor for Union Minière was deep-sea mining (Figure 3.5, also called seabed mining). In the 1970s, Oceanic Mining Associates, an international consortium of mining companies, including Union Minière, developed new technologies to collect and process "oceanic nodules" (small spheres found on the open ocean floor) containing high percentages of manganese (Union Minière*,* 1978; Wertenbaker, 1977). This controversial venture envisioned suctioning up manganese nodules from an area between Hawai'i and mainland United States. As Umicore's history publication had stated, "[p]art of the appeal was that this was a way to break free of dependency on the mining countries" (Brion and Moreau, 2005: 57). In 1978, the ship "Deepsea Miner II" concluded successful experiments retrieving oceanic nodules from a depth of 4500 meters at a rate of 50 tons per hour (Union Minière, 1979: 13).

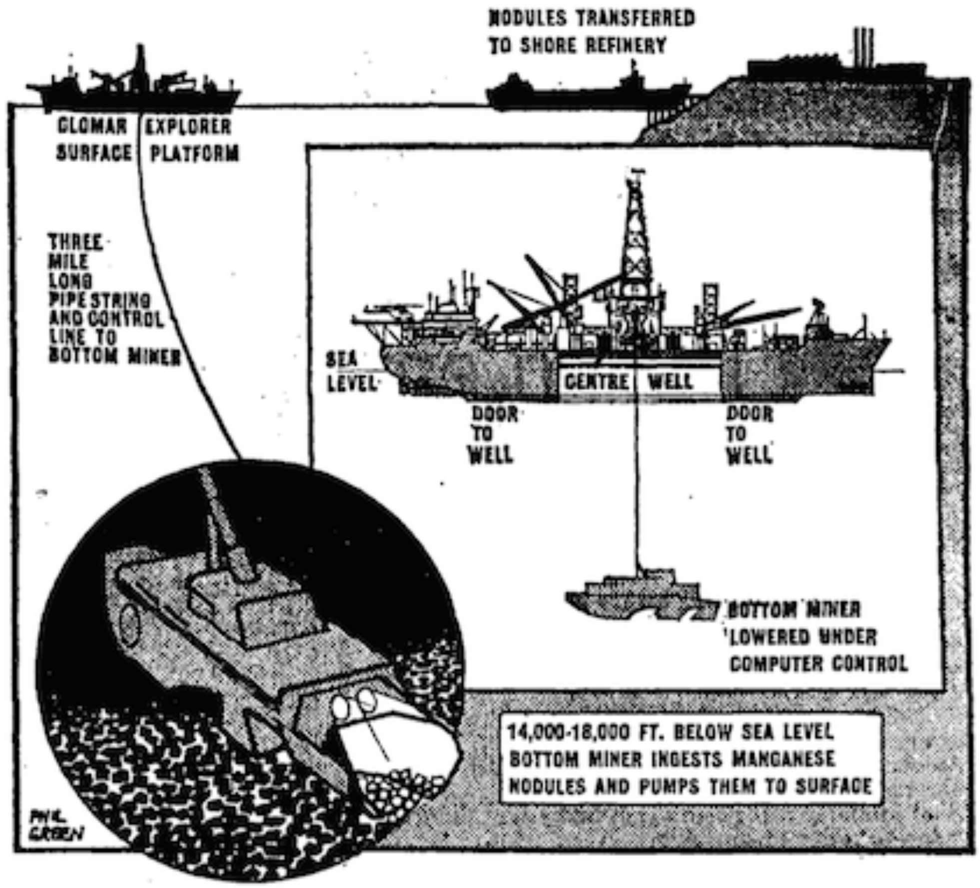

Figure 3.5: Illustration of deep-sea mining extractive technology (Wilson, 1978).

Deep sea-bed mining sparked heated debates within the United Nations on both environmental and economic grounds leading to multiple sessions of the United Nation's Conference on the Law of the Sea (Wertenbaker 1977). The complexity of these debates rendered this frontier too politically expensive to pursue at the time. The various consortia dissolved shortly thereafter.

However, the same deep-sea region is now being explored extensively with new permits issued by the International Seabed Authority: "Insatiable demand for minerals and rare earth elements, coupled with dwindling resources on land have stakeholders across the world looking to a new frontier: the deep sea" (Harvey 2013). However, Umicore has not been prominent in the more contemporary push.

Union Minière faced major challenges in recovering after the loss of their vast Congo mining infrastructure. "…most of these new investments are turning sour, squeezed between rising start-up costs and collapsing metal prices on the world markets" (Lewis, 1978). Their corporate activities, divided across mining and metallurgy, geological prospecting, and engineering services, returned mixed profits due to depressed copper and zinc prices, poor prospecting results, and projects still in development or bidding stages (Union Minière, 1979). Union Minière's numerous investments, ranging from below 10% to over 75% shareholding and including the 45% shareholding in the Hoboken smelter, also returned mixed results with some investments returning dividends and others none. Largely, the Thierry mine in Canada (developed from scratch by Union Minière) was blamed for the majority of losses on the Union Minière books. In 1982, Union Minière announced that it was going to close the Canadian mine, a hopeful greenfield site only a decade prior, due to losses related to depressed copper markets and high operating costs (Edwards, 1982; Union Minière, 1983: 26). The group waited for a few years in hopes of a recovering market, but finally flooded the mine in 1986, writing off 62.5 million Canadian dollars (nominal: not adjusted) as extraordinary loss (Union Minière, 1987: 14).

3.7. Survival, Just

Union Minière viewed the period between 1975 and 1988 as its "crisis" period (Brion and Moreau, 2005). These years were characterized by corporate take-overs and dramatic restructuring meant to streamline operations, diversify outside of the massively depressed copper and zinc markets, and otherwise increase profits in the complicated multinational group.

The financial details for Union Minière help to explain the tumultuous decade and the vulnerability of the nearly-century-old extractive giant. The 1970s brought a steep decline in the share price of Union Minière (from $760 in 1968 to $220 in 1978), prompting one analyst to suggest that there would be "'little improvement in Union Minière's performance until 1980 or 1982'" (Lewis, 1978). Further, financial reporting highlighted the halving of the dividends paid out to shareholders in the 1970s. As shown in Figure 3.6, the early part of the 1980s did not bring any financial improvement. The losses for Union Minière carried knock-on effects for their shareholders as well: "Union Miniere's problems hurt Tanganyika Concessions (TCL or Tanks), which holds a 17.6 per cent stake. This has been reflected in the Tanks share price which, this week, has fallen 9p to 182p" (Cheeseright, 1979). Most of the losses during the latter part of 1970s and the early part of 1980s were attributed to the increasing production costs for the newly developed Canadian Thierry mine in combination with the depressed global markets for copper and zinc (*Financial Times*, 1981; Union Minière, 1979; Union Minière, 1980; Union Minière, 1981).

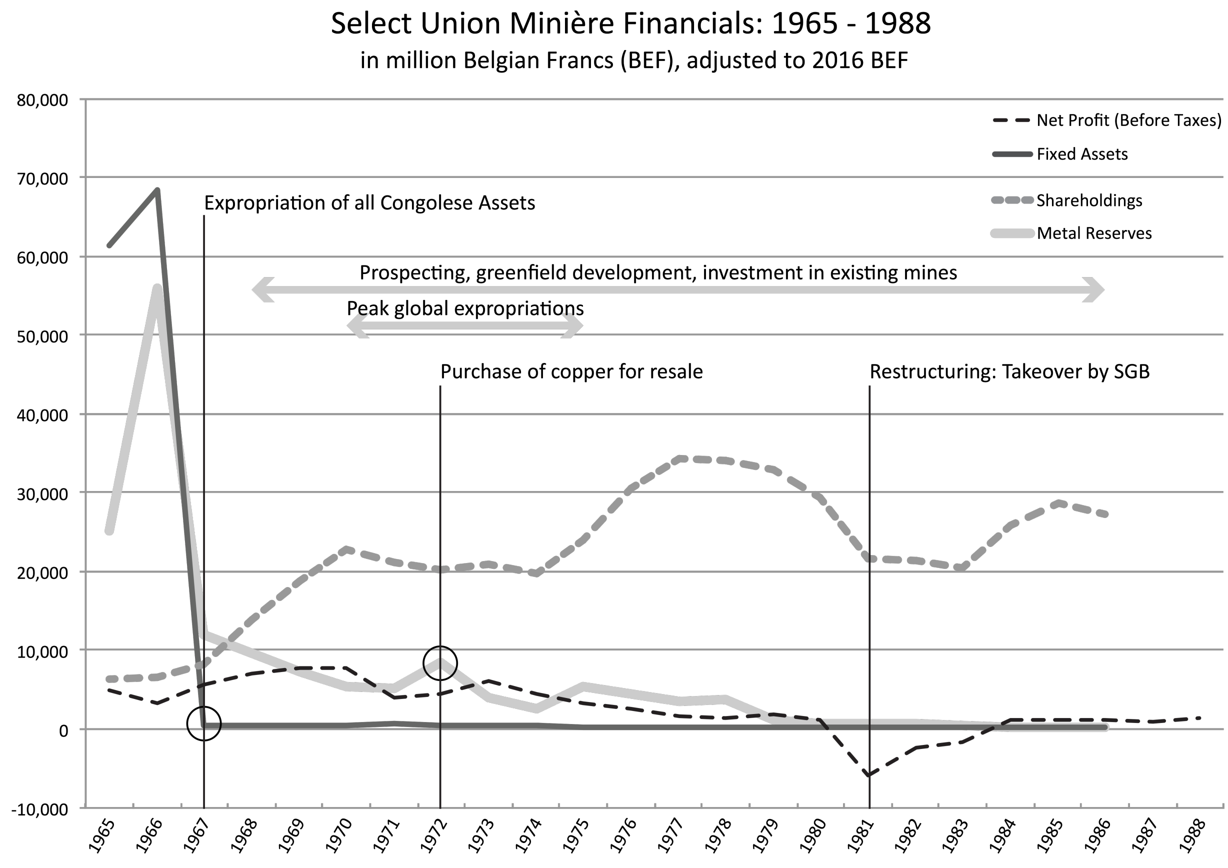

Figure 3.6: All values are adjusted to 2016 real Belgian francs (euro equivalent, 1-Jan 2016). I tracked profit using "net profit before taxes" which was one of the few accounting measures that remained consistent across the decades. Three of the measures were truncated at 1986 because of a radical change in accounting methods and consolidation of accounts which shifted what finances were included and how they were tracked. I tracked profit through 1988 to fit with Union Minière's self-described "crisis" period. Source: Author's calculations from Union Minière annual reports 1965-1988.

In 1981, Société Générale de Belgique (SGB), the Belgian holding company with an 18.5 per cent stake in Union Minière, carried out an aggressive strategy to take control of two of its subsidiaries, Union Minière and Finoutremer (a financial house) and restructure SGB holdings into a streamlined non-ferrous metals sector with Union Minière[27] as the head. In order to alleviate some financial pressure, the plan was to seek out a mining industry partner to share equity in the new Union Minière, but this proved challenging (*Financial Times*, 1983). This consolidation was called the "biggest corporate reorganization of recent Belgian history" (*The Times*, 1981a), comparing it to the expropriation of Congolese assets in 1967 (*The Economist*,

[27] SGB dissolved the old Union Minière (renamed in corporate records to "Ancienne Union Minière") and formed a new corporation, continuing the name Union Minière s.a.("Union Minière Notice to Shareholders," 1981).

1981). The takeover was also part of a larger trend of consolidation in the mining industry and a streamlining of a too-complex ownership structure (see also Figure 3.7):

> [T]he development must be seen as part of a pattern into which are woven the purchase by British Petroleum of Selection Trust, the effective abandonment of Charter Consolidated by Anglo American, the Anglo and De Beers 25 per cent stake in Consolidated Gold Fields, and the much publicised takeover of mining companies in the United States... Société Générale, which was founded in 1822... has long held a 29.9 per cent stake in Tanks. The connexion -- as is common with mining companies -- is made more incestuous by the Tanks 17.6 per cent holding in Union Miniere, the main Belgian mining concern, itself more than 18.5 per cent owned by Société Générale and its multifarious offshoots. Depending on your viewpoint, therefore, the purchase of Tanks can be see as a tidying up. (Prest, 1981)

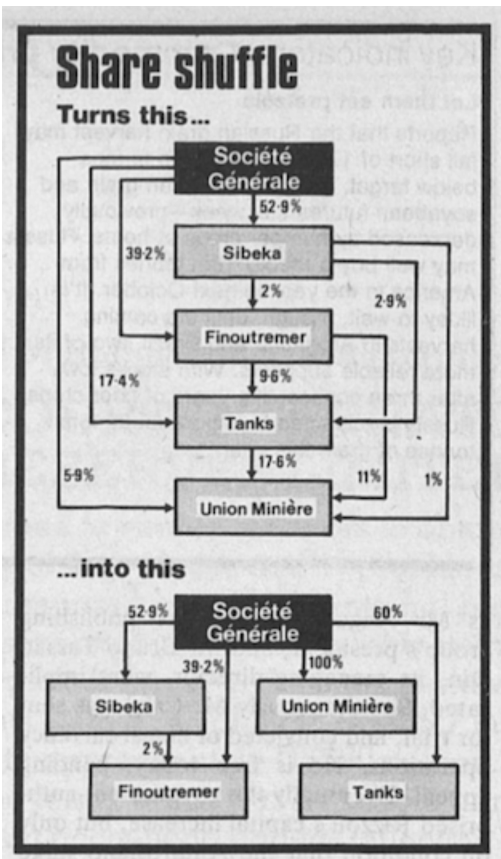

*Figure 3.7: Schematic of Union Minière takeover and reorganization by Société Générale de Belgique, shifting to 100% control of Union Minière. (*The Economist*, 1981)*

Though the complicated restructuring signaled a sea-change in Union Minière's mining strategy it initially brought further financial losses to SGB, despite the massive gain in equity: "The Brussels-based group pointed out yesterday that it was the consolidation of its accounts with what is now known as Ancienne Union Miniere which provoked extraordinary losses. [Union Minière] suffered a loss of BFr 2.62bn through a fall in the value of several of its investments" (*Financial Times*, 1982) (Figure 3.6). After the reorganization, Union Minière began to reduce activities in areas that had been sources of losses for many years, namely the overseas subsidiaries created since 1967. In addition to the closing of the Thierry mine in Canada, 1982 brought the shelving of two major mining projects in the United States and the massive reduction of investment in deep sea ocean-bed mining (Union Minière, 1983: 6-8). They continued to invest, however, in greenfield mine development until the early 1990s, and made a failed attempt at developing a gold mine in Guinea (Union Minière, 1993: 21).

A hostile takeover bid by Italian Carlo de Benedetti threw SGB leadership and the Belgian state into turmoil in 1988. SGB's (the holding company with the largest stake in Union Minière) efforts to diversify and find friendly investment partners instead attracted partners who could take advantage of its weak performance to wrest control away from the Belgian leadership by purchasing a majority of the shares. News stories described a hot mix of both financial aggression by foreign interests and old cultural discords within Belgium, between the French-speaking leadership and the Dutch-speaking Flemish Belgians, long kept out leadership positions at the top of the giant corporations. René Lamy, head of SBG since 1981 and a director on Union Minière's board since 1969 (Union Minière, 1989: 13), found himself shouldering both the blame for the poor financial performance of SGB and also the mantle of the old order of French aristocracy in Belgium. André Leyson, a Flemish business man and former Nazi sympathizer (Flynn and Pressley, 2000), made public statements about increasing Flemish control within SGB; his son, Thomas Leyson, later rose to become chief executive officer of Union Minière. In response to the attempts by the Italian businessman to take over SGB, Lamy ironically called de Benedetti's moves "imperialistic" and an attempt to "colonize" Belgium (Nelson, 1988). The Belgian finance minister and Belgian courts were enrolled in the battle of who could legally purchase shares. De Benedetti threw accusations of illegal purchasing, while Leyson (Flemish-speaking Belgian) accused them of deploying nationalist (French-speaking Belgian) sentiment (Braude, 1988). By the end of the year and after some strategic issuing of additional shares to "friendly" investors, de Benedetti was only able to purchase 45% of the shares in SGB, and majority control of SGB instead went to Suez, a giant French holding company and investment house, much friendlier to keeping Belgian leadership in place at the 166 year old firm (Dickson, 1988).

After the Suez takeover, SGB underwent massive restructuring to address its unwieldy and sprawling portfolio, as well as to change the lavish and unproductive aristocratic leadership. However, in a move contrary to simplifying the non-ferrous holdings in the portfolio, SGB decided to merge Acec, an electrical engineering subsidiary that had been unable to pay dividends to shareholders for more than twenty years (Acec Union Minière, 1990: 5), with Union Minière, possibly to offset Union Minière's 1989 profits with Acec extraordinary losses (Hagerty, 1989). This was followed, however, with the more strategic merger of three other non-ferrous metals companies, including Metallurgie Hoboken-Overpelt. All were subsumed within the newly renamed Acec-Union Minière company, with 87.5% of the resulting shares held by SGB. The new company was called a "Giant In Metals Field" resulting in "one of the world's largest producers and refiners of non-ferrous metals" (Du Bois, 1989). Mining and manufacturing investments were still pursued to reduce the company's dependence on global commodity fluctuations, despite the broad portfolio of metals produced,[28] but downstream manufacturing was emphasized as the future strategy for growth. Only three years later, beset with massive losses affecting SGB, Union Minière shed Acec (a company unrelated to mining or refining) both in name and in activities and assets (Union Minière, 1993). Shortly thereafter, SGB began to sell off its shares of Union Minière (Union Minière, 1994). In 2003, SGB was absorbed into the Suez-Tractabel merger. In an obituary of sorts and with a narrative that completely missed the decades of scrambling and decline presented in this chapter, it was described as the "once champion of Belgium's industrial revolution, the issuer of its banknotes and the financier of the brutal colonisation of the Congo" that lost its footing in the de Benedetti battle for control (Castonguay, 2003). Union Minière, however, did not suffer such a fate. New directions for the old mining firm carried it into the twenty-first century and a renewed leadership role as a sustainable development and high technology expert.

3.8. Seeds of the Future: Growth and Diversification

A few of the subsidiary and affiliated companies in the Union Minière family were successful in the 1980s, such as Unimeta in Brazil (mining gold and diamonds) and Union Mines in the United States (mining cadmium and germanium) (Union Minière, 1987). The Hoboken facility (part of Metallurgie Hoboken-Overpelt) also showed growth in the existing production of refined precious and specialty metals such as platinum, rhodium, tellurium, and indium. Research at the Hoboken facility focused on new technologies for high-purity precious and specialty metals. New recycling technologies were also developed at the Overpelt and Olen facilities in order to expand the diversity of input materials to, for example, used batteries or cobalt-containing waste streams, and further investments were carried out at the Hoboken facility to improve their ability to refine metals from "complex" input materials (Union Minière, 1983; Union Minière, 1984; Union Minière, 1986).

Société Générale des Minerais s.a., the sales brokerage company that had formed the bridge between decolonization, expropriation, and final independence by handling the purchase of Congolese mining concentrates and the sales of refinery products, expanded their investment portfolio to include a majority interest in a United States-based company that specialized in the recovery of metals from scrapped telecommunication and electronic equipment. This marked, perhaps, the first explicit investment in electronics recycling for the family of non-ferrous companies, beyond the modest amount of electronics scrap already processed at the Hoboken facility (Union Minière, 1984).

[28] 1989 Annual Report to shareholders listed the following products: Copper, Zinc, Cobalt, Lead, Tin, Antimony, Bismuth, Cadmium, Silver, Gold, Platinum, Palladium, Rhodium, Germanium, Silicon, Selenium, Tellurium, Indium, Mercury, Gallium, Arsenic, Nickel, Thallium, and Tantalum.

The early reorganization and streamlining of non-ferrous industry companies under Union Minière, was followed by diversification. Key to the story of transition from the colonial apparatus to the soon-to-emerge sustainable specialty metals group was the aforementioned subsumption to direct Union Minière control of the Hoboken refinery, and also the restructuring of Société Générale des Minerais. At the close of 1985, Union Minière acquired over 99 percent control of Société Générale des Minerais, and split the firm into four entities. The one retaining the original name and original administrative offices was subsumed into Metallurgie Hoboken-Overpelt and charged with handling all commercial activity for that group (Union Minière, 1987).

The end of the 1980s brought systematic investments in new industries aimed at long-term development strategies for Union Minière. For example, the group invested in a laser-mirror manufacturing firm in California and a venture capital firm specializing in "advanced technology industries" (Union Minière, 1988: 7). Meanwhile mining activity and mining investment remained a core part of Union Minière's portfolio with continued investment in existing mines and in speculative partnerships aimed at developing new mines. At the end of the decade, Union Minière again streamlined its portfolio by shedding a number of interests such as the mine investments in Brazil, reorganizing the diversification investments in technology sectors to its subsidiaries, and taking more direct control of the core infrastructure including the Metallugie Hoboken-Overpelt group. This group was touted as the "leading European copper refiner" in the 1988 annual report to shareholders (Union Minière, 1989: 10). More germane to their future development as a specialty metals powerhouse, the same annual report boasts, for the first time, their expanded capabilities in higher-value metal production such as tellurium, germanium, selenium, indium, and the precious metals group (gold, silver, platinum, palladium, rhodium), indicating a payoff for the many years of research investment into new and complex processes (Union Minière, 1989). Union Minière's reports to shareholders started to take a more positive note at the turn of the decade.

3.9. "Capitalism as if the World Matters" (Ethier, 2007)

The global trend of expropriating mining assets and running state-owned mining operations largely reversed in the 1990s: many countries liberalized investment opportunities both in existing operations and for new greenfield sites (Bridge, 2004; Minor, 1994; Warhurst and Bridge, 1997). However, despite the opening up of foreign direct investment and privatization of mining operations, the industry continued to face increasing regulatory pressure to invest in cleaner technology and instead of continuing to pursue mines, Union Minière embarked on a radical transformation under new leadership and eventual independence of Société Générale de Belgique. The group reorganized again to develop, among other pursuits, their specialty metals recycling capacity. They also began shifting their corporate discourse to address the growing trend in environmental and sustainability reporting, which dovetailed nicely with their pursuit of recycling secondary goods and industrial wastes as a substitute for mining ores and concentrates. The interpretive flexibility inherent to recycling activities, allowed Union Minière to eventually gain special access to emerging global markets of scrap goods via their positioning as a sustainable development partner.

After the dramatic merger and restructuring into Acec-Union Minière, the corporate reports began to emphasize a strategic move towards diversifying their feedstock for the refinery at Hoboken, explicitly developing new infrastructure focusing on recycling so-called "complex" materials (Union Minière, 1994). Their 1989 annual report contained the first mention of directly substituting "traditional ores and concentrates" with "secondary materials, such as by-products of the non-ferrous metals industry and recycled materials," resulting in a "flexible" metallurgy (Acec-Union Minière, 1990: 14). As part of this shift, they refined techniques to handle materials that came bound in new matrices such as plastics or resins. By 1993, only one third of the feedstock at the Hoboken refinery came from primary mines. The remainder came from "intermediate products" from other companies and recyclable materials (primarily from the automotive, electronic, oil, and film industries) leading to record-high platinum group metal production in the Hoboken facility (Union Minière, 1993: 25).

Union Minière's organization and non-ferrous metals profile shifted and changed through the 1990s, reflecting a honing in on copper and lead-based specialty metal processes that would dominate their Hoboken facility in the 2000s. Acec-Union Minière restructured its new "integrated group" into five units based on their primary metals at the time: copper, germanium, cobalt, zinc, and precious and speciality metals (exclusive to the Metallurgie Hoboken-Overpelt division) (Acec-Union Minière, 1990: 4). Union Minière, in 1992, created a dedicated recycling unit, in addition to the Hoboken facility, that focused on zinc products and end-of-life vehicle recycling for non-ferrous metals (Union Minière, 1993) reflecting the ongoing investment in recycling. In 1994, Union Minière completely exited the zinc mining industry when they sold off their United States and Austrian zinc mines, followed by their Swedish zinc mine, retaining their zinc refining facilities in Belgium and France (Greiff, 1994). They allocated the revenue from these sales to invest in copper, precious and specialty metals processing. Remaining mining stakes, such as copper in Mexico and silver in Morocco followed suit.

3.9.1. The Environment

Mining companies began developing separate environment or sustainability reports, highlighting environmental controls and safety measures, to compliment their annual reports to investors in the 1990s. This was in the context of a global trend of adoption of Corporate Social Responsibility norms across diverse sectors, and an expansion of governance approaches from prior state-centered governing (Dashwood, 2012). In Union Minière's first environmental report, they summarized the political stakes of this shift toward making the environment explicit in corporate documents: "the environment agenda is changing very rapidly, with growing emphasis on sustainable development, and this will have far-reaching effect on our business... the environment [is now] recognised as a major strategic issue" (Union Minière, 2000: 4). These stakes were described in the first chapter arguing for the concept of the flexible mine (Knapp, 2016).

Environment as an object of concern appeared as early as 1974 in Union Minière's annual reports to shareholders, but most of the references focused on projects at the Hoboken facility and not necessarily across the entire organization. Throughout the 1970s and 1980s, infrastructure investments in the Metallurgie Hoboken-Overpelt group such as gas scrubbers and dust control were highlighted to demonstrate a consideration for their environmental impact: "As a heavy industry, MHO [Metallurgie Hoboken-Overpelt] is systematically modernizing its metallurgical units by incorporating sophisticated techniques, with a particular emphasis on protection of the environment" (Acec-Union Minière, 1990: 11). Union Minière also invested heavily in cleaning up toxic legacies at a number of their facilities. The largest projects were around their Hoboken facility in Belgium and the copper smelter and refinery that they acquired in Pirdop, Bulgaria. The Bulgarian facility had been state-owned and the cleanup plan was a requirement of privatization, financed by the Bulgarian government, and funded by the World Bank (Union Minière, 2000: 16). The cleanup at the Hoboken facility included the surrounding fenceline community that had been complaining for years about local pollution from the massive refinery complex.

In Union Minière's 1992 annual report a separate section was devoted to discussing their environmental efforts and demonstrating their socially responsible corporate activities for the first time, sprinkled with images of workers installing environmental upgrades (Union Minière, 1993: 22). They cited the broad sweeping changes in environmental governance:

> On the environment front, 1992 was marked by the publication of numerous decrees, regulations and new obligations. It is worrying to note that these initiatives are being taken at many different levels, from the UN, OECD and EEC, down to the national, regional and even local authorities. This wide range poses serious problems as regards monitoring and planning the company's activities" (Union Minière 1993: 16).

They responded by drafting their first environmental charter which is distributed in their 1993 Annual Report (pp 23). They also began to link their industrial change towards recycling with environmental goods: "This new equipment [blast furnace gas cleaning equipment] allows Hoboken to process unlimited quantities of electronic scrap in the most ecologically positive manner." (Union Minière, 1994: 33).

Many mining companies engaged in global policy either directly through involvement with multilateral organizations such as the United Nations Environment Programme, or through industry associations such as the International Council on Metals and the Environment (created in 1991) and the International Council on Mining and Metals (successor to ICME, created in 2001) (Dashwood, 2012: 4). Thomas Leyson, chief executive officer, emphasized Umicore's (Union Minière's new name) growing leadership in international sustainable development projects by emphasizing their adoption of the sustainability principles of the International Council on Mining and Metals, and sustainability awards, such as the Belgian Environment Prize for 2003-2004 for their involvement in the Bulgarian cleanup (Umicore, 2004a: 3). These accolades, however, stemmed from controversy: some claimed that their involvement in Bulgaria was engineered through privileged access to the World Bank. According to a Bulgarian news service, a Bulgarian energy coordinator accused the World Bank of conspiring against the Bulgarian copper industry by hiring a consultancy to valuate the Pirdop smelter in the interests of Union Minière prior to the issuance of a loan, and then making the loan to the Bulgarian state conditional upon privatization by Union Minière (*BTA News Agency*, 1998). The majority of funding for the cleanup came from this World Bank loan, though the work was done by Umicore. Umicore subsequently spun-off the cleaned-up Bulgarian copper works, renamed Cumerio, in 2005 (Umicore 2005d).

3.9.2. Shedding the Old

In September of 2001, Union Minière officially became Umicore. The report to shareholders stated, "[t]he decision to abandon a name rich in tradition and prestige after almost 100 years was not taken lightly... while the Union Minière name was well known, many people associated the company primarily with mining activities. This was despite the fact that mining ceased to be the principal business of the Group over thirty years ago" (Umicore, 2002: 15). While it might be a stretch to say that mining had not been a dominant activity in thirty years, since Union Minière had been actively pursuing and investing in numerous mining endeavors up until the 1990s, this statement was a clear expression of their desire to dissociate themselves from the mining industry and legacies of dirty and violent extraction. Press coverage reinforced this new identity and analysts argued that Umicore was vastly undervalued given the new focus on specialty metals used in optical fibers, lithium batteries, and catalytic converters, among other pursuits. As one article argued, "it is a world away from the gritty African mines long associated with Umicore" (Fulford, 2004). Umicore applied for industry reclassification to, for example, Specialty Chemicals from Diversified Metals & Mining on the Morgan Stanley Capital International index (Umicore 2005b).

Business analysis suggested that Umicore's "most spectacular growth" was due to its recycling services (Cohen, 2013: 481). So called end-of-life materials began to dominate their refining feedstock throughout the 2000s. For example, in 2004, using a metric of refining charges (not tonnage), their feedstock was only one percent from mining concentrates. Ninety-nine percent was a combination of industrial by-products, scrap materials, and other sources (Umicore, 2005). In a promotional flyer for their Precious Metals Refining division, Umicore stated that they processed 250,000 tonnes of metal-bearing materials with a "special focus on new sources of feed such as electronic scrap and spent catalysts" (Umicore, 2005a). In its 2005 Annual Report, the Chief Executive Officer and the Chairman stated that "the concept of sustainable development [was]... exemplified by [their] commitment to recycling" (Umicore, 2006).

Umicore's recycling technologies also earned them environmental prizes, such as the European Environmental Press Association's Gold Award 2005 for advances in recycling lithium-ion batteries (Umicore, 2004 b). One manager in particular, Christian Hagelüken, tirelessly promoted Umicore's sustainability services, co-authoring scientific papers, industry trade articles, and presentations that discussed the growth of hazardous wastes, plastics and flame-retardant pollution, and scarcity of technology materials. Umicore's efforts to build a trend-setting green image is what earned Marc Grynberg, paraphrased in the introduction, an hour of televised media exposure to discuss Umicore's transition to sustainable development and their resulting business success.

More strategically, Umicore's foray into "sustainable" international development brought them together with the United Nations University and other research and technical institutes in Europe focusing on the increasingly concerning global issue of electronic waste shipping and disposal. Through Umicore's partnership with the United Nations' Solving the E-waste Problem partnership (StEP), they have been able to steer scientific agendas and international development goals to their advantage as I discuss in the third chapter. Umicore staff have co-authored scientific papers (Sepúlveda et al., 2010; Wang et al., 2012), United Nations reports (UNEP and UNU, 2009; UNEP, 2013), and sustainable development book chapters (Hagelüken, 2012; Hagelüken and Meskers, 2012), influencing the global conversation around how to best govern metal-bearing wastes.

3.10. Conclusion

The convergence of Umicore's struggle with below-ground mining, the current era of sustainable development, and recycling's salience as a win-win solution to waste management and resource scarcity, has resulted in Umicore's emergence in the vanguard of flexible mining. Though this story of industrial transformation traces a number of technological and logistical changes for an extractive giant, I argued that Umicore retains its long-standing relationship with the global South, but cloaked in a green neo-colonial garb. Further, Umicore's corporate history as a violent exploiter in the "heart of darkness" is a direct cause of their current success: the wealth amassed, the political shielding from scandal and criminal investigations, the tangled web of leaders with multiple hats, have all nursed Union Minière through the shock of expropriation and subsequent failed attempts to regain hold of the underground.

Colonial systems of rule are often simplified into a coarse model that relies upon distinct and clear geopolitical boundaries defining the colonizing power (or "home" country) and the colonized territory with formal systems of rule and trade. Stoler (2006) argues that colonial scholarship would benefit from taking the opposite view, that moments in empire can be characterized as much by their exceptions to clear analytical categories. In contradistinction to scholarship focused on the creation of order by colonizing forces (for example, Anderson, 2006; Scott, 1998), Stoler (2006:140) further argues that "agents of imperial rule have invested in, exploited, and demonstrated strong stakes in the proliferation of geopolitical ambiguities." That is, fuzzy boundaries and opaque relationships are part and parcel of exerting empire.

Umicore can be characterized as a company that has never fit into clear and distinct analytical types: from the opaque boundaries of early colonial structures to the contemporary fluidity between private corporate interests, scientific consultancy, and soft-policy authorship. Umicore now thrives because of geopolitical (and identity) ambiguities. A flexible mine containing a global portfolio of clients "mining" the detritus of society for metal-bearing scrap disrupts neat boundaries between "host" and "home" country. Further, public statements made by Umicore staff that suggest their clients in the global South focus only on the manual labor of dismantling (producing a higher-quality scrap product for Umicore) and not on developing infrastructure to manage hazardous waste recycling suggests that "certain behaviors and attitudes of the past," despite the statement by Mr. Leysen, are still, in fact, "consistent" with their present values. Umicore's colonial legacy of extraction continues in the intangible neocolonial approach to creating new geographies of extraction.

Transition to Chapter 4

I next return to the moment in which Umicore, now transitioned away from its dirty and violent mining past, attempts to construct a flexible mine via science in the name of sustainable development. I will show how they leverage their connections to trusted global institutions and universities to construct a model of international trade that feeds their bottom line and their need to capture above-ground ore (printed circuit boards). My analysis will unpack the mechanism through which they exert their continuing imperial desires to extract value from the global South and restrict Southern improvements that could compete with their niche providing a sustainability service to the world (and the continuing demand for raw materials with which to manufacture innovative information technologies). In the finish, my analysis lays bare the strength that numbers have in obfuscating neocolonial endeavors and the challenges in governing socio-environmental natures and problems in an era of public-private partnerships and neoliberal development.

Chapter 4

4. How a model is made: The Best of Two Worlds and a new imperialism

4.1. Introduction: International model-making

> "So, how should it be optimized? We call it the Best of Two Worlds. Combine the strength of what you do here with the strengths plus the technology abroad… It doesn't make any sense in India or other emerging countries that you start to develop immediately from the beginning end-processing technologies. That doesn't make any sense. First, be sure that you manage the critical mass. Focus on dismantling…. There is no mechanical, physical, higher tech instruments that can have the same selectivity as the well-trained hands of your employees. And they are really an asset for you. They do a very good sorting job."
>
> – Umicore regional sales director giving the Golden Jubilee Lecture at a science college in Bangalore, India (March 18, 2013)

Electronic waste (e-waste) trading has risen up the global agenda as campaigns by activist non-governmental organizations, such as the Basel Action Network, have highlighted the extensive and toxic environmental pollution deriving from end-of-life electronics. Like many environmental problems, however, solutions are neither simple, nor easy. Poverty in areas where waste comes to rest, resource scarcity of metals needed for electronics manufacturing, manufacturing processes and redesign, and environmental regulation are just some of the intersecting issues related to e-waste.

I show that an emerging model for international e-waste trade governance called the Best of Two Worlds (Bo2W) is the result of post-colonial imperial encounters (Doty, 1996) in which an elite public-private partnership in the global North constructed a story about global North and global South recycling industries. The Bo2W "model" for mining the valuable parts of electronic waste in the global South and recycling them in the global North is little more than an e-waste-based value capture/transfer project that mimics the inequitable international divisions of labor perpetrated by most extractive industries. I further argue that the Bo2W is based on false science (experiments conducted poorly despite available scientific expertise and misrepresented findings), driven by the profit-motives of Northern elites, including Umicore, one of the partners involved in the project and a vanguard of flexible mining (Knapp, 2016).

My analysis shows how historic capitalist extraction remakes itself through a transnational epistemic community (Haas, 1992) operating as a public-private partnership. The partnership constructed The Best of Two Worlds through two mechanisms. The first mechanism is the politics of representation, in which actors compete over the meaning of ambiguous things in the world (Mehan, 2000). For e-waste recycling, this takes the form of defining who is an expert, what is efficient, and defining the problems that need solving. I unpack what is meant by "best," examining the attempts to represent the "Two Worlds" (global North and South) with numbers that reduce and elide the complexity of the realities they measure, but carry the weight of scientific authority. In particular, my analysis reveals that the most critical number – the lowest measure of yield for "informal" global South recycling practices – was the result of Northern elites mimicking what was thought to be Southern recyclers' practices: the primary study that measured recycling rates was not actually measuring recycling rates. These numbers, through their uptake into multiple publications, citations, reports, and figures, disarticulate the numerical representations from political moment of measuring and observing. I then show what happens when a model of trade, based on this representation is implemented. When that experiment fails, my research argues that the drive to promote a model that economically benefits Northern elites overpowers a process of evaluation and instead, compels actors to amplify the representations and continue promoting the model in trusted venues.

My research addresses a weakness inherent in public-private partnerships that have been entirely designed by private entities by tracing the influence of a private corporation in problem-definition, fact-finding, model design, and results dissemination. In this case, the resulting Bo2W model reproduces the very inequity and environmental harms it is intended to address (promoted as a win-win scenario) by selectively ignoring the environmental problems associated with e-waste. The model then creates a solution that competitively cuts-out whole parts of the world from participating in the more profitable part of e-waste recycling: extracting the precious metals. Further, my analysis shows how scientific authority was leveraged to construct this neocolonial model of capitalist production, continuing the exploitation of the global South as a reservoir of raw natural resources and cheap labor.

4.1.1. Public-private partnerships

The growth of neoliberalism since the 1940s, and particularly since the 1980s, has influenced the structure and organization of science. In particular, the stark decline in public funding for public universities, combined with legal and financial incentives to privatize scientific results though patents suggests another trend for privatizing science (Lave, Mirowski, Randalls, 2010).

One contemporary approach to international environmental problem-solving is the public-private partnership, in which corporate (private, for-profit) partners are explicitly included in projects alongside traditional state- or multilateral agencies. Proponents of public-private partnerships claim that this approach produces win-win solutions through pooling of resources and expertise, and fills a gap created by failures in either state or market governance. Critics of such arrangements argue that public-private partnerships only manifest broader trends toward the privatization of environmental resources and problem-solving. The latter also claim that PPPs implicitly prioritize profit-making from the environmental problems "elsewhere," exacerbating and creating (new) asymmetric power relations. Privatized science is a another problematic facet of public-private partnerships in international development. They generate private data or methods and keep results private through intellectual property protections. Their general effectiveness therefore cannot be integrated into problem-solving. Further, the funding of research by corporations has triggered concerns over the steering of scientific agendas toward commercial applications, proprietary scientific results, and delays in publication. Most concerning are situations in which the regulated are able to write their own regulations; negating a core expectation of regulatory oversight or processes that legitimize and prioritize "private knowledge" over other forms of knowledge production[29] (Cashore, 2002; Mansfield, 2004).

Despite these concerns, and despite a great deal of scholarship on the forms of these partnerships that pursue public goods such as reduced environmental harms and increased profit, there is still a need to understand how the small moments of interaction between representatives of private interests and representatives of public institutions do the work of the partnerships (institutional and development anthropologists have examined the small bureaucratic interactions within development aid organizations (see for example Goldman, 2005; Mosse, 2005; Rottenburg 2009). Public-private partnerships at the global scale may have less concrete regulatory outcomes such as the production of laws, but may also be more challenging to govern: The discursive power of expertise and authority can serve, instead, to compel businesses or states to buy-in to the recommendations of the partnership work.

4.1.2. Chapter Structure

After a description of the methods used, I first provide background including a description of The Best of Two Worlds model, the process of global electronic waste recycling, and information on the organizations represented in the construction and promotion of The Best of Two Worlds. I next provide a discussion of the primary mechanism at work in the creation of the Bo2W: the practices and politics of representation. The analysis is then divided into two parts. In part 1, I analyze the construction of The Best of Two Worlds, focusing on the student projects that provided the scientific foundation for the model and trace how biased interest construct a problem, a focal point for a solution, and lastly flawed scientific results. In part 2, I analyze the first implementation of the model across two projects in Bangalore, India that have fuzzy boundaries: the Clean E-waste Channel, a project of the Indo-Swiss-German e-Waste Initiative and Crystal, a project led directly by Umicore. I show how the political economy of Northern refining services benefits only large, wealthy businesses. I also show how the focus on so-called formalization of the unlicensed sector obscures deeper inequalities and how cultural difference and representational politics frame the failing interactions. The chapter concludes with a return to the traveling numbers to show how the model has been taken up and promoted globally, despite both the flawed underlying logic and the failed results in India. I show how the politics of representational numbers and expertise (objective truths from trusted sources) allow a neocolonial model of extraction to mobilize and gain strength in United Nations reports and scientific papers.

[29] For additional analyses of public-private partnerships see Bakker, 2010; DuPuis and Garaeu, 2008; Garaeu, 2013; Garaeu and DuPuis, 2009; Harvey, 2006; Lucier and Gareau 2016; and Schäferhoff et al., 2009.

4.2. Methods

This chapter is a result of tracing the genesis and life of a number, 25 percent; a number produced through a deeply misrepresented summary of a surprising finding: the worst measured e-waste recycling performance was work conducted by an elite graduate student in a "formal" recycling facility – not from work by "informal" recyclers. This chapter examines how actors in the epistemic community conducted studies and constructed the traveling fact that the "informal" recycling sector in the global South is only able to retain 25 percent of the gold that is embedded in printed circuit boards. The analysis then examines what happens when a model based on that fact is implemented, and shows that the outcomes of that test carry little weight if they counter the interests of the business elites.

Scholars in the Science and Technology Studies fields have demonstrated how tracing seemingly small or mundane everyday objects can reveal surprising controversies or political battles. Calculations and classifications have been the entry point for studies showing how state control may be exerted and or how the representation of material worlds may produce surprising results (see e.g. Bowker and Starr, 2000; Latour, 1999; Princen, 2005; Scott, 1998; Star and Greisemer, 1989). Relevant to e-waste, Lucier and Gareau (2016) applied this focus to historic controversies around the definition of "hazardousness" in the making of the Basel Convention (the primary international-scale regulatory tool affecting e-waste trade) and the role private companies had in steering the definition toward their business interests. Relatedly, Himley (2008) argued that critical geographers apply ethnographic methods to the study of practices at work in neoliberal environmental governance projects.

Data collection used a multi-sited, mixed qualitative methods approach (semi-structured interviews, textual analysis, observations). Field work locations, interview participants, and data resources were determined through a snowball sampling approach in which initial information or subject-matter experts provided additional referrals or resources. Interviews were supplemented with participant-observer interactions and extensive review and analysis of archival materials, including scientific and policy literature and reports, conference and promotional materials from e-waste industry events and companies, and publicly accessible videos about e-waste recycling facilities, techniques, and politics.

4.3. Background

4.3.1. Best of two worlds: Optimizing electronic waste recycling

The practices of E-waste recycling can be broadly characterized into four steps: e-waste *generation*, *collection* of discarded electronics, *separation* of electronic components and materials, and final *extraction* of elements (e.g. plastics or metals). E-waste recycling steps occur nearly everywhere in the world. There are many ways to process it. One recycler may mechanically grind plastics and press them into a new form, while another may burn the plastics as fuel for other processes. Another recycler may only seek the embedded gold, while another the copper.

My analysis focuses on attempts to "optimize" the precious metals extraction from electronic waste, which can occur anywhere from small shops using "wet chemistry[30]" to large industrial refineries. Optimize, in this context, refers to modifying recycling steps to maximize metal recovery yields. Figure 1 shows a yield comparison between formal (global North) and informal (global South) published by the United Nations University. The net yield on the right is a product of multiplying the proportions of estimated yield along each recycling step. The informal sector is credited with a far superior yield in both collection and pre-processing. This means that, despite the lower yield in the final processing (refining) step, the overall net yield is higher for the informal sector in the global South. The Best of Two Worlds is focused on uniting the “best” collection/pre-processing with the “best” final-processing to produce a higher net yield.

In the idealized Bo2W model, global South laborers (represented as cheap and abundant) hand-disassemble and sort discarded electronic scrap, producing better-separated and sorted materials for next steps. The metal-bearing portions are then shipped to the global North where capital-intensive refineries extract the metals from the sorted scrap (Figure 4.2). The point of the Bo2W is to prevent metals extraction (“final processing” in Figure 4.1) in the global South and to improve supply of high quality scrap in the North, which means limiting the amount of plastics and other materials that increase costs of discard management. The justification the company uses is that: Inherently better collection and separation in the South, combined with better extraction yields at a refinery in the North means more metals are recycled overall. The Bo2W thus promotes an international division of labor that claims that segregating recycling into global sectors will optimize what each region is stereotyped as doing best (collect and sort, extract and refine).

[30] Wet chemistry is a colloquial term for hydrometallurgical or solution-based chemical processes. This is distinct from pyrometallurgical (heat-based) or biometallurgical (biologically-based) processes. A more specialized process, using microbial solutions in order to extract and process metals is referred to as biohydrometallurgical processes.

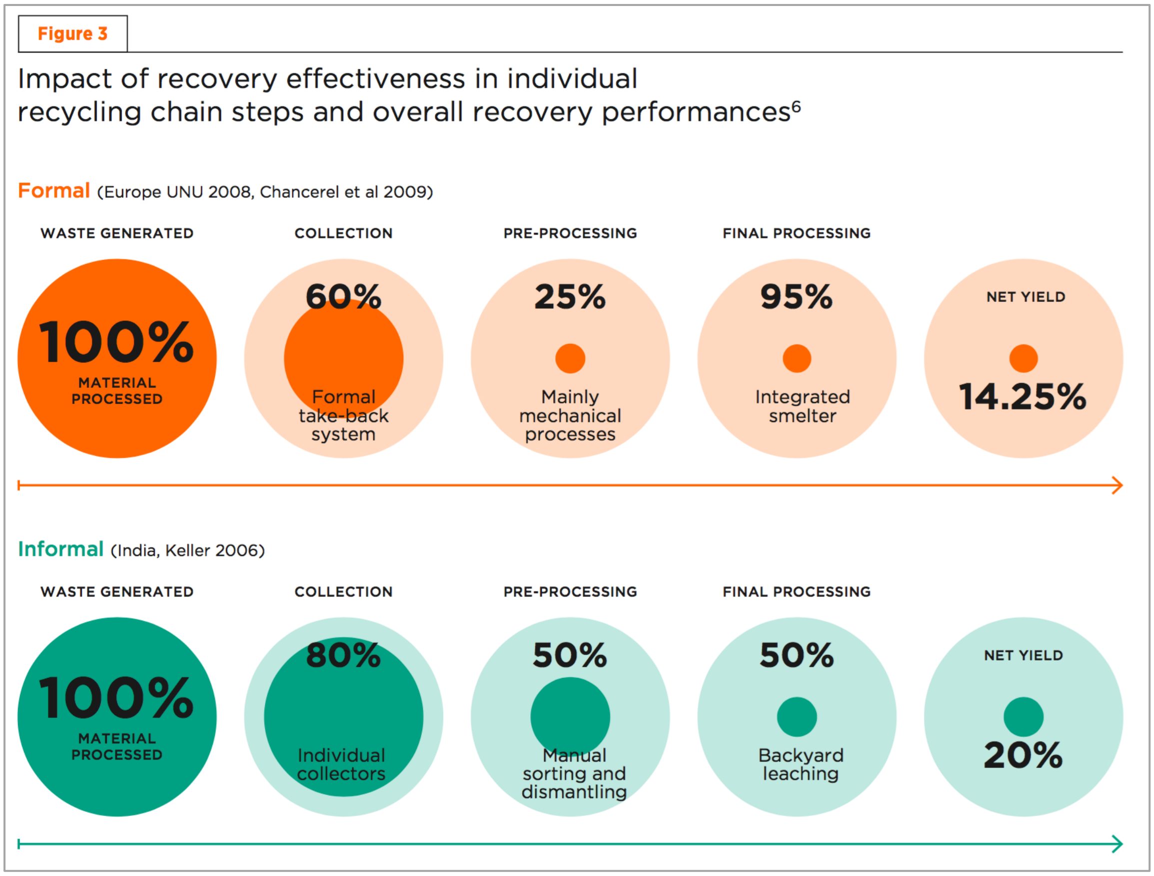

Figure 4.1: Graphic showing relative recycling yields for the formal and informal sectors, globally (UNU-IAS, 2015, p.13).

The scientific foundations and assumptions that underly and justify the Bo2W are only understood after unpacking the three student projects that produced the needed representations of Southern e-waste industry. The findings from these studies allowed for the calculations of net yield by the United Nations University in Figure 1: without the Bo2W, both net yields from e-waste recycling are low but with Bo2W, the net yield increased by focusing each region of the world on what they do “best.” This is a “win-win” scenario increasing net profit and ostensibly reducing environmental harms.

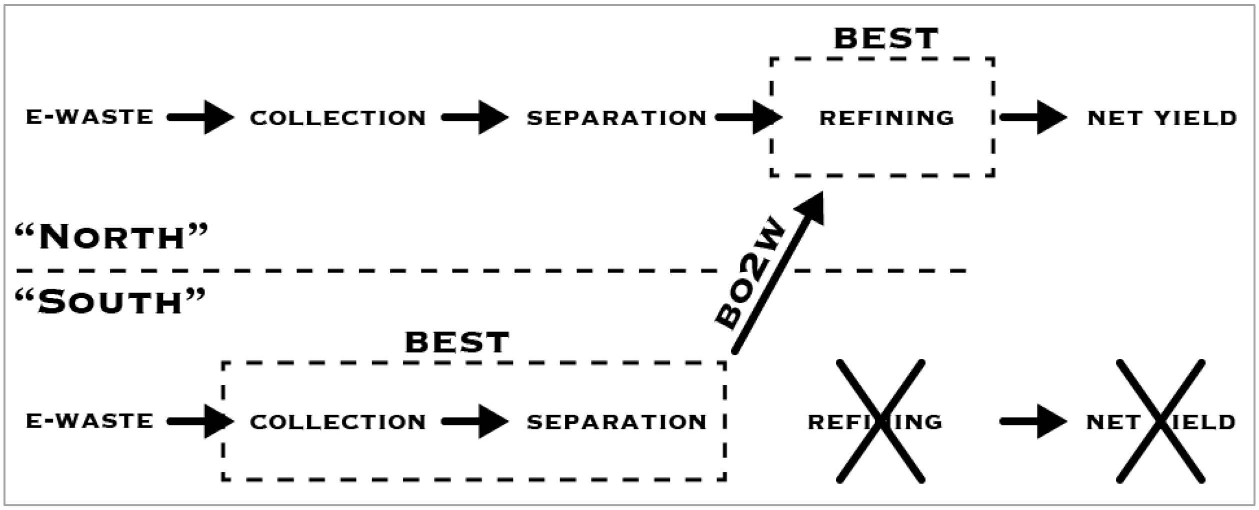

Figure 4.2: Schematic of The Best of Two Worlds model for international trade and (de) manufacturing of e-wastes. Source: Author's analysis.

Reddy (2015a), in her analysis of development experts and the Bangalore e-waste sector, argues that the Indo-Swiss-German e-waste initiative was a precursor to the Bo2W. I show that the Bo2W was constructed and justified using the results of three student research projects conducted across both India and China (Gmünder, 2007; Keller, 2006; Streicher-Porte, 2006), only two of which was related peripherally to the Indo-Swiss-German e-waste initiative. I also provide needed details for the various projects within the Indo-Swiss-German e-waste Initiative, some of which were strictly private arrangements between private companies and entrepreneurs. The three studies collectively argue three points. First, precious metals are the primary driver of e-waste recycling for Southern e-waste recyclers. Second, the so-called "informal" sector, which dominates e-waste recycling economies in the South, is particularly inefficient at recovering the gold: they lose much of it to the ambient environment through poor methods. Third, the economic gains resulting from higher estimated overall recycling yields in the model provide the right incentive for the model to work across "worlds."

The first part of the analysis shows that the yield calculations reported in the UN publication (and replicated in a number of other documents) are fundamentally flawed because the study did not actually measure what was stated and the study is not reproducible or externally verifiable: the studies used proxies, estimates, and privately-supplies numbers. The Bo2W is a theory that was untested and based on flawed representations. It was applied and failed. Despite this, the model lives on in publications and taking new life within global e-waste advocacy and policy organizations.

4.3.2. The nature of e-waste recycling

The Bo2W is presented as a model that is inclusive of all parts of discarded electronics. However, it is constructed upon research that only focused on select processes and only printed circuit boards (of a certain value – determined by estimated gold content). Umicore prioritizes extraction of precious metals from high-value circuit boards[31]. It is a myopic model that misses out the nature of e-wastes and recycling, thus producing inequities in environmental harms by selectively leaving out the low-metal-bearing portions of electronic discards, creating the impression of a more "pure" fraction of wastes with little redeeming value left behind.

E-waste is composed of different integrated materials that recyclers must first separate before further processing. As a high-value component of discarded electronics, printed circuit boards vary dramatically in material composition[32]. They are made of plastics and precious metals, such as gold and copper, which are hidden or embedded in layers of resin. The purpose and design for a particular board determines the amount and placement of metals, plastics, resins, and other chemicals in manufacturing. Further, improved manufacturing techniques have produced boards that generally contain less of the precious metals, but retain or improve the board's performance. In addition, new metals and chemical compounds are substituted or added as part of continuing innovations in product design. Thus, the material nature of printed circuit boards, and the proportion of precious metals contained within them is constantly changing.

The markets for scrap printed circuit boards reflect this variation in the grading of boards into categories of higher and lower quality. Recyclers know the significance of the amount of "apparent gold" on the surface, of the embedded gold in the resins, and the value of removing and separating gold connectors and other parts that can first be plucked from the remaining "nude" board. For example, in one facility in Bangalore, nude circuit boards were considered to be of too low quality (i.e. too little gold) to be recycled and instead were used as construction materials to provide a hard work-surface upon which to dismantle other electronics (March 15, 2013, personal communication). Thus, not all printed circuit boards are intrinsically valuable as recycling scrap.

4.3.3. Informality at the site of e-waste recycling enterprises

Much of economic activity in Bangalore, India – the site of key Best of Two Worlds evidence-making and early piloting – could be considered part of the informal sector. This is generally thought to be a result of the long history of bureaucratic growth and the subsequent hurdles for small business owners through the extensive licensing requirements for small businesses

[31] This is in contrast to Umicore's competitors who largely accept lower- and mid- grade printed circuit boards and other electronic scrap. There is no standard definition for these grades, but a general rule of thumb is high-grade boards have greater than 400 parts-per-million of gold embedded within. This is important to note because the other smelters do not pursue hand-dismantled (intact) boards with the same intensity. Refer to Knapp (2016) for a discussion of smelters pursuing electronic waste materials.

[32] The differences between Printed Wiring Boards and Printed Circuit Boards depend on two physical details: more and less "complexity" in the numbers of circuits embedded in the resin matrix for the board, and the numbers of additional parts installed on the surface of the board. There is no agreed-upon boundary between the two terms, however, and I refer to either board, with explicit discussion of relevant material differences when necessary (such as gold connectors).

(Schenk, 2001). The "Licensing Raj[33]" was developed over a number of years and embodied the most challenging side of bureaucracy for small-scale entrepreneurs. The number of government offices that were involved in licensing a business was massive and required patience, literacy for the countless forms, and significant finances to pay fees or bribes. This directly contributed to the growth of a large informal economy throughout India. The poorest residents in the city were rarely able to meet these requirements and thus were relegated to irregular wage labor. By the early 1970s, more than half of the workforce was employed in the informal sector. This percentage grew to nearly 70 by the early 1990s (Nair, 2005). It is important to place the activities of informal recyclers in context: working in a system that both needs them (waste management services in particular) and in cultures that often blame them for environmental and health problems. Multiple interview participants in this research described extensive and burdensome licensing procedures with attendant environmental regulations without the necessary infrastructures with which to comply, such as literate staff, efficient bureaucracies, waste management systems, and land-leases in appropriately zoned areas (March 2013, personal communications).

In relation to avoiding the extensive and prohibitive licensing requirements, informal small-scale industries are also less subject to environmental or labor laws due to the unregistered nature of their operations (Kerkum, 2001). Scrap recycling is often found in unregistered enterprises, in slums or very low income neighborhoods, and can produce significant environmental pollutants and hazards for workers. For example, I visited different neighborhoods in Bangalore, India, broadly characterized as slums (auto-constructed homes, few urban services, open piles of trash) and which were the locations of numerous specialized scrap processing businesses. Some businesses were operated on front steps and others within a network of closed buildings. Environmental releases from these businesses appeared to be more probable than not. Business transactions that I witnessed were occasionally recorded, but many were not, characterized by quick conversations and cash exchanges. For these reasons, e-waste recycling epitomizes an environmental and human health problem requiring intervention and leading to the flurry of projects discussed in this chapter.

4.3.4. Setting the stage: Organizations with scientific authority

I extend Haas's notion of epistemic communities – a community of professionals with shared normative and causal beliefs, criteria for validity, and policy goals – to examine the role of private, for-profit business within this framework (Haas, 1992). I connect the contemporary practices of elite international development experts to the historical trajectory of post-colonial capitalist resource extraction by unpacking how Umicore's vision of extraction became embedded in a blue- and green-washed model of environmental governance. Thus, I connect the

[33] The License Raj (or Permit Raj) is a play on the phrase British Raj, which refers to the period of British colonial rule in India. The License Raj is a term that describes the extensive red tape that was required to license businesses in India for the first half-century after British independence.

contemporary practices of elite international development experts to colonial and post-colonial capitalist resource extraction.

The (primarily) European-based scientists, policy experts, corporate liaisons, and development professionals that make up The Best of Two Worlds epistemic community can be linked through a handful of institutions in addition to Umicore[34]. The primary connection is through the United Nations' public-private partnership focused on e-waste, called the "Solving the E-Waste Problem (StEP) Initative."[35] StEP, officially launched in 2007 but with leadership roles credited as starting in 2004[36], is one of the most productive networks for e-waste projects, publications, science, and policy planning. StEP is similar to the transnational policy networks described in Goldman (2005). Goldman argues that network success is due to credibility, monopoly, and influence that is carried by the range of actors and institutions included. StEP's membership includes an impressive list of trusted and authoritative organizations such as Basel Convention[37] regional centers and the Convention secretariat, four separate United Nations organizations (UN University, UN Environment Programme, UN Industrial Development Organization, and UN Conference on Trade and Development), the United States Environmental Protection Agency, along with multiple private corporations spanning electronics manufacturing through recycling. StEP reported more than thirty official projects in 2013 with a budget of € 2.65 million, largely funded by project partners (United Nations University / StEP Initiative 2014: 9-10, 19).

[34] It is important to note that the strength of the community comes from both the individual experts and from the dynamics of institutional support: administrative, logistical, and financial. This means there is no clear and defined boundary for the epistemic community by looking at institutions or individuals alone: individual actors contribute at various times, collaborate from seats at key institutions periodically, and move in and out of involvement with e-waste trade politics and science, as well as in and out of the various institutions. There are a few other institutes that are connected in this network, such as the United Nations Environment Programme's Department of Technology, Industry, and Environment; the German Development Organization, GIZ; and a handful of other technical universities in the Netherlands and Germany.

[35] StEP, a self-described public-private partnership, is administered through the United Nations University's European Vice Rectorate's Sustainable Cycles program, based in Bonn, Germany (UNU-ViE SCYCLE) and entirely funded through contributions and fees of members. In the 2013-2014 Annual Report, membership dues ranged from €1200-€12000 annually (United Nations University / StEP Initiative, 2013). As a membership organization, StEP includes representatives from universities, research institutes and corporations such as computer manufacturers and end-processors. The steering committee has been comprised of individuals representing companies such as Dell and Ericsson, government departments, supranational governmental organizations, research universities, and non-governmental organizations.

[36] On the StEP website [http://www.step-initiative.org/the-steering-committee.html, accessed November 14, 2016], some current and former steering committee members' service is noted as beginning in 2004, including corporate representatives from Umicore, Hewlett Packard (HP) Germany, and Exxon Mobile Thailand, which is when StEP was described as being "first discussed by a handful of scientists and experts" (United Nations University / StEP Initiative, 2008: 5).

[37] The Basel Convention is a multilateral environmental agreement that is intended to control the movement of hazardous wastes across national borders and prevent "dumping" of toxic materials in places that are politically or economically less powerful. It has delivered mixed success. For more information see Clapp, 2001. Whether something is governed under the Basel Convention is determined by its definition (classification), which can either be open to interpretation or which change over time. Further, not all countries are signatories to the Basel Convention and thus do not comply with its requirements.

Umicore has been involved with StEP since 2004 when Umicore staff served on the inaugural steering committee. Umicore's strategic positioning has provided business development staff privileged access to knowledge-making opportunities, networking events, and policy-shaping discussions. Umicore has sponsored E-Waste Academy Scientists Edition workshops (formerly "E-Waste Summer School"), provided representatives to serve on the seven-member StEP steering committee – including a period as chair, and has co-authored UN publications on e-waste[38].

The Best of Two Worlds model is credited to the StEP initiative (United Nations University / StEP Initiative, 2009: 22), but the individuals who participated in its construction and its mobility preceded StEP. Aside from Umicore, two public-private partnerships and two research institutes have been central in developing and promoting the Bo2W. The Indo-Swiss-German E-Waste Initiative, a public-private partnership focusing on India, was the platform for key studies supporting the Bo2W and a launching point for the first pilot project using Bo2W logic, spanning two projects: the Clean e-Waste Channel and Crystal. The Indo-Swiss-German E-Waste Initiative linked EMPA, Umicore, and the nascent StEP to the German Development Corporation (GIZ) which had ongoing projects related to waste in India, Indian non-governmental organizations, Indian manufacturing associations, and Indian state departments. The Indo-Swiss-German E-Waste Initiative produced multiple outcomes; from e-waste "agencies" to newly licensed recycling businesses to abstract schemes for reworking the local e-waste recycling economies. StEP followed on the heels of the Indo-Swiss-German E-Waste Initiative partnership, formalizing some of the existing relationships and expanding the focus to a more global scope.

Of the handful of universities and research institutes tied to this epistemic community, two deserve a closer look. The Swiss Federal Laboratories for Materials Science and Technology[39] (EMPA) and the German Institute for Applied Ecology (Institute for Angewandte Ökologie, or Öko-Institut), two research institutes that also provide consulting for private clients, were central in supervising scientific studies, publishing reports and articles, and leading e-waste development projects in the global South. Staff from EMPA played central roles in both the ISGeWI and StEP, and in supervising graduate student research on e-waste in the global South

[38] Christian Hagelüken, a professional from Umicore who has co-authored dozens of publications on electronic waste recycling processes, served on the StEP steering committee from 2004-2012 (http://www.step-initiative.org). In an interview, I was told the key networking event that connected Umicore to the epistemic community was the 2004, Electronics Goes Green meeting, held in Berlin, at which professionals from Umicore, the United Nations University and EMPA met (October 17, 2013, personal communication).

[39] EMPA is networked with five other universities or research institutes within the ETH Domain. The Swiss Federal ETH (Eidgenössische Technische Hochschule) Domain includes: Swiss Federal Institute of Technology in Lausanne (EPF Lausanne), Swiss Federal Institute of Technology in Zürich (ETH Zurich), Swiss Federal Institute of Aquatic Science and Technology (Eawag), Swiss Federal Institute for Forest, Snow and Landsape Research (WSL), Paul Scherrer Institute (PSL), and Swiss Federal Institute for Materials Science and Technology (Empa).The ETH Domain is housed under the Swiss Federal Department of Economic Affairs, Education and Research (EAER).

with the support of Umicore[40]. As one informant stated in describing the structure of the work in India: "Mr. M [EMPA professional], he was the project manager and he was leading in all the discussions and the design. He's like the hub of the whole thing" (July 2, 2014, personal communication). That same EMPA professional has been serving on the StEP steering committee for a number of years and co-authored influential e-waste publications. The Öko-Institut is currently the most prolific academic booster[41] of The Best of Two Worlds model of e-waste recycling trade. Experts from the Öko-Institut have authored peer-reviewed journal articles and consultancy reports on national e-waste evaluations in the global South in support of The Best of Two Worlds. Umicore is an explicit partner in their Bo2W projects in African countries[42]

4.4. Two mechanisms of imperial encounters

4.4.1. Politics of representation

The environmental problems posed by the global e-waste industry are myriad and diverse and encompass ecological and human health impacts related the release of dioxins, mercury fumes, heavy metal pollution, and emissions of persistent organic pollutants. How stakeholders prioritize addressing these environmental impacts in turn drives which scientific lines of inquiry are emphasized in terms of characterizing their human and ecological effects. Moreover this prioritization has implications for the financing of further study, regulation, as well as sanctioning and investing in particular recycling businesses over others.

Ola Söderström summarizes representation as the politics of "who has the power to produce authorised representations of the world and what/who are the legitimate objects/subjects of scientific representation" (Söderström 2005: 13). Applied to North-South relations, Doty calles the interactions that produce biased "realities," imperial encounters (Doty, 1996). My analysis reveals two representations that are produced in The Best of Two Worlds model: "wasteful", polluting, and low-tech Southern recyclers; and efficient, safe, and high-tech Northern refineries. Euro-centric scientists with seemingly objective methods of analysis, scientific publications, and trustworthy institutional affiliations produce these twin objects through their scientific authority and asymmetric access to resources, such as funding, venues for disseminating results, and institutional connections.

[40] In 2003, the Swiss government funded the "Knowledge Partnerships with Developing and Transition Countries in e-Waste Recycling," coordinated and implemented by EMPA (Widmer, 2005: 452) and focusing on three counties: India, China, and South Africa. India and China were the sites of early Bo2W scoping and pilot projects. The project in South Africa focused on coordinating already-existing industries with new businesses to address the growing volumes of discarded electronics and has been characterized as a case of contested power negotiations in an industry transition (Lawhon, 2012), producing lackluster results for ongoing involvement by the European-based experts.

[41] WorldLoop, a Not-For-Profit and Non-Governmental Organization is arguably the most prolific private (organization) booster of the Bo2W. Umicore is a formal partner of WorldLoop.

[42] Other partners were Vacuumschmelze (VAC), Johnson Controls, City Waste Recycling (Ghana), CE- DARE (Egypt). See 2015 Öko-Institut annual report, pp 12: "Best of two Worlds: Sustainable recycling in Africa"

Scholars of international development have shown how large projects are supported by the smallest of visits by elite experts, such as rapid, three-day village assessments by anthropologists, or weeklong project overviews by water-policy consultants (see e.g. Goldman 2005 and Rottenburg 2009). Goldman (2005), in his ethnography of World Bank-led development, calls these communities transnational policy networks and highlights their central role in transnational issue formation and close connections to international decision-making fora. Other scholars have shown how complex livelihoods and cultures are rendered-technical (converted into numbers and statistics) in attempts to simplify and ultimately make solvable (Ferguson, 1994; Li, 2007). These small visits that render-technical the complexity of local communities comprise the politics of representation, or as Latour argues, the process by which "the few may dominate the many" (Latour 1990). It is through the small, mundane moments of observation, note-taking, calculation, writing, and movement that representations and models of the world are made.

4.4.2. Informality

The use of the term “informal,” as applied to groups of people or places, is an othering practice generally aimed at the poor (it can be a term that is used to simultaneously exclude and call for intervention or action). It is additionally used to indicate unregulated by the state and thus beyond state authority, except for law enforcement. Informal can refer to, for example, economic activities that take place outside legal licensing sanctions, or to construction of homes without municipal permits (Agarwala, 2006; Agarwala, 2009; Medina, 2008; Nas and Jaffe, 2004; Rogerson, 2001; Roy, 2009). It is often applied as a blanket term to encapsulate a loosely correlated set of characteristics of a social group in a region. For example, scholarship on auto-constructed homes and neighborhoods often links “informal” settlements with overall economic poverty and limited or no state infrastructure (Ahonsi, 2002; Caldeira, 2000; Castillo, 2001; Ghertner, 2008; McFarlane and Vasudevan, 2014; Ranganathan, 2010). Scholarship that focuses on economic informality commonly also examines issues such as employment security, licensing, taxes, environmental standards, and education or training as characteristics that may coexist with notions of formal or informal (Agarwala, 2008; Gill, 2010; Lave, 2011; Simone, 2004). Some scholars have argued that so-called informality, rather than something separate from main-stream practices, is just another mode of everyday functioning. For example, Ananya Roy argues that informal settlements are one of multiple “modes” of planning and urban development. She cites examples of wealthy homeowners who build additions to their homes without permits, arguing that these are also “informal” constructions and thus the term “informal” extends beyond the poor (Roy 2005).

In the context of municipal solid waste management (which often includes hazardous waste in the South), informal recycling is typically comprised of individuals or small groups that provide labor-intensive, (often) low-skilled, unregistered and unregulated scavenging, sorting, and processing services to extract value from discarded materials (Moreno-Sánchez and Maldonado, 2006; Wilson et al., 2006). Informal recycling is thought to exist primarily in places with high rates of unemployment, poverty, available markets for recovered materials, and a sufficient supply of recyclable material made available usually by insufficient municipal solid waste collection or disposal. However, the informal sector in the global South is typically considered highly efficient at collecting discarded materials and other recyclables or waste streams (Vergara et al., 2016) and makes up a significant portion of gross domestic product in some countries (Gidwani, 2015). It is sometimes called the "unorganized" sector due to the illegibility of the functioning by outsiders. This could be, instead, a function of simple familiarity: for example, James Scott (1998) highlighted the challenges felt by outsiders when encountering local systems of organization.

4.5. Building The Best of Two Worlds with student science

Who is legitimated to extract the gold and other embedded metals is often determined by scientific proclamations of resource efficiency and environmental safety. There are few publicly available analyses of e-waste recycling yields and even fewer measures of economic and environmental efficiency by small-scale recyclers in the global South. Projects that claim to fill gaps in e-waste recycling knowledge can be quickly taken-up into agency reports, hungry for facts with which to make recommendations.

In the case of the e-waste recycling industry in India, early studies quickly narrowed their scope to focus on printed circuit boards as both a driver of the industry and as a problem to solve. This emphasis narrows the science to only those problems that are unique to those materials and extraction processes, and ignores other critical stages of recycling and disposal. This is because there are large differences between material composition and recycling practices for printed circuit boards compared to other component parts of e-waste like cathode ray tubes or plastic housings. Focusing on printed circuit boards, therefore, preferentially includes recyclers who specialize in precious or specialty metals, such as Umicore, in assessments and recommendations, instead of recyclers who specialize in ferrous metals, plastics, leaded glass, or aluminum. It also means the environmental and economic problems with other parts of discarded electronics may not be addressed despite the fact that these processes, arguably, have more pressing need for analysis and regulatory action.

Amongst the dozen or so graduate student theses produced within the Bo2W epistemic network, three students' work have provided the economic and scientific justification for the model and were guided by Umicore and EMPA professionals. The first two students' work was based in India (Streicher-Porte, 2006, Keller, 2006) and the third's in China (Gmünder, 2007). A policy expert and former graduate student in the epistemic community described the role of student theses and the influence of on-site supervisors from EMPA in the projects in India:

> "The first phase of the... Indo-Swiss-German, ewaste project. So this was also the EMPA project. We went forward based out of Bangalore, [after a 2004 study by a graduate student from Switzerland] who did a study on the emissions and the soil samples in Delhi. So these were more the science side of the project....
>
> [Q: Who was designing the projects? Supervisor in science? Or student-led?]

> I am not sure I can answer this entirely correctly. But from what I understand, because I was not obviously supervising anyone myself, but [EMPA professional] and EMPA as such were also quite involved. I think it was probably their input that counted much more in the designing and the scoping, even the practical aspects of the study, as compared to the university [ETH Zurich]. And I think that way the universities in Switzerland, they give you quite a lot of freedom to do the way you want to do your masters thesis. Design your own methodology and implement it, and as long as you have some of these kinds of things they are happy. Supervisors, and I think it was the case for me as well, they were not so hands-on intensely, you were kind of left to your own devices." (July 2, 2014, personal communication)

The close involvement of EMPA, along with Umicore and other StEP experts, is confirmed in the acknowledgements in the thesis documents. Umicore provided key support for student research through financing field work, providing in-kind technical assistance, sharing un-published private industry data, and serving as expert informants for interviews.[43] As I looked closer at what Umicore was deriving from these studies, it became clear that they were not only interested in one line of inquiry but they were actively steering the students' research to support a narrow view of e-waste problems and solutions benefitting their economic interests. The following analysis describes the three key studies supporting The Best of Two Worlds logic: the first study identified the most important part of the e-waste sector, the second study measured that part of the e-waste sector, and the third applied economic calculations to justify the Bo2W model across global South informal sectors.

4.5.1. Study 1: Identifying the key driver: Precious metals in personal computers

The first student's work identified gold-recovery as the key economic driver in the Indian informal recycling sector[44] (Streicher-Porte, 2006) and was also published in a peer reviewed journal article (Streicher-Porte, Widmer et al., 2005). The study was largely predictive and not an assessment of existing local recycling practices. Instead, the research in India relied on extensive estimations, assumptions, and complicated modeling, using little original data. Local data – market values for refurbished computer parts – were supplied by Delhi-based cathode-ray-tube refurbishers, not precious metals recyclers. Additional data included estimates of new personal computers sold and an example of global commodity prices. The student and co-authors stated that "profits from sales of nonferrous metals have not been included in this calculation" (Streicher-Porte, Widmer et al., 2005: 486) and "the study revealed no information of the future fate and behavior of [non-ferrous] metals." (Stretcher-Porte, 2006: 75) In other words, the studies did not use any economic data and did not follow the actual recycling processes. Despite this, the journal article concludes that "the precious metal flow is one of the key economic drivers of

[43] Umicore staff have also authored a number of publications which are cited extensively in student literature reviews.

[44] The research in New Delhi, India was part of a joint program between GIZ and the Indian Ministry of Environment and Forests, called "Advisory Services in Environmental Management" or ASEM.

the system" (Streicher-Porte, Widmer et al., 2005: 486), arguing that an international division of labor is necessary to address the problem of e-waste recycling in the South.

Other studies conducted at the same time contradict the conclusion that precious metals recycling is a key economic driver in the e-waste recycling sector. First, another graduate student, supported by the same Swiss-funded program and conducting empirical research in Delhi, chose not to evaluate the extraction of gold from printed circuit boards because the practice of gold recovery was not limited to e-wastes: it was a method to extract gold from other substances as well[45] (Steiner, 2004: 12). In other words, what gold-extraction economy existed in Delhi was not limited to processing electronic discards: Precious-metals recycling is its own sector, irrespective of the raw (discards) that are processed, of which e-waste makes up a small proportion. Second, a report conducted and written by a professional hazardous waste consultant and published by the Swiss Federal Laboratories for Materials Science and Technology (EMPA), argued that the materials of highest concern for environmental harms across the licensed and un-licensed recyclers in Bangalore, India were batteries, capacitors, toner powder, barium getter (barium deposited on a substrate to maintain vacuum conditions), and luminescent powder from cathode ray tubes (EMPA, 2006). The expert consultant did not mention gold or silver recovery as a primary environmental concern in relation to e-waste as compared to the observed releases related to these other materials and recycling processes.

Separately, an informant from one of the NGO partners in India made clear that *refurbishment* (repair) of used electronics was likely the most profitable sector of e-waste processing for the local sector, suggesting that this would be the primary economic driver for the e-waste sector. She stated that in order to profit from extraction of metals, a recycler "requires volumes" – a challenge for small-scale recyclers without access to big enough areas of land where they could conduct this work (March 12, 2013, personal communication). This suggests that gold-leaching (the process typically used in India for gold recovery) would not be an effective focus of intervention: gold leaching, as a practice, would continue irrespective of the supply of printed circuit boards. Meanwhile, e-waste problems would remain unaddressed.

Despite these contradictory findings, the next study focused on gold and copper recovery as the assumed "driver" of the recycling sector in India; citing the first study as evidence that copper

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[45] Steiner (2004) focused on estimating health impacts from e-waste recycling practices in Delhi that were predicted to be the most toxic, were feasible to study, and which were specific to e-waste recycling. She calculated an environmental exposure and risk assessment of cable-burning practices for copper recovery, focusing on airborne dioxins and furans as representative of a highly-toxic release from e-waste recycling practices as previously documented by local NGOs. Poly-brominated dibenzo-dioxins/furans and poly-chlorinated dibenzo-dioxins/furans: PBDD/Fs and PCDD/Fs. These substances are both known to harm human health and are also known to be created when burning plastics in discarded electronics, such as the casings on cables or printed circuit boards. Her results were inconclusive given the small sample size and the heterogenous environmental conditions, but she concludes that results were justification for concern and for further study.

and gold were the "two main sources of income for recyclers" (Stretcher-Porte, Bader et al. 2007: 329).

4.5.2. Study 2: Representing Southern inefficiency: Wasting gold and polluting the environment

The second student's work focused on the gold recovery processes used in India, quantifying the inefficiency and identifying the most polluting recycling steps. Indian recyclers' amount of extracted gold were compared to Umicore's amount of extracted gold and an economic justification for shipping printed circuit boards was enumerated (Keller, 2006). This study produced, arguably, the most important fact in support of The Best of Two Worlds: that the so-called "informal sector" is highly inefficient at gold recovery: recovering less than 30% of the gold embedded in e-waste[46].

Data in the study included interviews with local and visiting development professionals, local recyclers, and quantitative assay results from chemical analyses, provided by Umicore as in-kind support. The student also spent time observing in recycling facilities. With guidance from her European-based mentors, she designed and implemented a Materials Flow Analysis[47] to measure the recycling efficiency of two different recycling companies in Bangalore: one designated "formal" and the other, "informal." Supplying a box of Pentium II printed circuit boards to the recyclers, the student measured and described all the materials they used and discarded, plus the amount of gold they each recovered.[48] The yield calculations were subdivided into two sub-processes: dismantling (preparation of the printed circuit boards) and gold-recovery[49]. Each sub-process was observed for yield in addition to the net yield of the whole process. She then

[46] The studies results reported a wide range for the results due to the imprecise material preparation done by the student. The results have also been mis-reported in subsequent publications, but generally fall within the study's range of values.

[47] The Materials Flow Analysis focuses on the net inputs and outputs of a set of recycling steps. It was accompanied by a Substance Flow Analysis focused on tracing the net mass of gold-species that resulted from the recycling steps: the yield.

[48] The student's methods can be generalized to the following steps. First, she supplied each of two recycling businesses with printed circuit boards and asked them to use their typical process to recover gold from the boards. She then observed the dismantling process for each recycler, occasionally weighing the boards as they were processed and collecting small samples that she sent to a laboratory for content analysis. Once the boards were prepped, she then observed each chemical step in the gold-recovery process, again measuring the materials used and produced. After the recyclers completed their processing steps, she used the assay results from the laboratory to calculate the gold content in the raw boards, using this to calculate the yield of gold recovered. It is important to note that the student calculated three yields for each recycler: dismantling (subsystem 1) yield, gold-recovery (subsystem 2), and overall yield.

[49] Methods to extract gold from printed circuit boards, for example, use different combinations of solution-based chemical reactions and heat. First, the boards are prepped by separating undesirable components from the gold-containing parts. This could mean chiseling off small chips and battery-containing parts by hand, or shredding the boards mechanically and then using various mechanized techniques to sort the fractions like bouncing along a conveyor belt and using air guns to blow off the light-weight plastics. Next, the gold-laden parts are soaked in a solution to dissolve the desired metals. The remaining steps focus on separating the metals in the solution through strategic precipitation steps (forming solids), using other metals (e.g. mercury) to form an amalgam and heat to burn off the mercury, or using electricity to plate dissolved metals onto an electrode ("electrowinning"). All of which produce gold or other metals in solid form that can be collected.

compared the Indian yields to pre-calculated yields of Umicore's process of gold recovery, supplied by Umicore. It is this comparison that produced the economic argument for the Bo2W (Table 4.1).

Recycling "Sub-Processes"	**Gold Yields**		
	Indian "Formal" Recycler	**Indian "Informal" Recycler**	**Umicore ***
Dismantling	17-56%	16-60%	N/A
Gold-Recovery	24-46%	36-60%	N/A
Net	8-14%	10-18%	95%

*Table 4.1: Study Results: The numbers represent the amount of estimated gold is retained at the end of that process. The losses are attributed to "the environment" in the form of dust and other particles, and in waste solutions. The wide range of results was due to two different assay (content) results for the starting material: 112 and 200 parts-per-million gold-content. *Umicore data not supplied. Overall yield reported to the student for reporting in the study and use in comparative findings. Source: Author's calculations.*

Note that the lowest overall yield is attributed to the Indian formal recycler. This is due to the lower estimated yield in the dismantling stage (the formal facility shreds materials, which produces a great deal of losses in the "fugitive" dusts). The Bo2W is an attempt to link the "best" dismantling (and collection) in the informal sector with the "best" gold-recovery at Umicore.

Quantifying this inefficiency was necessary to confirm what they already suspected, and to convince others that The Best of Two Worlds was a viable model of flexible mining. The importance of this study to Umicore was made explicit in an interview with two Umicore professionals who specialize in liaising with international development partners:

> "[a]n important outcome of what they call 'the project of India' with EMPA so far, was of course also the results from [student]'s thesis that clearly made the distinction in the efficiencies of an end-processor like Umicore, which is in the upper 90s [percent], versus the metal – precious metals – recovery efficiencies done by the backyard recyclers, which is in the, uh, below 25, 25 [percent], yeah, which is also in our presentations. Which is very low. That was a quite important outcome, yeah, that was indeed an important outcome for us to conclude under the estimation that in emerging countries like India if we suppose that the backyard recycling is indeed the main competitor to professional international end-processors and to organized, professional, and transparent recycling. So... the estimation that backyard recycling is really the competitor." (December 19, 2013, personal communication)

In other words, Umicore staff had an idea that the Indian ("backyard") sector was both a major industry competitor and was highly inefficient in recycling gold.

Critically, the student's methods and results were, in fact, measuring *her* process of preparing and testing material, and her and her supervisors' politics of representation, rather than anything attributable to Southern recycling efficiencies. First, the greatest source of loss of gold in the sub-processes was attributed to the dismantling phase in which whole printed circuit boards were prepped for the gold-recovery process. The “informal” recyclers did not perform this work. The description of the student and staff at the “formal” recycling facility performing *all steps* of the dismantling and sorting for the experiment is only found in the appendix to the thesis document and is not elsewhere described. Further, the student reported that both the “formal” and the “informal” recyclers in this study were not working with the quality nor the quantity of materials they normally would be, thus chemically affecting their processes and requiring that they modify their procedures[50] (Keller, 2006: 38).

In an interview with one of the small recyclers who became licensed through the Indo-Swiss-German partnership work, they described the differences between their preparation technique, dismantling to retrieve whole circuit boards, and the product that was supplied by the student, ground circuit boards:

> "We spent two years working with EMPA. There are those who wish to grind up the [printed circuit boards]. If it comes from the powder, we cannot recover the precious metals. Even the [Karnataka State Pollution Control Board] approves hand dismantling.... Manual dismantling takes more time, but means more metals." (Marach 17, 2013, personal communication)

According to the student’s results, the “informal” Indian recycler captured more gold in the recovery phase than the “formal” Indian recycler, despite the “informal” recycler being asked to work with material prepared in the worst way. Addressing the poor yield attributed to the “dismantling” process, conducted by the student and “formal” recycling, the thesis recommends sending un-processed (whole) printed circuit boards abroad for recycling: "A key conclusion that originates from this assessment is that *the main gold loss takes place during the dismantling and not during the chemical gold recovery processes*" (Keller, 2006: 65, emphasis added).

The student's results were published in a conference paper the following year, co-authored by a Bangalore-based consultant from EMPA, a policy-liaison from Umicore, the student, and one of her two thesis supervisors, also from EMPA (Rochat, Hagelüken, et al., 2007). The paper focused on the question of economic profit in two scenarios: gold recycling in India, versus dismantling in India and gold recovery in Belgium. Importantly, only some of the results from the material flow analysis were selectively taken up and summarized in the conference paper. Further, a number of things were conflated across the informal/formal classification. The conference paper ignored the surprising outcome: a lower recycling yield for the “formal” recyclers compared to the “informal” recyclers in Bangalore and that the biggest source of lost material was the work the student performed with the “formal” recycler. The conflation and confusion between results produced a homogenization of all of Indian businesses, which, in

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[50] The chemical solutions, the plastics, the embedded copper, the amount of gold on the surface or hidden inside layers of resin, the size and type of shredded printed circuit board pieces matter in how well a chemical process of extraction works. All of these things influence the amount of gold one can recover from a printed circuit board, that is, the yield or material "efficiency" of gold recycling.

subsequent studies and articulations of Bo2W further morph into the global South. The conference paper reported that the Indian e-waste recycling sector yields only 25 percent of the embedded gold in e-waste. This is the moment the number 25 percent emerges as a solid fact. Subsequently, this number strengthens through the reproduction of it in publications from trusted institutions such as the UN or scientific journals.

4.5.3. Study 3: Justifying the economics of The Best of Two Worlds

The third student's study, the first under StEP's Best of Two Worlds, applied these results to the case of China, and concluded that The Best of Two Worlds model of international trade was both an economic and environmental win for any global South country (Gmünder, 2007). It was a study that investigated the optimal level of dismantling before sending precious-metals bearing parts to Umicore for refining, referencing the Bangalore study as evidence that the Bo2W would work.

In the China study, Umicore provided direct financial support, in-kind support in the form of laboratory analysis of material samples (similar to the second study), and provided expertise in interviews: three Umicore staff were research informants. This study, supervised by the former graduate student who produced the "key driver" study, calculated the "eco-efficiency"[51] - a measure of efficiency that includes environmental and economic considerations - of three levels of dismantling a personal computer (excluding cathode ray tubes) before sending the precious-metals bearing fractions on to Umicore for metals recovery (Gmünder, 2007: 18-19).

The calculations and data used in the study are only partially available for review within the published theses (Streicher-Porte, 2006, Keller, 2006; Gmünder, 2007). The actual economic costs and samples of material in China were unknown and unmeasured. Instead, the pricing data and model were taken from "European settings" to stand in for the missing data from China. Further, the cost data and calculations were kept confidential:

> "All the terms do reflect the operational costs and are taken from the industry.... The cost of the precious refining process are based on complex calculations taking into account a general treatment charge and the penalty charges for certain substances into account. Further the costs do also depend on the value of the input material and therefore a general price does not exist. *Due to confidentiality reasons the cost model is not presented within the study*." (Gmünder, 2007: 28-29, emphasis added)

[51] The concept of "eco-efficiency" used in the Gmünder thesis was developed by Jaco Huisman from TU Delft, the UNU, and StEP. His PhD dissertation developed and applied this concept by analyzing whether it was better to dismantle and segregate, or simply send whole mobile phones to refineries for metal recycling. Huisman was one of the primary supervisors for the work in China developing the Best of Two Worlds model. Umicore has used his eco-efficient concept to show that the "direct to smelter" route for cell phones is a best-approach. Eco-efficiency also appears throughout others publications and in interviews with the members of the epistemic community. (Huisman, 2003)

This study continues the trend of estimating and mimicking Southern recyclers in order to produce numbers that pre- justify a global model of trade relations benefitting a flexible mining company, which due to its nature as a for-profit firm in incapable of conducting an unbiased study.

4.6. Putting The Best of Two Worlds in practice

The official pilot of The Best of Two Worlds focused on setting up a new large-scale dismantling facility in China.[52] However, the following year's global recession affected many scrap dealers and the project did not take off (November, 2013, personal communication). Concurrently, two projects – not official pilots of Bo2W – were conducted in Bangalore, India and later referenced as successful trials of the Bo2W concept despite their failure to enroll small-scale local e-waste recyclers.[53] One project was a partnership between private and public entities. The other was a strictly-private project led by a Umicore salesperson with local recyclers. A researcher in India during this time described the start of these efforts as experimental:

> "The model was obviously not very well defined to begin with. We all learned on the job, as it were. I even remember these discussions with [EMPA professional]. You know we are sitting in Bombay and it was you know in one of these horrible traffic jams behind a milk van and I say hey you know these milk guys, they do this cooperative business so well and could it be an idea to translate this cooperative model to e-waste? And that's how we started thinking about these recycler cooperatives. So there were a lot of ideas which were developed along the way, there was no guidebook or formula or set path that we followed." (June 18, 2014, personal communication)

The first project in Bangalore, the Clean e-Waste Channel, was designed to funnel electronic scrap into newly licensed (or "formalized") operations for manual disassembly and sorting, followed by metals extraction in Europe from the portions of e-waste that contained the highest concentration of gold[54](Arora, 2008; Rochat, 2007, for a critique see Reddy, 2013). The environmental harms of concern were exposures to hazardous materials used in the recovery of gold such as cyanide and mercury, both of which was mentioned in the second student's thesis and which had been previously documented through extensive work conducted by a local NGO. A second project in Bangalore, organized separately and largely run by representatives from

[52] The third student study in China, which was the first articulation of the term "Best of Two Worlds" was folded in to the ReCycle task force within StEP, led by Jaco Huisman. Huisman (2003) had proposed the notion of "eco-efficiency" in his Ph.D. Thesis, published at TU Delft, focusing on prioritizing the recycling pathway for mobile phones (dismantling and sorting, or direct-to-smelter). Eco-efficiency calculations were the focus of the assessments in China to test the viability of the Best of Two Worlds: optimizing the eco-efficiency.

[53] The two countries were lumped together in a 2009 UNEP/StEP global report on e-wastes, co-authored by professionals from Umicore, EMPA, and UN University. India and China's shared characteristics were "an established informal and formal sector" with significant volumes of e-wastes. The "formal sector" was perceived at a competitive disadvantage (UNEP and UNU 2009: 58).

[54] For a critical discussion of the Clean e-Waste Channel, see Reddy 2015a.

Umicore, entitled Crystal, was also designed to divert the flow of the most hazardous fraction of e-waste away from so-called "informal recyclers" by connecting them to a mid-sized recycler who would collect printed circuit boards from them and then contract directly with Umicore for toll-refining services (December 19, 2013). The two projects represented a similar end-goal for Umicore: gain competitive and nearly-exclusive access to a source of e-ore.

In the Crystal project, Umicore and E-Parisaraa (a newly licensed "formal" e-waste recycling business in Bangalore, India), signed a Memorandum of Understanding, facilitating an exclusive export license for E-Parisaraa to send materials to Umicore for refining. This was the only export license for electronic scrap issued in Bangalore at the time. Two associations of small-scale recyclers, e-WaRDD and Eco-Birdd, were approached to negotiate the collection, dismantling, separation, and shipping of high-value printed circuit boards and other gold-bearing parts to Umicore with E-Parisaraa acting as an intermediary. E-WaRDD and Eco-Birdd had previously been un-licensed ("informal") e-waste processors, but were assisted with the licensing process by GIZ, EMPA, and the Bangalore E-Waste Agency (formed through the Indo-Swiss-German initiative) in the Clean e-Waste Channel project. Umicore offered some up-front funding to ease the economic costs of waiting four months for payment under their typical contract structure. The head of E-Parisaraa described the beginning of the Crystal project:

> "We did a lot of handholding with them [unlicensed recyclers]. Training them. I visited them. We took pictures, photographs. We invited them for the program. I invited them to see my facility. They also came, they were really happy and I said that sometime you should have a facility like this – working like this, and your children, and their education. That was happening in the year with EMPA and GIZ. EMPA, GIZ, and E-Parisaraa. E-Parisaraa's name you will not see in any of the reports [did not get formal recognition]. Anyway, that doesn't matter. And so we started and then we said that you should get formalized. So that's why Eco-Birdd was started. And then it was EWarDD. Sorry, first it was EWarDD, then it was Eco-BIRD, and now I think six or seven of the informal [recyclers] have become formal [businesses] with all the compliance. But then the problem of circuit boards still remains, because they were not doing it in the scientific way, even though they were also recovering part of the gold and silver, but not complete. So we brought a scheme called the Crystal project. Where the Umicore also came into picture, we signed an agreement, MOU, in front of the government officials with their witness. But that was only for one year with upfront funding from Umicore." (March 15, 2013, personal communication)

According to the head of E-Parisaraa, the licensing of their facilities and the regulatory requirements (including waste disposal and chemicals management protocols) did not modify the gold-recovery practices of concern. Further, due to conflicts of trust between the various businesses, only one shipment of "informal sector" printed circuit boards was sent to Umicore under the Crystal project. After two years, the experiment had ended: E-WarDD and Eco-Birdd had ceased collecting material for E-Parisaraa and Umicore had pulled the experimental up-front funding[55] (March 15, 2013, personal communication).

Despite this result, the pilot in Bangalore has been referenced as a success in subsequent reporting and promotion of the Bo2W such as in the 2009 UNEP/StEP report, "E-Waste: from Waste to Resource":

> "The favourable framework conditions to allow for initiating e-WARDD were predominately given by the network and intensive capacity building of the Swiss e-Waste Programme and strong local leadership by individuals. The biggest barrier for the implementation of the alternative business model was the typical five-month delay between the shipment and the payment by an integrated smelter… In any case the successful implementation of the pilot alternate business model was found to be a "condicio sine qua non" for allowing the maximum, but safe participation of the informal sector to the Clean e-Waste Channels. We see this as an opportunity for the formal recyclers to get access to higher e-waste volumes and for the informal sector to still create their income in a safe way." [UNEP and UNU, 2009: 81]

The Bo2W was intended to sustain itself without government subsidy or agency involvement after initial implementation. One of the lead development agency consultants in the Indo-Swiss-German partnership articulated this expectation:

> "And then we also had an experiment, a project called Crystal. I'm sure E-Parisaraa must have told you about that? That was another important milestone, which we had. Wherein we convinced these people that [by] actually doing the leaching of all kinds of precious metals fractions, they are losing out on resources and it's more harmful. They [local recyclers] get just 30 percent recovery whereas if they [local recyclers] sent it to these recycling units [at Umicore] they actually make a lot of money. So we had all of them come together with E-Parisaraa and they would accumulate the container there-and-then and sort it. So it really helped. And now all of them are doing it on their own.… we made sure we didn't give any funds. No grants were given, it was not necessary also because it was all paid [profitable].… and that was why it worked and it is still working. So that was a very good approach that we did here." (March 17, 2013, personal communication)

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[55] E-Parisaraa has continued to collect materials from the informal sector, but has evolved their business practices in response to early conflicts about quality and pricing, and the frequency and timing of phone calls from sellers: they only buy from one or two brokers and they only buy materials that are delivered in full for inspection before price negotiations. Formerly, they would evaluate samples to negotiate price, but when picking up materials in the "godown," it would appear to be of lesser quality than what was promised. The owner of E-Parisaraa also complained about the number and time of day of phone calls from individuals wishing to sell small amounts of materials.

This interview was conducted a few years after the Crystal project had folded. The three Indian businesses, E-Parisaraa, e-WaRDD, and Eco-Birdd, all confirmed the failure of the Bo2W experiment in Bangalore.

In the following section, I provide a deeper analysis of the two pilot projects in Bangalore. I show how other forces such as class politics, business structures, and cultural mistrust supercede the thinly justified and biased results from the experimental studies at the foundation of Bo2W.

4.6.1. Licensing the unlicensed: "Formalizing" the backyard without expanding it

A major focus of the pilot projects in Bangalore was licensing the local recyclers. This process did not include the same level of support for EWarDD and Eco-BIRD that was provided to to E-Parisaraa. The costs of meeting the licensing requirements were not compensated by either a larger market-share of e-waste collection, nor government subsidies to assist in the transition from unauthorized to licensed business with the concomitant bureaucratic responsibilities and health and safety changes required by the state. As a result, these small businesses, unable to improve their business finances through formalization, commonly reverted to the kinds of recycling practices that the pilot project was intended to curtail.

E-Parisaraa was founded by a businessman who had three years gold-plating[56] experience in Singapore, and who returned to India to enter the e-waste recycling market. He submitted a business proposal to the organizers of the first national e-waste workshop[57] and was invited to participate. It was at this meeting that he met individuals from EMPA, GIZ, and various government offices. With the support of the Indo-Swiss-German partnership, E-Parisaraa was granted both a permit to operate and land: a large industrial estate on which he could build a recycling plant from the ground up. The owner was also able to network with e-waste suppliers such as Hewlett-Packard, General Electric, and IBM at subsequent meetings. In contrast, the level of government support, particularly in the form of access to land, was minimal for the "informal" recyclers.

The challenges to small-scale recyclers include limited access to land, and onerous reporting requirements to retain licensing with a constantly changing inventory. E-WaRDD, a cooperative of individual recyclers, was the first so-called "informal-to-formal" licensed business in Bangalore, assisted primarily by staff at GIZ. E-WaRDD was led by a recycler who had been in the business for about six years at the time of licensing in 2006. By 2013, E-WaRDD was still operating as an association and had more than forty members (March 7, 2013, personal communication). The second company to transition from the so-called informal sector to being "authorized," also in 2006, was Eco-birdd, led by a recycler who had about fifteen years of experience at the time (March 19, 2013, personal communication). Neither businesses had benefits like exclusive collection contracts with major suppliers, access to large land-leases to develop facilities, or government subsidies for providing hazardous waste processing services.

[56] Gold-plating processes are similar to gold recovery from e-waste using solution-based chemistry. E-Parisaraa has two business arms now: gold-plating and e-waste recycling. Gold from e-waste supplies the gold-plating business.
[57] National Workshop on Electronic Waste Management, India Habitat Centre, New Delhi, March 15, 2004

Further, the speed with which transactions occurred, the complexity of the materials taken in, and the pressure to relieve the sellers of their hand carried goods was not conducive to meticulous record keeping to meet licensing requirements (March 7, 2013, personal communication).

The president of e-WarDD summarized the difference between this scale of operation and the large permitted recyclers in India:

> Electronics recyclers like E-Parisaraa and Ash Recyclers are very strong financially. They have capital and land to have big facilities and big machinery. The informal-to-formal are very poor with no machinery. It is not really a question about pricing of materials. We have the experience - more than E-Parisaraa. Our facility is very small though and materials are still expensive. We get no support from the government. It is easy to get a license but that is all. We have asked for business loans or access to land [government owned] but there is no support for us. However, there is support for big firms like E-Parisaraa and Ash.... We would like a project like government loans or land to expand and support our business. Nowadays we decided to stand ourselves. This is our family business. My father did this before me, and his [associate] father before him. The government gave commitment to support, but they turned their face, they changed.
>
> [Me] What part of government?
>
> ... Pollution Control Board is not the problem - they gave the license and that is their only responsibility. It is the Karnataka Industrial Development Board who has not provided additional land or other support (March 7, 2013, personal communication).

In other words, the licensing requirements were relatively easy to meet, but the challenges of doing business in a competitive market with few assets or capital reserves are significant, despite years of experience.

Confirming this point, one of the NGO partners in the Indo-Swiss-German e-Waste Initiative argued that the failure of the Crystal and Clean E-waste Channel projects was related to the different levels of access to resources, such as land-leases, and the socioeconomic differences between working class and middle class businesspeople in Bangalore:

> “see none of our, none of our SMEs [Small and Medium Enterprises: the "informal" sector] have ever had that luxury, with [government subsidies]. Support, which is what they really need to [have], initially at least. So that's where the other stress comes from, you know when you, when you don't get any other support except then that you straight away [are] given this business model, you find difficulties meeting all your costs of operations. So at the point SMEs are also, they tend to go back into their informal ways of working. So that's where we are getting some problems in

terms of them being not as accountable to their to their authorization...” (March 9, 2013, personal communication)

4.6.2. The political economy of toll-refining contracts: Balancing business risks and managing knowledge

Typical e-waste refining contracts, such as those used by Umicore, reproduce power inequities through unequal access to information and resources and through the imbalance in temporal needs between small and large businesses. The structure of contracts for refining services is therefore another key aspect that determines the success of a model in which economically precarious businesses are asked to contract with multinational corporations.

Toll-refining is a business model commonly used by smelters and refineries in the global North. In this type of contract, the owner of metal-bearing materials, such as printed circuit boards, contracts with a refinery to provide the refining service for a fee (a "toll"). The owner of the material retains ownership during this process and either pays for the refined materials to be shipped back, or contracts for a brokering service from the refinery if the refinery offers it. The brokered material is then sold on the open commodities market and the proceeds, minus an additional brokerage fee, is delivered to the original owner of the materials. The structure of toll-refining is best suited for larger businesses that can afford to wait for material to be tested, negotiated, refined, and sold. Further, toll-refining is best for businesses that have sufficient capital or other resources to negotiate contract terms, independently test samples, witness testing, and negotiate additional testing from a referee laboratory if necessary. Small-scale recyclers are at a disadvantage with this model of refining because of the time delay between shipment of material and final payment, and the unequal access to information and testing resources.

The refining contract details are determined by first testing a sample of the metal-bearing material to estimate the amount of metals that could be refined. Both parties – the refinery and the owner of the material (or "shipper") – may test their own samples in a laboratory to confirm the results. Additional samples are typically set aside for a referee, or "umpire" laboratory that can be used to settle any disputes over estimated content. The contract structure typically has very clear procedures for settling disputes, including a provision for the owner of the material to witness the testing to verify that their material was, in fact, tested.

The fee structure in a refining contract may be very complex. A project lead for a UN-based e-waste recycling project in Ethiopia described a complex collection of three or four primary fees, sometimes complimented by additional security margins if the refined materials were going to be brokered by the refinery[58] (November 24, 2013, personal communication). A circuit board

[58] The "lot charge" is a standard fee charged per "lot," whether it is five tons or fifteen tons, given the total amount falls between certain upper and lower size limits. This charge is intended to cover sampling and assaying costs. The "treatment charge" is calculated per-ton of material in the lot and is meant to cover the handling of the volume of the material. This means that if you have low-quality material (low precious metals content), you are paying more for the handling of the plastics and other non-valuable contents than a shipper with high-quality material. The "refinement charge" is the fee that is based directly on the assaying results that estimate the content of the precious

broker[59] stated that the fee structure was a defining characteristic between each refinery's pricing and competitiveness, alongside the specific metal commodity profile in which they specialize (March 12, 2016, personal communication). A former specialist from a Canadian facility explained the complexity and importance of assaying contents for refining printed circuit boards and contract negotiation in an interview:

> … there's a lot of work and expertise in the art of sampling, sampling techniques. It can make or break your profit.
>
> [Me] How does that relate to the contract structure? If the sampling does not accurately predict the actual content, does it cause problems?
>
> My experience was that our sampling methodology was much more rigorous than the people shipping the material. So we were actually coming up with a really accurate assessment of the metallic content. But a lot of times it was lower than what the customer was hoping for. "what are your talking about, it was dripping with gold!"
>
> [FK] what did you do to settle those disputes? Did you send it to a third party.
>
> So we had quite a standard procedure where we would provide a copy of our sampling procedure to the customer - to the shipper - they had the right to be there to witness the weighing and sampling, to make sure we were following our procedures. And then the sample was always divided into four different portions. So one for the customer - one for the shipper, one for the smelter's lab, one for the umpire lab, and a research sample so if there are ever any problems. So, typically what would happen is that the shipper would have his portion assayed by his own lab, the Horne [refinery] would have their lab sample their portion, and there would be an exchange of assays [test results] between the shipper and the smelter. And if the split [difference in results] fell between agreed splitting limits, then there were rules for how it would be settled. You know, the average of the two assays would be used for settlement or, you know, that sort of thing. And if the assays fell outside the splitting limits, that's when you would go to umpire. That's the recourse is to go to umpire lab. So you'd take that third sample fraction and send it off to an agreed between both parties, agreed umpire lab. And in the contracts, we typically had an umpire, a list of three umpire labs and we would rotate them. So there was

metals contained in the lot. For example, copper is less expensive to refine than gold, so the refinement fees for a lot that contains more copper than gold are less than a lot that contains more gold than copper. There are two additional security margins that may be built in to the fee structure by refineries (likely only if they are brokering the material): a reduction in the analyzed contents and a reduction in the current price for the metals (e.g. using the London Metal Exchange) by calculated percentages.

[59] A circuit board broker is a professional who negotiates refining contracts for many individual "shippers" under one contract, typically to secure more competitive pricing based on bulk processing.

> no bias kind of thing. And then there were rules for settling based on what the umpire assay gets as well (November 27, 2013, personal communication).

The quality of sampling and assaying results are critical in determining the fees and thus the profit and costs of each contract. As the expert from Noranda described, the sampling procedure (grinding up boards and statistically sampling from a stream of pieces) and the ability to independently test the samples is critical for negotiating contract fees and proceeds. This process was similar for the contracts between Umicore and E-Parisaraa. The head of E-Parisaraa described his facility's ability to test their own samples of material in parallel to Umicore's testing. He also mentioned a time when he had rejected Umicore's assay results and had pushed for a referee lab in London to settle the dispute. He highlighted the challenges for the small-scale recyclers in Bangalore to fit in to this model due to the delay in payment during which time assaying was negotiated (March 15, 2013, personal communication).

Testing, traveling to observe procedures, and contesting results all take time, money, and access to networks of expertise not typically available to small-scale recyclers. Refineries also prefer to contract for large quantities of material in one contract. Small-scale recyclers rarely have access to land with secure storage for collecting valuable materials until the volume is high enough to contract for refining. The Crystal project was organized such that only E-Parisaraa had an export license to contract with Umicore, serving as a collection hub through which e-WaRDD, Eco-birdd, and any other small-scale recyclers could funnel printed circuit boards.

One of the small-scale recyclers involved in Crystal critiqued the distribution of business risk inherent in the structure of the toll-refining. He described how the turnaround time for payment from the refined metals was about 90 days and in the contract, Umicore charged for the cost of shipping, fees for refining, and transaction fees. He said he had requested a fifty percent advance because the economic risk was unbalanced ("why should I take all the risk?"). The model required sending a large amount of valuable material overseas by container and no guarantee of responsibility by Umicore against losses while in transit. Umicore offered a much smaller percentage of payment up front instead (March 7, 2013, personal communication). In the following section I discuss trust and class conflict in relation to the Crystal project.

4.6.3. Cherry-picking the value: Contracting discord across cultures

Trust, or lack thereof, was a recurrent theme in interviews with recyclers and NGOs in India, and with Umicore. Many informants described false representations of the quality of circuit boards in contract negotiations, unfair pricing, and blatant expressions of self-interest or intimidation. One of the small-scale recyclers in India summarized these tensions as class conflicts, using the idiom "oonch-neech" ("up-down") (March 7, 2013, personal communication).

In an interview with the head of one of the NGOs in India, she described how cultural difference, bordering on disdain, infused business negotiations:

> [X] there is also the informal sector that wants to collaborate with the big players and there could be a level of, you know, win-win for both, but we are still seeing the big players not willing to actually talk terms which, you know, can be attractive for the informal sector, or for what we are calling the SMEs… they don't give them the appropriate prices for the materials.... it's [Bo2W] a very corporate approach, which doesn't go over well with the SMEs.... So they look at each other as competitors and then they start to talk business then you know the larger players look at them as they are uneducated or you know their margins are not so important for them perhaps, or they are important but we can negotiate - "If you know we can drown you" kind of thing, "we are the big players" you know? - So all of these typical kinds of interactions on both sides don't seem to meet. (MAR 9, 2013 Saahas)

The bigger recycling businesses do not value enough the collection, dismantling, and segregating skills of the smaller recyclers, and this was reflected in the prices offered for the materials. Development professionals, social justice activists, and some researchers have published research and reports that show the deep industry-specific knowledge and the significant and largely unrecognized contribution by the small-scale sector to environmental sustainability and urban functioning (Vergara et al., 2016).

The cultural conflict around status in these interactions was described clearly by the head of e-WarDD in his discussion of their short-lived relationship with Umicore. Umicore representatives came and met with him a few years prior to our interview and sat in his shop just as we had. At that time, he was not yet licensed, but he was in the process. Umicore said that they were trying to help the informal sector but it was clear that they were only looking out for their own interests: "Wo h unki hi faidha ko sochthe hain" ("they are only looking for their own interests"). E-WaRDD tried to make the relationship work for two years, requesting to sell the material right away, but the relationship failed and they decided to return to gold-recovery recycling practices instead (March 7, 2013, personal communication).

The small-scale recyclers were also accused of misrepresenting the quality of material they were trying to sell or ship for refining. In general, older boards tend to have more gold but over time, manufacturers have been able to embed or plate less gold while continuing to improve performance, resulting in newer boards that are valued less than prior generations. This was summarized by the expert from the Canadian facility:

> So you were asking about trends, and you know one of the trends that has been happening for a couple of decades is they are getting better at using the precious metals more efficiently in computers. So there's less metal value per ton, it's declining in value, even though some components, individual components might be higher in content. For example, a CPU [central processing unit] chip might have very high gold content, but it represents only a small fraction of the overall total weight. And this is where it gets really challenging in terms of sampling accurately, because you need to make sure that you not only capture some of the high grade

> gold chips on a board but also the pieces that don't have anything on it. So you have to get that overall assay (November 27, 2013, personal communication).

Given the complexity of printed circuit board composition and the importance of assaying, or analyzing for the contents, in contractual agreements as described in the previous section, significant differences between expected and actual content can break trust. Cherry-picking, or selectively removing high value parts and thereby reducing the value of the remaining materials, is a common accusation. For example, many circuit boards have gold-plated parts that are easily picked off manually (referred to as "apparent" gold) and could be removed between the initial collection and sorting and the subsequent shipment to a refinery for final processing.

Cherry-picking has also been used to describe Umicore's interest in only the highest-value portions of e-waste, leaving behind the rest of the plastics, leaded-glass, and other low-value portions in India or other global South locations. This issue of overlapping and multi-directional accusations of cherry-picking was described by one of the individuals involved in the early Indo-Swiss-German project and who has remained involved with the United Nation's Solving the E-Waste Problem Initiative:

> Of course cherry picking is used wherever you have printed circuit boards because of all the gold and associated other precious things around it. But it's, I think it's cherry picking only if you look at the circuit boards and not the rest of the fractions. I mean if you say ok what do you do with the plastic fractions? Is it better to do it or send it to the country outside?... so it's not a very straightforward answer to say ok, you know if it's printed circuit boards it's cherry picking, if it's plastics, it's not. I think it just depends on where the technology is available and the most efficient, both environmentally and economically. When you are going to pay extra money, it's stupid for anyone to think that yeah, anyone does this out of the goodness of their heart. (July 2, 2014, personal communication)

Accusations of cherry-picking the "apparent gold" from the boards, or cherry-picking the boards from the rest of e-scrap has been used to critique the competition from a rival business or industry, or to critique a business practice that does not address other desired outcome such as environmental remediation of hazardous or bulky wastes. The Bo2W can be considered a cherry-picking model of e-waste governance because it inherently singles out higher-value components of e-wastes for recycling, leaving the low-value scrap behind.

4.7. Conclusion: Neocolonial liveliness in the numbers

Why should we care about a few student-conducted studies of gold-recovery from e-waste in India and corporate Belgium? Because corporate Belgium is making money that is at-partially based on lies that were developed through small moments of encounters and seemingly mundane choices in writing and publication. These small moments cover up the poor assumptions, questionable methods, and fundamentally racist colonial views of the capacities of workers versus machines in two different places in the world. The studies never proved what they said they did. Data was hidden and failures pushed under the rug. Despite this, broad claims were made about sustainability and cleaning up pollution. Umicore shores its reputation as a sustainability leader. UN elites continue to churn out glossy expert reports. All of which is built upon scientific pillars of sand and capitalistic drive. The Bangalore study was transformed easily into digestible graphics, disarticulating the biased conclusions and misrepresentations of the study, the reality of how it was conducted, and the lackluster results of Crystal and the Clean e-Waste Channel.

Umicore's use of European graduate students' projects is a particular mode of evidence-making, characterized by small-n data sets, unverified methods, and biased expertise and data. These studies were the foundation of the recommendations to improve both the environmental effects and the efficiency of unlicensed recyclers in India, and later, the global South.

The privileged position – association with a trusted global institution, the United Nations – of the elites conducting the studies supported the uptake of questionable results into politically salient publications and reports. Once a number is produced and printed, it is attractive for ease of communication, replication and transportation, and for the trust that numbers embody through their perceived objectivity (Porter, 1995), regardless of the things they represent. Due to the ease with which numbers can be easily reproduced, referenced, combined, and transported through other documents and texts, the embedded values in the science, such as corporate interests, can display a "liveliness" that extends beyond the library shelf containing the master's thesis or the collection of conference proceedings. In an academic game of operator, the efficiency calculation for the Bangalore recyclers, cited in other texts, presentations, and documents, has come to represent the entirety of "informal" recycling in India and the global South, writ large. The inefficiency numbers are contextualized in discourses of Best Available Technology to argue against locally-designed recycling systems in the South.

This liveliness is enhanced by the promise of a number to fill a much-desired information gap. Because there are few (or no) published studies quantifying the yield in small-scale recycling operations, any study that produces these kinds of facts is more easily taken up in support of further research and policy. A peer-reviewed journal article, published just after the Bangalore thesis and authored by the graduate student who produced the "key drivers", captured this sentiment: "Up to now, no published data is available for informal recycling of gold and copper in the informal sector. Yet, a recent diploma thesis on gold recovery in India shows that metal recovery rates in informal recycling are significantly lower than in formal recycling (Keller 2006)." (StreicherPorte et al., 2007: 338).[60] The key role of the student's thesis was highlighted in an interview with one of the actors in the StEP network:

> "So in a way it started –the project – we kind of said the whole hazardous bit in the whole chain is the actual recycling - where all the chemical leaching, all the burning, all the cyanide, all the mercury are. [So.] what is the best way to evacuate

[60] this contains a factual error as well: the informal recyclers in India had a *higher* yield than the formal recyclers

that from the chain and build a business case around that? And the [student study] was sort of the first step in building this case by saying ok, you know the efficiency of these guys… if you take the same sample and you process it in Bangalore versus processing it in Umicore the efficiency is I think, I don't know, 20 percent in Bangalore and 80 percent in Umicore or something like this. And that kind of gave us the building blocks for the economics here to build the case: ok, you know if you have enough material… it makes more sense to ship it to Umicore because they can extract much more and give you much more value than if you recycle it yourself here in Bangalore, *So I think that was the building block of the whole model*, but it took a really long time before it could really be operationalized… the study by [Keller] was *one of those steps to actually identify the economic driver*." (July 2, 2014, personal communication, emphasis added)

Taken together as evidence of informal e-waste recycling metrics, this particular student's thesis and the related conference paper have been directly cited in more than eighty documents and the yield calculation has been taken up and replicated in even more, referencing the references. Many are in refereed articles in journals such as Journal of Industrial Ecology or Environmental Science and Technology. Other citations are in reports published by agencies and institutes, conference proceedings, publicly available corporate presentations, and a handful of academic theses and dissertations. Many of these citations are found in documents authored by members of the epistemic community. None of the citations examined in this articles analysis acknowledge that the dismantling stage – the source of the greatest loss – was performed by the student and the staff at the formal facility. None of these citations mention the Crystal project.

The effects of the students' studies have reverberated through subsequent development projects organized around e-waste recycling in the global South (Manhart, 2010; Sepúlveda et al., 2010; Schluep, Hagelüken et al., 2009; Wang, Huisman et al., 2012). For example, a UNEP report from 2013 on global metals recycling cites the thesis numbers, but suggests the losses are from poor visual inspection (which was solely the practice of the masters student):

"... Keller (2006) carried out a substance-flow analysis for investigating the processes of recovering gold from printed wire boards (PWBs) during informal precious-metal recovery in Bangalore, India. He [sic] compared two different processes, both starting with manual dismantling of PWBs to remove the parts containing apparent gold, which later was recovered by cyanide leaching and gold stripping. Between 40 % and 84 % of the contained gold was lost during pre-processing (dismantling), mainly because of poor visual recognition of apparent gold. The recovery of gold through chemical processes caused further losses, so that, in all, only 8 % to 18 % of the gold was recovered." (UNEP, 2013: 128)

Notwithstanding the factual errors (silver and copper were not assessed), a peer reviewed journal article magically multiplied the thesis study, stating that "studies in India indicate that recovery yields tend to be on the order of 25% or less of gold, silver, and copper" (Bollinger and Davis, 2012). Bright green and orange graphics with simple numbers overlaid on top of shrinking circles obfuscate the underlying politics of conducting corporate-influenced science, producing highly uncertain and biased results (UNU-IAS, 2015: 13). The United Nations, with its attendant scientific and policy authority effectively has both blue- and green-washed[61] a corporate strategy to define the South as a source of cheap labor and raw natural resources.

The Best of Two Worlds model of electronic scrap recycling has continued to grow as an idea, having been taken up by new groups and individuals promoting variations of an international division of labor for electronics demanufacturing and recycling. For example, WorldLoop, a Belgian-based NGO focused on developing e-waste disposal systems in the global South (primarily in Africa and South America), has promoted their version of The Best of Two Worlds philosophy in their projects. One of their partners is Umicore, but they partner with many other businesses as well.

My research shows this larger finding, that "….efficiency, despite its new clothes of scientific and market-led neutrality, its association with all that's modern and good, even democratic, is, in practice, political. It is a means of determining who gets what and how…" (Princen, 2005: 72-74). The recyclers in the global South are characterized as a sector that only yields 25% of the gold embedded in scrap electronics, losing 75% through inefficient and polluting recycling practices. Conversely, Umicore is presented as a highly efficient and safe alternative, yielding above 95% of the gold contained in electronic scrap, achieving both a blue- and a green-washed sustainable partner veneer. I argue instead that these data embody an inequitable power of representation: the ability for Northern elites to speak for the Southern recycler. Very little data was generated by, or collected with the recyclers in the South. Instead, the students under the guidance of the scientists and professionals in the StEP initiative, abstracted, and otherwise produced studies that confirmed preconceived assumptions about recycling methods in the South: techniques are crude, highly inefficient, and could not possibly be profitable. Data were estimated (assumed) from European businesses, grand abstractions were produced to represent entire economies, and the data collected from so-called Southern recycling practices was actually collected from attempts to replicate the practices of Indian recyclers by the Northern elites. In sum, the results of these studies say more about the interests and practices of Northern elites than they do about Southern recyclers.

This analysis reveals the flawed evidence for and biased construction of the e-waste problem in the South: that the thriving e-waste recycling economies within exemplar cities are first, motivated by printed circuit board gold-recovery, and second, use practices that lose most of the gold. The analysis further highlights some key reasons why the pilot projects meant to solve this constructed reality failed. Lastly, my research shows how simple calculated results bring a liveliness to the concept of Southern inefficiency that propel this representation through broader networks of partnerships seeking to intervene in e-waste economies. Corporate values, made

[61] "Blue-washing" refers to an organization or process gaining legitimacy through affiliation with the United Nations. "Green-washing" refers to an organization or process gaining legitimacy through perceptions of environmental goods.

portable through numbers and passing across the desks and screens of policy makers, scientists, project managers, and corporate representatives in the global North, have been transported to development projects in Ghana, Senegal, and Ethiopia. Modest graduate theses become sources of traveling "facts" after data and conclusions are taken up and transformed by profit-motivated elites. These facts then mix and mingle with otherwise-made numbers, charts, and texts, creating a complex web of e-waste knowledge produced by global elites that echo an old refrain: the informal sector (and the global South, writ large) is a place for low-skilled manual labor and a site of extraction.

I have shown that the Bo2W model deployed neocolonial representations of the global South that served to extend Northern hegemony in scientific authority and industrial expertise. The project thus reproduced socio-environmental injustices, corrupted by a racist profiteering. I lay bare the practices that produced subjective numbers and trace the disarticulation from their generative context. My analysis raises questions about the use of poorly conceived and implemented, pseudo-scientific studies, analyses, and insupportable results in addressing global environmental problems: Biased models provide little chance of success in addressing socio-environmental problems.

Chapter 5

5. Conclusion

Through the process of exploring why, at first glance, strange actors were involved with strange science, I found a thriving global economy that was far more about competition and access to valuable resources than it was about either dumping or cleaning up wastes. Further and more surprisingly, I found that e-waste struggles proved to be the continuation of colonial traumas and re-enacted historical practices/patterns: Colonial and neocolonial forms of rule, revolutionary African independence, and massive expropriation of infrastructure. E-waste imagery and knowledge production still deploy tropes of helpless “informal” recyclers demanding the e-waste problem be solved using the Best Available Technology.

In the first chapter, in which I propose the term “flexible mine” to describe the shift to recycling the detritus of modern consumption by mining companies, I show how multiple registers of flexibility attempt to solve three problems of below-ground mining: spatial fixity, resource limitations, and socio-environmental effects. The reframing of recycling as environmentally-sound “mining” promises a disarticulation from colonial and extractive mining legacies and a reframing of the urban “mining” industry as sustainable. The interpretive nimbleness of e-waste and recycling technologies supports the expansion of the flexible mine into new spatial and temporal geographies, creating novel governance challenges for extractive industry relations because of the (temporally and spatially) nimble character of procurement contracts, and a sustainable gloss that renders socio-environmental effects invisible. It is this interpretive flexibility that sets the flexible mine apart from well-established resource recovery industries such as textile or steel recycling. Similarly, discursively “solving” the environmental problems of below-ground mining directly supports mining actors prospecting for new flexible mining contracts, by redefining them as sustainability experts and a facet of flexible mining that differentiates it from earlier forms of scrap recycling.

In the second chapter, I show how a political ecology approach to writing a critical environmental history, situating current-day relations of production in historical trajectories of contested power, land control, and violent extractivist politics. The juxtapositioning of the flexible mine to those colonial era tales of the underground suggests reasons why Umicore has leveraged a seemingly apolitical sustainability trope. The company has inserted itself into non-traditional marketing fora for recyclable scrap: scientific meetings and development projects focused on e-waste hazards in the global South. Umicore's foray into "sustainable" international development brought the company together with the United Nations University (the office based in Germany) and other research and technical institutes in Europe focusing on the increasingly concerning global issue of electronic waste shipping and disposal. Umicore's partnership with the United Nations' Solving the E-waste Problem (StEP) program, has positioned them to steer global scientific agendas and international development goals to their advantage. Umicore now thrives because of geopolitical (and identity) ambiguities around its current and historical manifestations. Its new self : a flexible, multi-sited mine directing a global portfolio of clients who, in turn, mine the detritus of society for metal-bearing scrap. The multi-scalar flexibility disrupts any notion of neat boundaries between "host" and "home" country. Umicore's efforts to promote flexible mining through a program known as the "Best of Two Worlds," are built on and reflect patriarchal, patronizing, colonial forms of extraction. The new image is that of the old: Central Africa becomes “the global South” but remains positioned as a source of cheap raw materials (electronic scrap) for the mother mine of Umicore to reap the benefits of their value-adding refinery and brokering services. Production, consumption, market control, all rolled into one.

The third chapter presents a fine-scale analysis of knowledge production and politics of “expertise” at work in The Best of Two Worlds project: the medium by which Umicore took its place in the neoliberal world as an “efficient” Northern producer. I show how scientific authority and expertise were used to hide biased and faulty evidence-making. My analysis highlights the problematic role of private corporations in public-private partnerships focused on environmental problem solving and sustainability. Extractive accumulation motives are incompatable with sustainable solutions to environmental harms. Further, the involvement of racist colonial legacy institutions, including so-called Development work by Northern elites, dooms these projects to failure through resistance and ill-fitting solutions. Simplistic economic calculations, even when done “right,” cannot capture the underlying political economy and therefore will always miss the mark. In this case, the science and economic calculations do not approach these best-cases. Instead, the chapter shows the misrepresentations and misdirections even in the face of contradictory findings. The chapter concludes by showing the failure of this model to actually work, and the persistence of the flawed idea in ever-expanding networks of sustainability experts.

The small scale recyclers represented as helpless by the images of poverty and practice in activist exposés are not helpless. Nor do they want the solutions promoted by those hawking the Best Available Technology: they do not want to cede their business to competitors. The more pressing problems facing small-scale e-waste recyclers have more to do with worker and environmental safety, land use permitting, regular market access to materials, and business loans to improve their operations. There is also ample room to understand the environmental and social goods brought about by the informal sector in the global South (e.g. Vergara et al., 2016). Research and policy that focuses on addressing the challenges to improving economic development, working conditions, and the most intractable environmental challenges with the discard stream (e.g. use of plastics and flame retardants, product design that enables repair and recycling) would go much further in presenting Best Available Technologies that encourage participation by multiple sectors (Daum, Stoler and Grant, 2017; Davis and Garb, 2015; Williams, Kahhat et al. 2013).

My research highlights how discourses of green recycling and circular economies hide the extractive and capitalist underpinnings of this industrial change, producing inequalities amongst actors not equipped to engage in high-stakes knowledge-making or policy. This dissertations supports further inquiries into addressing environmental harms such as toxic releases from e-wastes that consider the need to retain higher-value materials, production, and economic opportunity in the global South. These lines of inquiry may produce conclusions counter to the interests of global North elites or private entities engaged in development partnerships, but I argue the goal of this work is not to ensure a steady stream of profit for a few elite firms, but to address wicked socio-environmental problems with the least harm to local communities.

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Appendix A

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A.2. Institutional Review Board approval

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A.3. Interview protocols

The interview guide is divided into six sections, the first containing general questions asked of all participants and the other five sections tailored for individuals associated with different types of organizations. Section two focused on electronic waste recycling industry actors who might be involved in collecting, sorting, dismantling, shipping, or brokering e-waste materials. The third section focused on precious metals refining and included individuals involved with refineries, smelters, or "traditional" mining companies. The fourth section focused on actors involved with private (non-governmental) consultancies conducting development policy or research work. The fifth section focused on governmental policy actors. The last section focused on non-governmental advocacy organizations. All of these types of organizations could include work portfolios focused on either or both domestic and international projects. Often, these scales are intertwined directly.

The interviews were semi-structured by design and thus the questions were treated as an entry into further discussions as the opportunities arose to explore a topic more fully. Similarly, not all questions might be addressed in one interview.

Section 1: General Information

1. How long have you been with this organization?
2. What is your job title/description in your organization?
3. How would you describe/explain the work that you do?
    a. What are some examples of projects/duties?
4. How long have you worked in this capacity?
    a. What did you do before?

Section 2: Electronic Waste Recycling Industry

1. What part of the e-waste industry does your organization specialize in?(e.g. dismantling, sorting, repair, shredding, smelting, recycling, resale)
    a. Probe – diversity of e-waste processing practices within organization
    b. Probe – evolution of business practices/specialty within organization
    c. Probe – specific materials that are focus (chemistry or tech classifications)
    d. Probe – specific challenges within this speciality (material, regulatory, labor, industry)
2. How would you describe your organization's role within the broader e-waste recycling industry?
    a. Probe – how long in this role
    b. Probe – why pursue this particular industry role?
    c. Probe – challenges in industry linkages/flows
    d. Probe – changes within the industry?
3. Describe the input material you accept
    a. Probe – from what sources?
    b. Probe – in what condition?

c. Probe – diversity of input material
d. Probe – material that is not accepted
e. Probe – challenges in obtaining input material
f. Probe – changes in material flows (what, why – speculation)

4. Describe the stages of e-waste processing within your organization
   a. Depending on organization, this may be more/less detailed
   b. Probe – challenges in material flow within organization
   c. Probe – challenges with industry linkages (output products, input materials, standards, processing materials)
5. Describe your output product(s)
   a. Probe – delivered to whom/where/what?
   b. Probe – diversity in outputs
   c. Probe – waste products?
   d. Probe – linkages to other industry
6. Have there been any major changes in e-waste materials and/or regulation that have affected your organization/job?
7. What do you think the upcoming trends in e-waste processing will be? Why?
8. Have you (or others in your organization) ever participated in public-private partnerships or initiatives focusing on e-waste recycling and environmental concerns?
   a. Probe – with whom?
   b. Probe – for what purpose/project?
   c. Probe – where?
   d. Probe – successful? Challenging?
   e. Probe – ongoing/multiple projects/partnerships?
   f. Probe – changing partners?

Section 3: Precious/Rare Metals Mining/Refining Industry

Technical Operations

1. Does your organization handle electronic waste?
   a. What kinds? Why?
   b. Benefits and challenges?
2. Describe the input material you accept
   a. Probe – from what sources?
   b. Probe – in what condition?
   c. Probe – diversity of input material
   d. Probe – material that is not accepted
   e. Probe – challenges in obtaining input material
   f. Probe – changes in material flows (what, why – speculation)
   g. Probe – what is best and worst input materials (and why)
3. Describe your output product(s)
   a. Probe – delivered to whom/where/what?
   b. Probe – diversity in outputs

    c. Probe – waste products?
    d. Probe – linkages to other industry
4. Describe the stages of refining at your facility
    a. Depending on organization, this may be more/less detailed
    b. Probe – challenges in material flow within organization – chemistry, tech issues
    c. Probe – challenges with industry linkages (output products, input materials, standards, processing materials)

Business Operations

5. What does your typical contract look like?
    a. Probe – for what services (e.g. assaying, refining, marketing, brokering)?
    b. Probe – variations in contract structure/design: why and for whom?
    c. Probe – timeline for refining services/payment
    d. Probe – logistics management (e.g. shipping, etc)
    e. Probe – what are benefits to this (these) contract structure?
    f. Probe – what are challenges to this structure? (e.g. time, logistics)
6. What is your firm's most profitable type of contract? Why?
7. What is your firm's least profitable (or most costly) type of contract?
8. What are the technical factors that influence the profitability of particular processes or services that you offer? (e.g. amount of plastics, flame-retardants, lead, etc)

Industry Overview and Context

9. What part of the mining and refining industry does your organization specialize in?(e.g. non-ferrous metals, precious/rare, copper/gold/silver refining))
    a. Probe – specific materials that are focus (chemistry or tech classifications)
    b. Probe – evolution of business practices/specialty within organization
    c. Probe – specific challenges within this speciality (material, regulatory, labor, industry)
    d. Probe – if large organization, describe this sub-sector and how it fits with the rest of organization (e.g. large multi-national materials specialist)
10. How would you describe your organization's role within the broader mining and refining industry?
    e. What services do you offer?
    f. Probe – how long in this role?
    g. Probe – why pursue this particular industry role – what is exciting about this speciality?
    h. Probe – challenges in industry linkages/flows
    i. Probe – changes within the industry?
11. Who do you consider are your industry equivalents?
    j. Probe – why? What qualities are similar? (size, organization, clients, technical specialities, location)
    k. Probe – what makes you different than these other organizations?

12. What is your organization’s most innovative/exciting contribution to the industry?
    l. Probe – sustainability criteria
    m. Probe – new/innovative products/processes
13. Have there been any recent (last decade) major changes in mining/refining industry and/or regulation that have affected your organization?
    n. How has your organization responded?
14. Describe some of the longer term challenges to mining and refining industry (last 60-70 years)
    o. How has your organization responded?
15. What do you think will be some upcoming trends in mining and refining? Why?
16. What do you see is the future of e-waste recycling technologies?
    p. Probe – hydro/bio/pyro metallurgy
    q. Probe – international trade
    r. Probe – particular challenges?
17. Have you (or others in your organization) ever participated in public-private partnerships or initiatives focusing on e-waste recycling and environmental concerns?
    s. Probe – with whom?
    t. Probe – for what purpose/project?
    u. Probe – where?
    v. Probe – successful? Challenging?
    w. Probe – ongoing/multiple projects/partnerships?
    x. Probe – changing partners?
18. What is your recommendation for sustainable recycling of electronic waste (describe details)
    y. Recycling actors/specialists?
    z. Types of recycling to avoid – why?

Section 4: (Private) Development/Policy/Research Consulting Organization

Role

1. What does your organization specialize in (policy, etc)?
    a. What are some challenges with this line of work?
    b. What are some exciting things happening in this field?
2. Describe the general process of your typical e-waste project
    a. Probe – do you form partnerships? With whom?
    b. Probe – how do you set your project agenda?
    c. Probe – what kind of role do you take in the project (if partnership)?
    d. Probe – generally how does financing work for an e-waste project?

Trends

3. What do you see have been the major challenges for e-waste governance?
4. What do you see are the coming changes for e-waste governance?

5. What do you see have been the major challenges for natural resource management?
6. What do you see are the coming challenges for natural resource management?
7. What do you see is the relationship between e-waste and natural resources?
    a. Is this relation changing over time?
    b. What are your recommendations for the electronics, recycling, and mining industries?
8. Who are the players most involved in e-waste trade/recycling?
    a. Do you see this changing going forward?
9. Who do you think should be the players handling e-waste? Why?
10. Are there segments of the e-waste recycling industry that you see as particularly well-suited to cooperate/link together? Are there others that appear to be in competition or not well-suited to link together? (related to input/output materials)

Section 5: (Public/Government) Policy Organization

Role

1. What does your organization specialize in?
    a. What are some challenges with this line of work and e-waste?
    b. What are some exciting things happening in this field with e-waste?
2. Describe the general process of your typical e-waste project
    a. Probe – do you form partnerships? With whom?
    b. Probe – how do you set your project agenda?
    c. Probe – what kind of role do you take in the project (if partnership)?
    d. Probe – generally how does financing work for an e-waste project?

Trends

3. What do you see have been the major challenges for e-waste governance?
4. What do you see are the coming changes for e-waste governance?
5. What do you see have been the major challenges for natural resource management?
6. What do you see are the coming challenges for natural resource management?
7. What do you see is the relationship between e-waste and natural resources?
    a. Is this relation changing over time?
    b. What are your recommendations for the electronics, recycling, and mining industries?
8. Who are the players most involved in e-waste trade/recycling?
    a. Do you see this changing going forward?
9. Who do you think should be the players handling e-waste? Why?
10. Are there segments of the e-waste recycling industry that you see as particularly well-suited to cooperate/link together? Are there others that appear to be in competition or not well-suited to link together? (related to input/output materials)

Section 6: Non-Governmental Organization (NGO)

Role

1. What does your organization specialize in?
    a. What are some challenges with this line of work and e-waste?
    b. What are some exciting things happening in this field with e-waste?
2. Describe the general process of your typical e-waste project
    a. Probe – do you form partnerships? With whom?
    b. Probe – how do you set your project agenda?
    c. Probe – what kind of role do you take in the project (if partnership)?
    d. Probe – generally how does financing work for an e-waste project?

Trends

3. What do you see have been the major challenges for e-waste governance?
4. What do you see are the coming changes for e-waste governance?
5. What do you see is the relationship between e-waste and natural resources?
    a. Is this relation changing over time?
    b. What are your recommendations for the electronics, recycling, and mining industries?
6. Who are the players most involved in e-waste trade/recycling?
    a. Do you see this changing going forward?
7. Who do you think should be the players handling e-waste? Why?
8. Are there segments of the e-waste recycling industry that you see as particularly well-suited to cooperate/link together? Are there others that appear to be in competition or not well-suited to link together? (related to input/output materials)