IISDREPORT

International Institute for Sustainable Development
Institut international du développement durable

Meeting China's Global Resource Needs

Managing Sustainability Impacts to Ensure Security of Supply

Copper Pilot Study

Jason Potts
Gabriel A. Huppé
Jason Dion
Vivek Voora
Maya Forstater

February 2014

www.iisd.org

Published by the International Institute for Sustainable Development.

International Institute for Sustainable Development

The International Institute for Sustainable Development (IISD) contributes to sustainable development by advancing policy recommendations on international trade and investment, economic policy, climate change and energy, and management of natural and social capital, as well as the enabling role of communication technologies in these areas. We report on international negotiations and disseminate knowledge gained through collaborative projects, resulting in more rigorous research, capacity building in developing countries, better networks spanning the North and the South, and better global connections among researchers, practitioners, citizens and policy-makers.

IISD's vision is better living for all—sustainably; its mission is to champion innovation, enabling societies to live sustainably. IISD is registered as a charitable organization in Canada and has 501(c)(3) status in the United States. IISD receives core operating support from the Government of Canada, provided through the International Development Research Centre (IDRC), from the Danish Ministry of Foreign Affairs and from the Province of Manitoba. The Institute receives project funding from numerous governments inside and outside Canada, United Nations agencies, foundations and the private sector.

Head Office
161 Portage Avenue East, 6th Floor, Winnipeg, Manitoba, Canada R3B 0Y4
Tel: +1 (204) 958-7700 | Fax: +1 (204) 958-7710 | Website: www.iisd.org

Meeting China's Global Resource Needs
Managing Sustainability Impacts to Ensure Security of Supply
Copper Pilot Study

February 2014

Jason Potts
Gabriel A. Huppé
Jason Dion
Vivek Voora
Maya Forstater

About this Paper

This report summarizes work to date on **how sustainability risks in China's global inward supply chains could be understood and managed to ensure security of supply.**

This study, presented in the Synthesis Report and three working papers (methodology, and cooper and palm oil pilot studies), has been prepared by a team led by the International Institute for Sustainable Development (IISD), with support from the UK Department for International Development (DFID).

This working paper has been led by IISD Senior Fellow, Dr. Simon Zadek, and a combined Chinese and international research and engagement team comprising Han Cheng, Jason Potts, Gabriel A. Huppé, Jason Dion, Vivek Voora, and Maya Forstater.

Mark Halle, Executive Director of IISD-Europe, and Shantanu Mitra, Senior Economic Advisor at DFID China, have also provided insight and guidance. We would in particular like to acknowledge and appreciate the contributions, through participating in surveys, reviewing this report and/or attending the consultation workshop in Beijing on January 10th 2014, from the following, in no particular order. DFID London, Bie Tao and Yan E (MEP), Xu Qingjun and Peng Jing (MOFCOM), Zhang Shiguo (CODA), Zhang Jianping (NDRC), Chen Xiaohong (DRC), Jiang Heng (CAITEC), Wang Haiqin (DRC), Zhang En (CASS), Chen Ying (CCCFNA), Li Yusheng (CNIA), Chang Xingguo (CMA), Wei Xueyan (CBCSD), Adam Lane and Bao Min (BSR), Ren Peng and Zhu Rong (GEI), Yang Jie (Greenpeace), Bai Yunwen (G-Hub), Li Nan (WWF), Zhang Su (DFID), Jill Peng (RSPO), Ji Guojun and Ji Guojun (Xiamen University), Liu Xianbing (IGES), Thomas Kastner (Alpen-Adria University), Lizzie Parsons (Global Witness), Feng Kuishuang (University of Maryland), and many other experts in China and internationally.

Errors and omissions in the Report are the sole responsibility of IISD

Comments on the paper are welcomed in English to the Project Director, Simon Zadek (simon@zadek.net), or in Chinese or English to Han Cheng, Project Manager (chenghan528@gmail.com)

International Institute for Sustainable Development | Institut international du développement durable

Table of Contents

Introduction

China's large and growing inbound supply chains are amongst the most direct ways in which China's rise impacts economies worldwide. For exporting countries this trade brings economic benefits such as employment, income and investment, but can also be associated with social and environmental (or "sustainability") problems. Negative impacts on land, water, air, biodiversity and communities can translate back into supply chain problems for China, whether through short-term disruptions or the broader impact on China's "brand" in international markets, which can affect the ability of Chinese enterprises to access international capital, resources, markets and talent.

China's strategic concerns to address resource scarcity and build an "ecological civilization" make effective management of the social and environmental footprint of inbound supply chains increasingly critical. Sustainability risks therefore should count for enterprises and policy-makers concerned with China's inbound supply chains. Yet for most companies operating in China, sustainability risks in inbound supply chains are poorly understood and often inadequately managed.

This initiative of the International Institute for Sustainable Development (IISD), supported by the UK Government's Department for International Development (DFID), is intended to help overcome this gap. The project:

- Developed and tested a methodology for assessing the relationship between sustainability and security of supply risks in inbound supply chains.
- Undertook two pilots to test the methodology, based on desk research, looking at the copper and palm oil supply chains.
- Surveyed and convened discussion with business people, policy-makers, academics, and NGOs to test the concepts, methodology and findings and to identify policy-relevant conclusions.

This paper, which outlines the *copper pilot study*, is therefore complemented by papers on the methodology and another pilot study on palm oil. These three input papers feed into the overall synthesis paper, which integrates the overall findings and draws out conclusions and policy recommendations, which are summarised below.

International Institute for Sustainable Development | Institut international du développement durable

Summary of Conclusions from the Overall Synthesis

This project has demonstrated a systematic approach to assessing sustainability-related security of supply risks, at both an enterprise and a national level. The methodology is an initial foundation which demonstrates the feasibility and relevance of applying a common framework to identify "hot spots" and systematically draw business and policy-makers' attention to them.

It is clear from international and Chinese experience that there are policy measures that can be taken to support better management of supply chain risks. Five policy steps are outlined, which could be targeted to key product and country risks to ensure that supply chain sustainability is recognized as a strategic issue and addressed in a professionalized manner reflecting its importance:

1. **Build supportive capabilities of Chinese embassies and consulates.** The Chinese government through the Ministry of Commerce (MOFCOM) should build the capacity of the Economic and Commercial Affairs Sections of its embassies and consulates to support Chinese companies in identifying and addressing social and environmental impacts.
2. **Strengthen engagement with international standards**. The Chinese government, through MOFCOM and the China National Institute of Standardization (CNIS) should accelerate its engagement with international standards that relate to strategic commodity supply chains at risk, identifying and addressing key gaps and risks, and building on its existing engagement with standards in areas such as conflict minerals and forests.
3. **Explore fiscal measures.** Fiscal measures may offer a lever for encouraging Chinese enterprises to address their own sustainability footprint, and that of their overseas suppliers. The Chinese government could engage in research to understand the potential of fiscal measures to incentivize the development of sustainable supply chains.
4. **Integrate supply chain sustainability into green public procurement.** Public procurement criteria can provide a further driver to improve sustainability impacts of China's inbound supply chains. The Chinese government, through MOFCOM, the Ministry of Environmental Protection (MEP) and key provinces could develop and pilot supply chain related green procurement criteria for a limited and targeted set of products.
5. **Develop supply chain risk criteria in existing corporate social responsibility (CSR) and green business guidelines.** Integrating supply chain risk into responsible business guidelines would make them more useful to companies and investors. This could draw on international best practice and the experience of leading Chinese companies.

In addition, an overarching approach is needed to China's international supply footprint part of its vision for resilient and sustainable development. One of the most notable findings from the discussions and consultations in developing this project is that there is no ministry or department with an overall vision and mandate for understanding China's import footprint and how it can be managed more effectively. Taking strong action depends on there being an overall vision articulated as part of the broader view of development. The National and Development Reform Commission (NDRC) could consider developing a broader goal and metric of performance on supply chain sustainability, as part of the national planning process in the lead up to the 13th five-year plan, and as part of China's development as an "ecological civilization."

The International Institute for Sustainable Development is committed to working in and with China to advance sustainable development, and views the area of inbound supply chains as a key strategic opportunity to achieve this mutual goal.

1.0 Global Supply

Copper prices have risen steeply in price in recent years, as seen in Figure 1. This has occurred within the context of an extended period of high metal prices since the mid-2000s. This rise in prices has been driven by growing overall demand, and although these high prices have generated significant investment in new capacity, overall, demand is rising more quickly than supply for copper and prices have remained high (World Bank, 2013b). It is estimated that there are 680,000,000 metric tonnes (MT) of copper reserves around the world (Edelstein, 2013). World mining production of copper was estimated at 17,000,000 MT in 2012 (Edelstein, 2013), and has grown at an average 1.9 per cent per annum over the last five years (2007-2012) (BGS Minerals UK, 2013). At this rate, copper reserves will be depleted by year 2041. For this reason, copper is one of the most recycled metals. World total scrap use of copper has remained steady over the last five years, hovering around 8,500,000 MT per year (International Copper Study Group, 2013). In contrast, world total refined production was estimated at 20,118,000 MT in 2012 (International Copper Study Group, 2013). Equipment manufacturing, infrastructure and building construction are the three largest copper end-use sectors globally (International Copper Study Group, 2013).

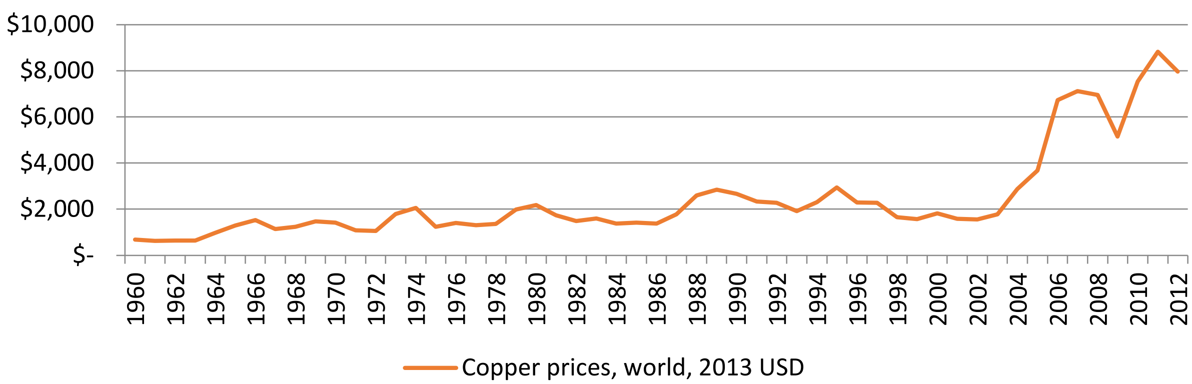


FIGURE 1. GLOBAL COPPER PRICES PER TONNE, 2013 USD

Source: World Bank, GEM Commodities database

China is responsible for a large proportion of growing copper demand (IISD, 2010; World Bank, 2013b). As seen in Figure 2, although overall demand grew for all but one of the seven largest copper importers between 2001 and 2011, it grew in China by a factor of three during this time. This strong growth in global demand taken against the comparatively slow growth in production as seen in Figure 3 underscores the importance of growing demand as a driver of today's high copper prices.

Copper production, which was flat in 2011, has not kept pace with consumption due to technical problems, labour disputes, declining grades, delays in start-up projects, and shortages of skilled labour and inputs. The tightness in copper production has been pronounced at the world's two largest mines, Escondida in Chile and Grasberg in Indonesia. However, high copper prices have induced a wave of new mines that are expected to come on-stream shortly—in several African countries, China, Peru, and the United States, for example (World Bank, 2013b).

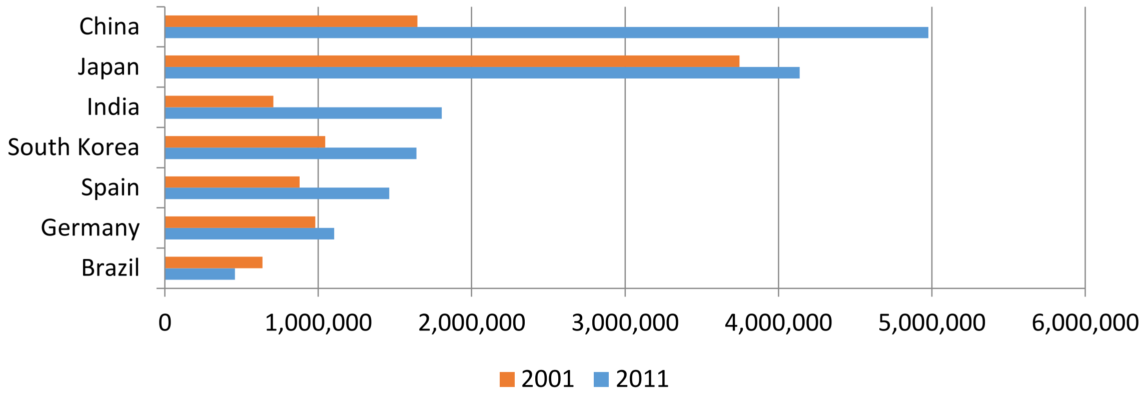


FIGURE 2. LARGEST IMPORTERS OF COPPER, TONNES

Source: UN, COMTRADE database

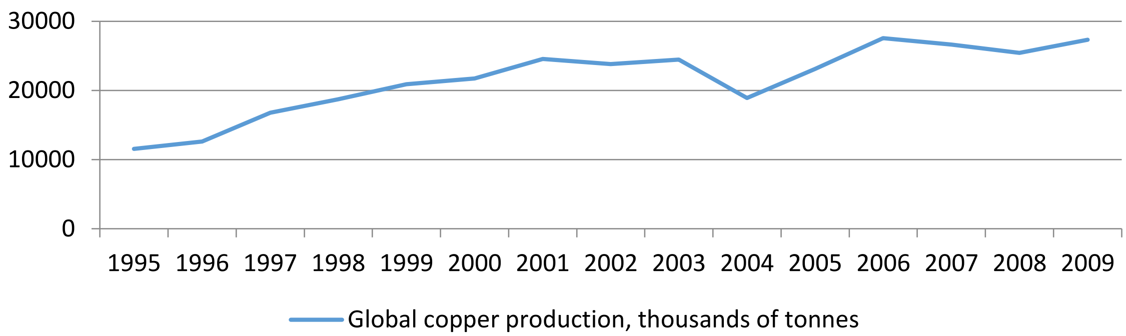


FIGURE 3. GLOBAL COPPER PRODUCTION, THOUSANDS OF TONNES

Source: UN, Industrial Commodity Statistics database

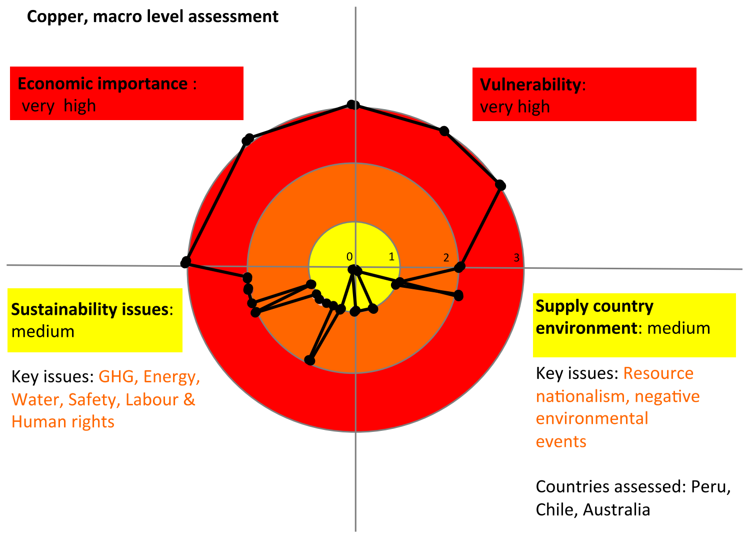
Despite the recent historical highs, copper prices fell sharply in Q2 2012 due to weakening import demand by China. Going forward, copper demand is expected to increase at a modest 2.5 per cent per annum and slowing even further over the long term as copper demand from China plateaus. In the shorter term, copper prices are expected to decline 2 per cent in 2013 and as much as 10 per cent in 2014, mostly due to substitution pressures (from aluminum prices) and slowing demand (World Bank, 2013b).

In terms of environmental and sustainability issues related to copper production and trade, the European Commission has deemed that the use of copper products is, in general, safe for the environment and human health. Using material flow analysis, researchers have highlighted the importance of recycling for future copper production and consumption in the world. While few cradle-to-grave life cycle assessments could be found on copper-containing products, the copper industry is developing information and data on the positive environmental contributions that the use of copper provides, particularly in electrical applications (IISD, 2010).

A prime concern for copper mining and for metals mining in general is levels of associated waste production and energy use. A tonne of copper is currently accompanied by 300 tonnes of waste (Moriguchi, 2010). Meanwhile, the energy used to produce metals is expected to approach 40 per cent of global energy supply by 2050, and copper will be an important part of this energy consumption (MacLean, et al., 2010).

2.0 Supply Risk

The IISD Supply Risk Tool was applied to China's copper ore supply chain. The results as well as the implications are discussed below, with further detail in appendix 1.



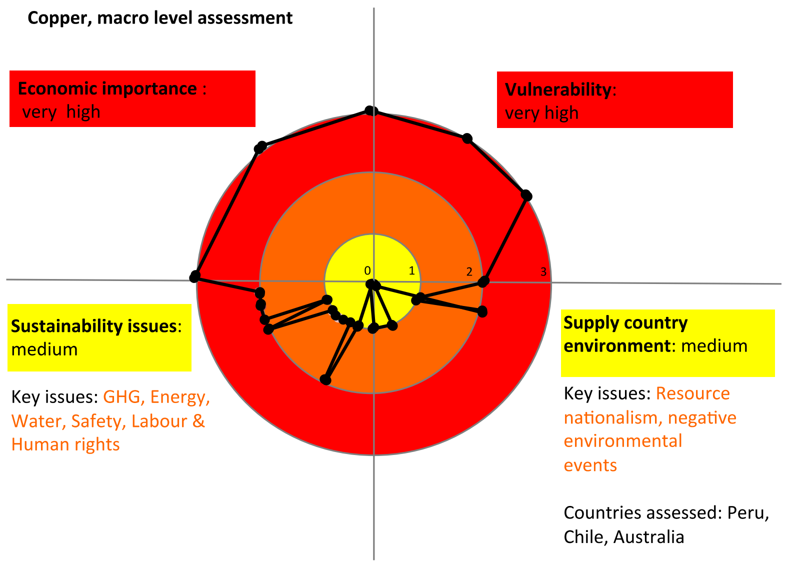


FIGURE 4. COPPER ASSESSMENT

TABLE 1. COPPER ORE ASSESSMENT

Component	Micro (enterprise)	Macro (country)
Economic importance	Very High	
Vulnerability	Very High	
Sustainability issues	High	Medium
Country environment	Medium	Medium

Sustainability issues	Land use	Low	Low
	Water use	High	High
	GHG Emissions	High	High
	Pollution	Medium	Low
	Biodiversity	Medium	Medium
	Deforestation	Medium	Medium
	Energy Efficiency	High	High
	Labour and Human Rights	High	High
	Society and Communities	High	Medium
	Maintenance and Safety	High	High
	Corruption	Medium	Medium
	Litigation and Compliance Risks	Medium	Medium
	Transparency	High	Medium
Country environment	Climate change policy	Medium	Medium
	Resource nationalism	High	High
	Natural and environmental disasters	Medium	High
	Strength of governance	Medium	Low
	Trade and interconnectivity	Medium	Medium
	Competition and markets	Medium	Medium
	Knowledge & access to information	Low	Low

2.1 Vulnerability – Very High

China is the world's largest importer and consumer of copper, with import volumes totalling 37 per cent of global copper trade volumes and 28 per cent of total copper produced globally. In 2012, China accounted for approximately 30 per cent of world copper smelter and refinery output, followed by Japan and Chile at approximately 10 per cent each (International Copper Study Group, 2013). Importing approximately $46 billion USD of copper in 2010, China is 68 per cent dependent on imports to supply its domestic manufacturing needs. Therefore, despite being one of the world's largest producers of copper, China is heavily reliant on other countries for copper supplies. Globally, only approximately 4 per cent of the world's estimated copper reserves are located in China. In 2010, China exploited 1.2 million MT, or 4 per cent of its copper reserves, which were estimated around 30 million MT. However, this rate of exploitation has been steadily increasing by 8 per cent per annum over 2006-2011. At this rate of mineral copper exploitation, China is expected to run out of

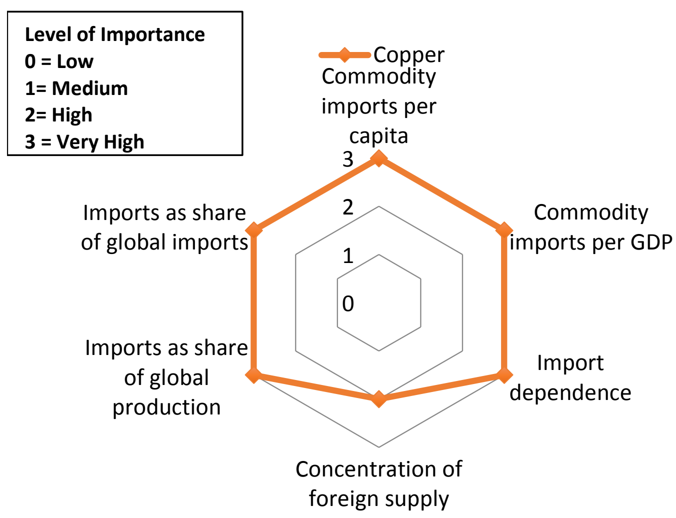


FIGURE 5. VULNERABILITY AND ECONOMIC IMPORTANCE INDICATORS

reserves in 2024. Australia, Chile and Peru account for over 50 per cent of global copper reserves which are estimated at 680 million MT. The national supply security of copper is especially vulnerable to supply disruptions because a large share of copper imports is sourced in relatively few countries. About 45 per cent of China's imports of copper ores and concentrates, copper scrap and refined copper originates from Chile, Australia and the United States. The United States, Australia and Spain alone supply 45 per cent of China's scrap copper imports, while Chile, Peru and Australia supply 60 per cent of China's copper ores, concentrates and refined copper.

2.2 Economic Importance – Very High

On a per capita basis, China imported about 10 kilograms or USD $34.42 of copper per person in 2010 for each of the 1.3 billion individuals living in China. Copper ore and concentrates, copper scrap and refined copper represent 97 per cent of China's copper imports. China's smelter production of copper was 2.8 million MT in 2010 while its refiner production was about 4.5 million MT. Copper smelters and refiners are currently the largest consumers of copper, but companies in secondary sector industries like electronics manufacturing are large buyers as well. Copper is an important input for electronic goods and components, of which China is the world's manufacturing hub and an important trading partner. It is estimated that the urban electronic and telecommunications manufacturing sector in China employs approximately 3 million people (Banister & Cook, 2011). More than 1 million people within China are directly employed in copper extraction, refining and manufacturing processes (Shang, Zhao, Duan & Zhou, 2011). It is estimated that approximately 140,000 Chinese are employed in the copper smelting sector and 522,900 are employed in the copper processing sector (Shang, Zhao, Duan & Zhou, 2011).

Electronics manufactured in China are sold domestically and exported to consumer markets all around the world. The electronics industry in China represented RMB 5.44 billion in 2010, contributing approximately 10 per cent to overall GDP growth in the last few years (APCO Worldwide, 2010). In 2009, the value of Chinese exports in electronics totaled about USD $457 billion (APCO Worldwide, 2010). China has been the largest consumer of copper since 2002. During 2006–2010, China invested heavily in power grid and subsidized housing, further contributing to the country's copper consumption, while automobile and home appliance industries grew significantly during this period as well. As a result, copper ore import volumes increased from 4.5 million tonnes to 6.4 million tonnes between 2007 and 2011. State-owned enterprises and foreign investment enterprises are the leading importers of copper ore. Between 2007 and 2011, imports of state-owned enterprises represented 41–56 per cent of total, while foreign investment enterprises represented 33–47 per cent and the share of private enterprise imports rose from 11 per cent to 23 per cent. The top consumers of copper are the electric power industry, electronics and communication technologies, machinery and equipment, transportation, and construction industries (Shang, Zhao, Duan & Zhou, 2011). The electric power industry accounts for 42 per cent of copper consumption, while the electronics and consumer goods industries each represent 15 per cent of consumption.

In China, the top 10 largest importers of copper ore represented 70–80 per cent of total imports between 2007 and 2011, indicating a highly concentrated market (Global Environmental Institute, 2013). The top 15 copper smelters in China have a processing capacity of 2.6 million tonnes per year and represent over 90 per cent of China's total smelting capacity (Streicher-Porte and Althaus, 2010). The top 15 copper refineries in China have a refining capacity around 4 million tonnes per year and represent approximately 80 per cent of total refining capacity in China (Streicher-Porte and Althaus, 2010). The production of copper semi-fabricated copper products (semis) in China is more widely distributed and diversified than copper smelting and refining, and copper semis enterprises feature large amounts and a wide variety of locations across China, and most of them are private enterprises (Shang, Zhao, Duan & Zhou, 2011). China produces approximately 8 million tonnes of semis annually, occupying 50 per cent of global production (Shang, Zhao, Duan & Zhou, 2011). The output of the top five copper fabricators represent 9.4 per cent of all copper fabricators in China (Shang, Zhao, Duan & Zhou, 2011). The value of China copper imports represents about 0.8 per cent of China's GDP. China is the third largest exporter of semi-fabricated copper products, after Russia and Germany (International Copper Study Group, 2013). Global copper consumption is expected to double by 2035, with China representing 68 pe rcent of this increase (Potts, J., Shang, F., Zhao, B., Duan, S., Zhou, Z., Streicher-Porte, M., & Atherton, 2011).

2.3 Sustainability Issues – High Micro and Medium Macro

The environmental impacts of primary copper production are mainly caused by the mineral extraction of copper ore (Streicher-Porte & Althaus, 2010) More than 70 per cent of the impacts for all primary processes are caused by mining or mineral extraction, whereas typically less than 25 per cent comes from the reduction or smelting (Streicher-Porte & Althaus, 2010). Because copper is only found in low concentrations in minerals (50 parts per million in the earth's crust and 0.5 to 5 per cent in copper ore), the extraction and processing of copper is highly energy intensive, producing large amounts of greenhouse gas emissions in the process (Streicher-Porte & Althaus, 2010). The extraction process which causes land degradation, stripped tailings and overburden, as well as emissions from the ore beneficiation process, cause environmental impacts that outstrip all of the other processes in copper production (Streicher-Porte & Althaus, 2010).

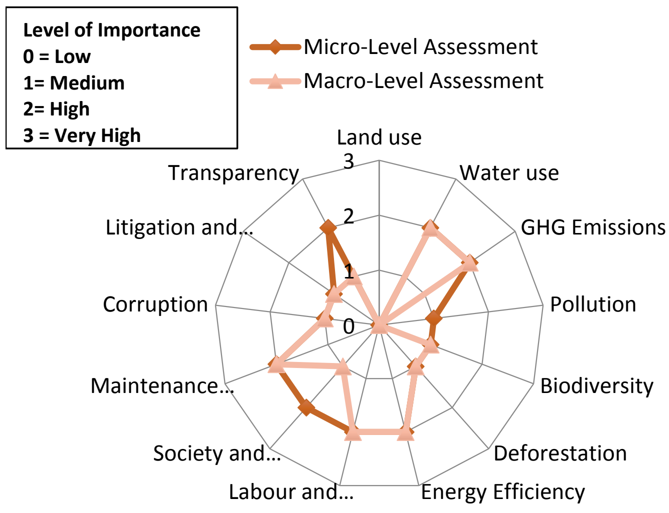


FIGURE 6. SUSTAINABILITY ISSUES INDICATORS

Wastes and tailings from copper mining cause the contamination of the soil surrounding a copper mine or smelter is a major concern in copper production (Dudka & Adriano, 1997). This pollution usually occurs via acid mine drainage (AMD), which is caused when metal sulfides in the underground ore are exposed to the natural elements. The sulfides are oxidized and the products released are sulfuric acid and free heavy metals which contaminate the surrounding areas. AMD's negative impact on the environment often results in the inability to sustain life in badly affected areas. Copper production can dramatically affect biodiversity in the surrounding area, and a recent proposed copper mine in a national park in Zambia was rejected for this reason (Mutterback, 2013).

Greenhouse gas emissions are one of the most prominent areas of concern with respect to the environmental impacts of copper production. These emissions are primarily driven by energy consumption in the industry which accounts for four fifths of its emissions (Metals Mining, n.d.). This itself is driven by the global prevalence of large-scale low-grade open pit mines, since grinding low-grade ores is a more energy-intensive activity than simply moving high-grade ore. In 2007 it was estimated that each tonne of global copper production required 35.7 gigajoule of energy, and resulted in 2.45 tonnes of carbon dioxide emissions (Metals Mining, n.d.). Figure 7 provides an estimate of the carbon emissions associated with Chile's production of copper. In the year 2000, copper production in Chile accounted for 12 per cent of the country's carbon emissions (Farias, 2008). In Chile as elsewhere, the carbon emissions associated with production will depend on the energy mix used for copper production. Energy efficiency is therefore a primary concern for the industry going forward.

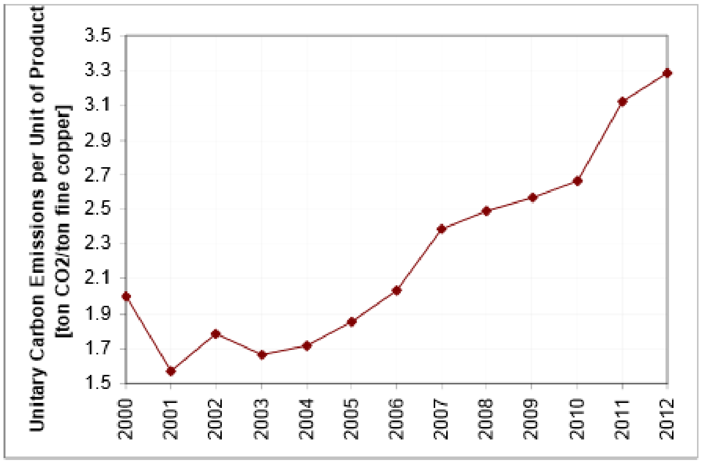


FIGURE 7. CARBON EMISSIONS ASSOCIATED WITH COPPER PRODUCTION IN CHILE.

Source: Farias, 2008

Impacts on water are also notable. All aspects of copper production—from mining and leaching to milling, smelting, and refining—have potential impacts on surface and groundwater quality. Adverse water quality impacts are caused primarily by land disposal practices that fail to contain wastes, by run-on and run-off controls that are inadequate to prevent surface water from flowing through impoundments, or by groundwater infiltrating surface impoundments. In addition, the large-scale land disturbances associated with open-pit mining may disrupt the natural flow of surface and groundwater, and may lower the water table in the mine area (U.S. Congress, Office of Technology Assessment, 1998).

In terms of social impacts and social license to operate, copper production can be controversial. Workers' rights, impacts on indigenous lands, issues of benefit sharing, the potential for environmental degradation, corruption, regulatory compliance and transparency are all significant factors affecting a mine's social license to operate. These forces are already prevalent, leading to response from the mining industry, such as Rio Tinto's biodiversity strategy (Rio Tinto, n.d.), and are expected to increasingly come into play, affecting the viability of copper production. They have been the primary drivers of the industry's increased level of sustainability reporting and the almost universal adoption of standardized Global Reporting Indicators (Science Alert, 2013; Metals Mining, n.d.).Impacts on human health can also be substantial. Some copper smelting processes emit large quantities of particulate matter, trace elements, and sulfur oxides. Sulfur dioxide (SO2) and the sulfates and sulfuric acid aerosols it forms in the atmosphere can be particularly dangerous since they act as lung irritants and can aggravate asthma. Fugitive emissions from furnaces and converters can cause health problems in the work place or result in elevated levels of toxic pollutants such as lead and arsenic in the immediate vicinity of the smelter. Generally, employees are exposed to the highest concentrations of toxic elements because they work in enclosed areas (Wilson & Pyatt, 2007).

2.4 Country Environment – Medium Micro and Medium Macro

The two greatest foreign country supply hazards in the copper sector facing the national level in China are resource nationalism and natural disasters and negative environmental events. Resource nationalism in the main supplier countries of Peru, Chile and Australia has been assessed in Maplecroft's Resource Nationalism Index, which looks at factors such as risk of outright nationalization and expropriation, export freezes or restrictions, and increases in taxes on revenues, as being at a medium risk level. The fact that resource nationalism is a significant risk across all of China's main suppliers indicates that the overall risk level is significant. The risk of natural disasters and negative environmental events are pronounced in Peru and Chile, two major suppliers. In Peru this is more driven by the country's vulnerability with respect to coping and adaptive capacity, while in Chile it relates more to the degree of exposure to such events and conditions occurring. The fact that the country has a diverse supply mix in that it also imports significant quantities of copper from Mongolia, United States and Mexico in addition to its main suppliers of Peru, Chile and Australia, helps reduce its vulnerability since its supply is relatively diversified. However, copper is such a critical commodity to the Chinese economy that the importance of the strongest supply-side risks should not be minimized simply because its vulnerability may not be as high as it is for some other commodities. Greater recycling of copper is a possibility, but Chinese demand for copper is expected to continue to grow and therefore supplies need to be secured regardless of the degree of recycling. The low level of national vulnerability would likely not be sufficient to offset the impact of a supply shock given the criticality of the commodity to the country.

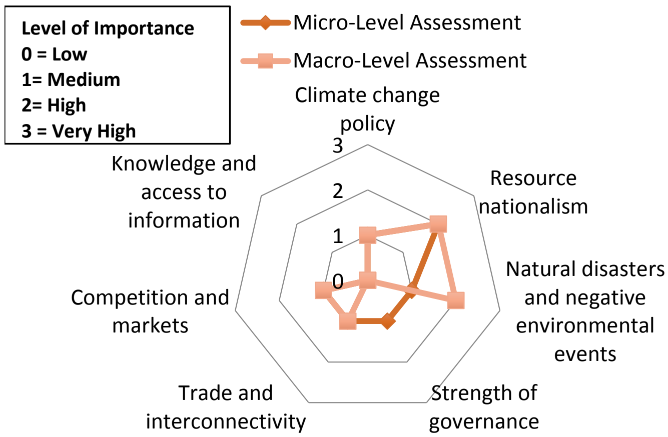


FIGURE 8. COUNTRY ENVIRONMENT INDICATORS

3.0 Implications

TABLE 2. COPPER NEXUS ASSESSMENT

	Supply chain risks									
	Price rise and volatility/ affordability risk			Supply disruption/ accessibility risk				Reputation/ acceptability risk		
Production associated with:	Resource pressure	Compliance costs	Environmental pricing	Local protests	Contract risk	Accidents, disasters	Export bans	Public concern at home	Consumer concern	International standards
Large areas of land use	Low (0)					Low (0)	Low (0)			
Water use in areas of water shortage	High (2)	High (2)	High (2)	High (2)		High (2)				
High levels of GHG emissions		High (2)	High (2)					High (2)	High (2)	High (2)
High levels of local pollution		Medium (1)	Medium (1)	Medium (1)		Medium (1)		Medium (1)	Medium (1)	Medium (1)
Deforestation	Medium (1)	Medium (1)		Medium (1)			Medium (1)	Medium (1)	Medium (1)	Medium (1)
Impacts on biodiversity		Medium (1)		Medium (1)			Medium (1)	Medium (1)	Medium (1)	Medium (1)
High energy use	High (2)					High (2)				
Labour and human rights abuse		High (2)		High (2)		High (2)		High (2)	High (2)	High (2)
Tensions with local communities	High (2)			High (2)				High (2)	High (2)	High (2)
Maintenance and security risks		High (2)				High (2)		High (2)	High (2)	High (2)
Corruption				Medium (1)	Medium (1)			Medium (1)	Medium (1)	Medium (1)
Litigation and compliance risks		Medium (1)								
Concerns over lack of transparency					High (2)			High (2)	High (2)	High (2)

Level of importance: Very High (3) High (2) Medium (1) Low (0)

This analysis highlights the high levels of vulnerability of China's economy, and of enterprises in key sectors to disruption to the supply of copper. While copper is a relatively homogenous commodity, and individual firms enjoy the possibility of shifting sourcing from one supplier nation to another, at the national level disruption to any of the major suppliers would likely have significant impacts. Furthermore, resource nationalism may increase across more than one country, leaving enterprises exposed to critical impacts.

The copper industry involves significant environmental, social and governance issues through its intensive use of energy, impacts on the environment and biodiversity, health and safety issues and tensions with societies and communities. As an industrial commodity product there is low consumer or public concern in the user country, however poor environmental, social and governance performance can result in significant risks in producer countries, leading to protests and social unrests on mining sites, and to the risk of government action which can adversely impact on supply; such as through refusal of mining permits, or uncertainty over taxation leading to lower investment.

While the scoring methodology focused on country risks related to the three largest producers (Chile, Australia and Peru) and found moderate levels of risk of resource nationalism, country risk is likely to be greater in newer sources of supply, such as Zambia and Mongolia, where Chinese companies are also established at the producer end, but where national frameworks for environmental and social regulation and resource revenue management are subject to significant political risk. For example, there is political and public concern that In Zambia concern that growing copper mining industry is not contributing sufficiently to national development, as well as safety and corruption concerns has contributed to resource nationalism. Companies are coming under greater scrutiny for their tax and revenue payments, employment conditions and environmental standards, however many fear that this is taking place in a politicized environment rather than through the rule of law (Caulderwood, 2013).

Chinese copper buyers and manufacturers are vulnerable to these environmental, social and governance hazards. Water use, greenhouse gas emissions, energy efficiency, labour and human rights, society and communities, maintenance and safety and transparency all pose a high level of risk to both supply stability and brand and reputational capital, while pollution, biodiversity, deforestation, corruption and litigation and compliance risks all pose moderate levels of risk. Losses that could accrue to Chinese enterprises as a result of these hazards are significant. Hazards that are environmental and social in nature can impose efficiency and productivity constraints on important copper producers which may disrupt supply—such as poor social or environmental performance that leads to protests and social unrests on mining sites—while poor environmental, social and governance performance may cause supply constraints due to the source of supply not being compliant with the Chinese enterprise's standards of sustainability and responsibility.

Hazards like greenhouse gas emissions, energy efficiency, labour and human rights, maintenance and safety and corruption are, to some degree, systemic across the whole copper industry, and affect a cross-section of producers. Some of these hazards, despite being generalized and systemic, represent only a marginal prospective impact on security of supply in China because of a lack of normative pressure or clear linkage to productivity and efficiency of copper production on an industry-wide level, and thus represent a smaller loss exposure at the macro China level, even though these hazards might represent significant loss exposures at the enterprise level. These hazards include pollution, biodiversity, deforestation, societies and communities and transparency. Other hazards like greenhouse gas emissions, energy efficiency, labour and human rights and corruption pose a real risk of affecting productivity and efficiency of copper production on a global scale, and therefore China's security of supply because of significant current normative pressures and clear linkage between the reduction of these hazards and copper productivity and efficiency of production. Water use, biodiversity, society and communities, litigation and compliance and transparency hazards pose moderate levels of national loss exposure. As normative pressures change the practices of producers on an industry wide level towards practices that are more responsible and sustainable, the quantity and stability of supply is affected. Conversely, the promotion of sustainable and responsible approaches to copper production now can help ensure that a large portion of global copper output can remain acceptable, available, accessible and affordable, as norms continue to evolve.

References

Accenture. (2012). *Sustainable energy for all: Opportunities for the metals and mining industry. UN Global Compact.* Retrieved from http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Sustainable-Energy-All-Opportunities-Metals-Mining-Industry.pdf#zoom=50

Agencia Venezolana de Noticias. (2010, October 12). Piñera reconoce que los trabajadores necesitan protección. Retrieved from http://web.archive.org/web/20120307173837/http://www.avn.info.ve/node/2269

Alliance Development Works. (2012). *World Risk Report 2012 – Focus: Environmental degradation and disasters*. Retrieved from http://www.ehs.unu.edu/file/get/10487.pdf

APCO Worldwide. (2010, November). Market Analysis Report: China's Electronics Industry. Retrieved from http://www.export.gov.il/uploadfiles/03_2012/marketelectronics.pdf

Apoyo Consultoria. (2009). *Study of the Yanacocha Mine's Economic Impacts: Final Report*. Lima, Peru: Prepared for the International Financial Corporation.

Baete, P. (2009, December 2). Copper sector stands to double carbon dioxide emissions by 2020 - Chochilco. BN Americas. Retrieved from http://www.bnamericas.com/news/mining/Copper_sector_stands_to_double _carbon_dioxide_emissions_by_2020-Cochilco

Banister, J., & Cook, G. (2011). China's employment and compensation costs in manufacturing through 2008. *Monthly Labor Review* (March), 39-52. Retrieved from http://www.bls.gov/opub/mlr/2011/03/ art4full.pdf

BBC. (2011, November 3). China mines Zambia's 'unsafe' says Human Rights Watch. Retrieved from http://www.bbc.co.uk/news/world-africa-15569310

BGS Minerals UK. (2013.). World Mineral Statistics. British Geological Survey. Retrieved from http://www.bgs.ac.uk/mineralsuk/statistics/worldStatistics.html

Bloomberg (2011). China Copper Stocks at Record 1.9 Million Tons at End-2010. Bloomberg. Retrieved from http://www.businessweek.com/news/2011-10-13/china-copper-stocks-at-record-1-9-million-tons-at-end-2010.html.

British Geological Survey (2013). World mineral statistics data. British Geological Survey. Retrieved from http://www.bgs.ac.uk/mineralsuk/statistics/wms.cfc?method=searchWMS.

Burk, H., Marten, F., & Bals, C. (2013). *The Climate Change Performance Index Results 2014*. Bonn, Germany: Germanwatch and Climate Action Network Retrieved from https://germanwatch.org/en/download/8599.pdf

Caulderwood, K. (2013, February 6). Chinese Copper Mining Operations Halted by Zambia's Environmental Agency. International Business Times. Retrieved from http://www.ibtimes.com/chinese-copper-mining-operations-halted-zambias-environmental-agency-1501396

Clark, A.L. and Clark, J.C. (1999). The new reality of mineral development: social and cultural issues in Asia and Pacific nations. Resources Policy, 25(3), 189-196.

Dudka, S. & Adriano, D.C. (1997). Environmental Impacts of Metal Ore Mining and Processing: A Review. *Journal of Environmental Quality, 26*(3), 590-602.

Edelstein, D.L. (2013, January). Copper. In U.S. Geological Survey, Mineral Commodity Summaries. (pp. 48-49). Retrieved from: http://minerals.usgs.gov/minerals/pubs/commodity/copper/mcs-2013-coppe.pdf

Farias, P. (2008). *Electric demand of the copper mining industry and reduction costs for carbon emissions in the SING*. (Unpublished thesis). Pontifical Catholic University of Chile, Santiago, Chile. Retrieved from http://web.ing.puc.cl/~power/paperspdf/Farias.pdf

Farrell, M.J. (2009, April). Carbon emissions from base metal mine sites. Mining Engineering, 28-32. Retrieved from http://www.minecost.com/Carbon_Emissions_ME.pdf

Global Environmental Institute. (2013). *Environmental and Social Challenges of China's Going Global*. China Environment Press. Beijing.

Global Witness. (n.d.). Oil, gas and mining. Global witness. Retrieved from http://www.globalwitness.org/campaigns/corruption/oil-gas-and-mining

Govan, F., Laing, A. & Allen, N. (2010, August 26). Families of trapped Chilean miners sue mining firm. The *Telegraph*. Retrieved from http://www.telegraph.co.uk/news/worldnews/southamerica/chile/7966590/Families-of-trapped-Chilean-miners-to-sue-mining-firm.html

Human Rights Watch. (2011). *"You'll be fired if you refuse": Labor abuses in Zambia's Chinese state-owned copper mines*. New York: Human Rights Watch. Retrieved from http://www.hrw.org/reports/2011/11/04/you-ll-be-fired-if-you-refuse

ICMM. (2010). *Mining and Biodiversity A collection of case studies – 2010 edition*. London: International Council on Mining and Metals. Retrieved from http://www.icmm.com/biodiversity-case-studies

ICMM. (2012). *Water Management in Mining: A selection of case studies*. London: International Council on Mining and Metals. Retrieved from http://www.icmm.com/www.icmm.com/water-case-studies

ICMM. (2013). *Community health programs in the mining and metals industry*. London: International Council on Mining and Metals. Retrieved from http://www.icmm.com/publications/community-health-programs-in-the-mining-and-metals-industry

ICMM. (n.d.) L*eadership matters: Managing fatal risk guidance*. London: International Council on Mining and Metals. Retrieved from https://www.icmm.com/page/37127/leadership-matters-managing-fatal-risk-guidance

ICMM. (n.d.) *Leadership matters: The elimination of fatalities*. London: International Council on Mining and Metals. Retrieved from https://icmm.com/page/12629/

IndexMundi (2013). Copper and articles thereof Imports by Country in US Dollars. Retrieved from http://www.indexmundi.com/trade/imports/?chapter=74.

International Chamber of Commerce. (2013). *Open Markets Index.* Retrieved from http://www.iccwbo.org/Global-influence/G20/Reports-and-Products/Open-Markets-Index/

International Copper Study Group. (2013). *The World Copper Factbook 2013*. Lisbon: ICSG. Retrieved from http://www.icsg.org/index.php/component/jdownloads/finish/170/1188

IISD. (2010). *Sustainable Development and the Global Copper Supply Chain: International research team report*. Winnipeg, MB: International Institute for Sustainable Development. Retrieved from http://www.iadb.org/intal/intalcdi/pe/2011/08523.pdf

IISD. (2011). *Sustainable Development of the Chinese Copper Market*. Winnipeg, MB: International Institute for Sustainable Development. Retrieved from http://www.iisd.org/pdf/2011/sustainable_development_chinese_copper.pdf

Long, G. (2010, October 5). How safe are Chile's copper mines? BBC News. Retrieved from http://www.bbc.co.uk/news/world-latin-america-11467279

MacLean, H. L., Duchin, F., Hagelüken, C., Halada, K., Kesler, S. E., Moriguchi, Y., et al. (2010). Stock, flows and prospects of mineral resources. In T. E. Graedel, & E. van der Voet, (eds.) *Linkages of sustainability*. Cambridge: MIT Press.

Maplecroft. (2012). Resource Nationalism Index 2012. Maplecroft. Retrieved form http://maplecroft.com/about/news/resource_nationalism_index_2012.html

Minerals Council of Australia. (2010, March). The Australian Minerals Industry and the Australian Economy. Minerals Council of Australia.

Miningfacts.org. (2012). What is the social licence to operate(SLO)? Fraser Institute. Retrieved from http://www.miningfacts.org/Communities/What-is-the-social-licence-to-operate/

Moriguchi, Y. (2010). Mineral resources: quantitative and qualitative aspects of sustainability. In Graedel, T. E & van der Voe, T. E. (eds.) Linkages of sustainability. Cambridge: MIT Press.

Mudd, G.M., Weng, Z., Memary, R., Northey, S. A., Giurco, D., Mohr, S., & Mason, L. (2012). Future greenhouse gas emissions from copper mining: assessing clean energy scenarios. Prepared for CSIRO Minerals Down Under Flagship by Monash University and Institute for Sustainable Futures, UTS.

Mutterback, C. (2013). Environment ministry drops copper mine in Zambezi park. Mongabay.com. Retrieved from http://news.mongabay.com/2013/0107-mutterback-lower-zambezi.html

Radio Australia. (2013, October 31). Pacific disappointed with Australia's shift in climate change policy. Radio Australia. Retrieved from http://www.radioaustralia.net.au/international/radio/program/pacific-beat/pacific-disappointed-with-australias-shift-in-climate-change-policy/1212510

Pandey, P.K., Sharma, R. & Pandey, M. (2007). Toxic mine drainage from Asia's biggest copper mine at Malanjkhand, India. *Environ Geochem Health, 29*, 237-248.

Potts, J., Shang, F., Zhao, B., Duan, S., Zhou, Z., Streicher-Porte, M., & Atherton, J. (2011). Policy recommendations for a sustainable copper supply chain: a Chinese perspective. Winnipeg, MB: International Institute for Sustainable Development. Retrieved from http://www.iisd.org/pdf/2011/policy_recommendations_china_copper_en.pdf

Rio Tinto. (2008). *Rio Tinto and biodiversity: Achieving results on the ground*. Rio Tinto. Retrieved from http://www.riotinto.com/documents/ReportsPublications/RTBidoversitystrategyfinal.pdf

Salazar, M. (2010, November 20). Peru's highlands lack legal protection. Tierramérica.

Science Alert. (2013). The future of copper production. Science Alert. Available at http://www.sciencealert.com.au/news/20130407-24545.html

Shang, F., Zhao, B., Duan, S., & Zhou, Z. (2011). *Sustainable development of the Chinese copper market*. Winnipeg, MB: International Institute for Sustainable Development. Retrieved from http://www.iisd.org/pdf/2011/sustainable_development_chinese_copper.pdf

Smith, D. (2011, November 3). Chinese mining firms in Zambia under fire for mistreating workers. The *Guardian*. Retrieved from http://www.theguardian.com/global-development/2011/nov/03/chinese-mining-zambia-mistreating-workers

Streicher-Porte, M., & Althaus, H-J. (2010). *China and global markets: copper supply chain sustainable development: a life cycle assessment study*. Winnipeg, MB: International Institute for Sustainable Development. Retrieved from http://www.iisd.org/pdf/2011/china_copper_supply.pdf

Tharoor, I. (2011, November 4). Human Rights Watch reports abuses in Chinese-run mines in Zambia. *Time*. Retrieved from http://world.time.com/2011/11/04/human-rights-watch-reports-abuses-in-chinese-run-mines-in-zambia/

U.S. Congress, Office of Technology Assessment. (1988, September). *Copper: Technology and Competitiveness*, OTA-E-367. Washington, DC: U.S. Government Printing Office. Retrieved from http://www.princeton.edu/~ota/disk2/1988/8808/880810.PDF

United Nations Statistics Division of the Department of Economic and Social Affairs (UNSD/DESA) (2013). UN Comtrade. Retrieved from: http://comtrade.un.org/db/.

United States Geological Survey (2013) Copper Statistics and Information. United States Geological Survery http://minerals.usgs.gov/minerals/pubs/commodity/copper/.

USEPA. (1995, September). *Profile of The Nonferrous Metals Industry*. EPA. Retrieved from http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/nfmetlsn.pdf

Wilson, B., Pyatt, F.B. (2007). Heavy Metal Dispersion, Persistence and Bioaccumulation Around An Ancient Copper Mine Situated In Anglesey, UK. *Ecotoxicology and Environmental Safety, 66*, 224-231

World Bank. (2013a). Worldwide Governance Indicators. World Bank. Retrieved from http://info.worldbank.org/governance/wgi/index.asp

World Bank. (2013b). Global Economic Prospects Commodity Market Outlook. The World Bank's Development Prospects Group. World Bank Retrieved from: http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1304428586133/Commodities2013A_FullReport.pdf

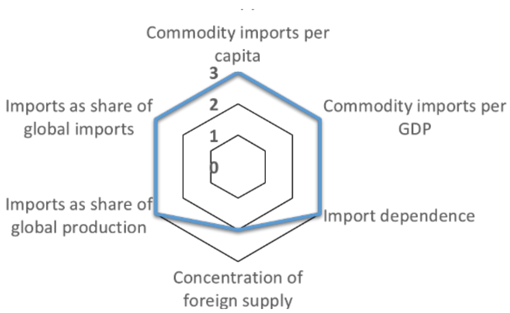
World Economic Forum. (2013). *The Global Competitiveness Report 2013–2014*. World Economic Forum. Retrieved from http://reports.weforum.org/the-global-competitiveness-report-2013-2014/#=WWF

Global. (n.d.). Amazon mining: Extracting valuable minerals and a Pandora's Box of problems.

WWF Global. Retrieved from http://wwf.panda.org/what_we_do/where_we_work/amazon/problems/other_threats/amazon_mining/

Appendix 1: Summary of analysis

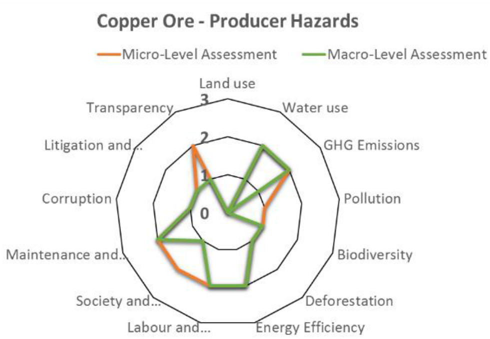
China Copper Supply Vulnerability and Economic Importance



China Security of Supply -- Copper	
Copper production – mine production (MT, 2010, BGS)	1,179,500
Copper production – smelter production (MT, 2010, BGS)	2,825,600
Copper production – refiner production (MT, 2010, BGS)	4,540,300
Copper production – total (MT, 2010, BGS)	8,545,400
China exports – matte & cement (MT, 2010, BGS)	0
China exports – ores & concentrates (MT, 2010, BGS)	187
China exports – scrap (MT, 2010, BGS)	2,264
China exports – unwrought alloys (MT, 2010, BGS)	302
China exports – unwrought, refined (MT, 2010, BGS)	38,730
China exports – unwrought, unrefined (MT, 2010, BGS)	506
China exports – total (MT, 2010, BGS)	41,989
China imports – matte & cement (MT, 2010, BGS)	132,796
China imports – ores & concentrates (MT, 2010, BGS)	6,144,396
China imports – scrap (MT, 2010, BGS)	3,998,018
China imports – unwrought alloys (MT, 2010, BGS)	53,016
China imports – unwrought, refined (MT, 2010, BGS)	3,184,961
China imports – unwrought, unrefined (MT, 2010, BGS)	228,279
China imports – total (MT, 2010, BGS)	13,741,466
Value of China copper imports ($USD, 2010, Index Mundi/ Comtrade)	46,124,156,424
Net commodity imports (MT, 2010, BGS)	13,699,477
Ratio of domestic annual mine copper production to reserves (MT, 2010, BGS)	4%
Five year increase in domestic annual mine production of copper (2006-2011), BGS)	46%
Import dependency ratio (2010)	68%
Copper stockpiles (MT, 2010)	1,900,000
Ratio of total commodity import as share of global production (2010)	28%
Ratio of total commodity import as share of global imports (2010)	
Ratio of value of commodity imports to GDP (2010)	0.84%
Ratio of commodity imports per capita (MT, 2010)	0.010
Ratio of value of commodity imports per capita ($USD, 2010)	34.42
Volume of copper in reserves (MT, 2012, USGS)	30,000,000
Percentage of imports coming from weak governance zones (Countries with Transparency International 2012 corruption index below 30: Top 3 – Russia, Pakistan, Venezuela)	1%
Percentage of imports coming from the three largest supplier countries	45%

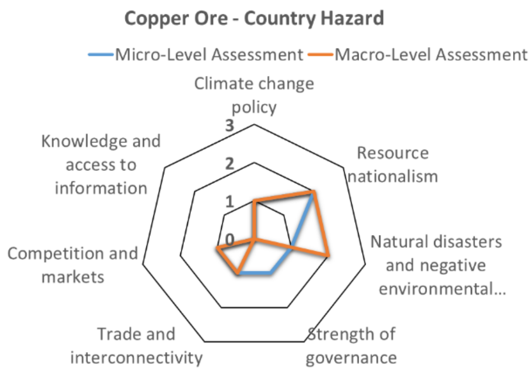
	Economic Importance		**Vulnerability**			
Aggregate Domestic National Vulnerability and Economic Importance Score	**Commodity imports per capita**	**Commodity imports per GDP**	**Import dependence**	**Concentration of foreign supply**	**Imports as share of global production**	**Imports as share of global imports**
Very High (3)	Very High (3)	Very High (3)	Very High (3)	High (2)	Very High (3)	Very High (3)

Copper Producer Sustainability Issues Assessment



<table>
<tr><th></th><th colspan="2">Fixed analysis</th><th colspan="3">Micro-level assessment</th><th colspan="3">Macro-level assessment</th></tr>
<tr><th></th><th>Relevance to the sector</th><th>Share of supply</th><th>Hazard loss exposure</th><th>Prospective Impact</th><th>Likelihood</th><th>Hazard loss exposure</th><th>Prospective Impact</th><th>Likelihood</th></tr>
<tr><td rowspan="2">Aggregate Producer Supply Hazards Score</td><td></td><td></td><td>Medium (1)</td><td></td><td></td><td>Medium (1)</td><td></td><td></td></tr>
<tr><td colspan="8">• Energy efficiency, greenhouse gas emissions, biodiversity, labour and human rights, society and community, maintenance and safety, and transparency are the highest-ranking hazards.</td></tr>
<tr><td rowspan="2">Land use</td><td>Low (0)</td><td>Low (0)</td><td>Low (0)</td><td>Medium (1)</td><td>Low (0)</td><td>Low (0)</td><td>Low (0)</td><td>Low (0)</td></tr>
<tr><td colspan="8">• Land use, in terms of the land area being used for copper mining, is typically small relative to agriculture. In Australia, for example, mining sites disturb approximately 0.25 per cent of landmass (Minerals Council, 2010). In Peru, 12 per cent of total land is under mining concessions, but only 0.08 per cent of total land area is being mined (Salazar, 2010).
• The likelihood of impact of land use from copper mining on Chinese enterprises is minimal at present, but can become a problem in the future with the continued expansion of copper mining in key countries like Peru and Chile.
• Land rights, however, can be a significant concern (covered under Human Rights and Community and Society hazards).</td></tr>
<tr><td rowspan="2">Water use</td><td>High (2)</td><td>Medium (1)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Water use by copper mining companies can lead to conflicts with agricultural users, relating to the total amount of water being used and changes in the quality of the water, especially in areas that are already water stressed.
• Lack of water availability can decrease mining productivity and/or increase costs (ICMM, 2012). Water is required in hydrometallurgical processes (to retrieve copper from a solution of chemicals) and pyrometallurgical processes (for cooling and other parts of mineral processing).</td></tr>
<tr><td rowspan="2">GHG emissions</td><td>Very High (3)</td><td>High (2)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• In Chile, it is estimated that expanding copper production 37 per cent between 2009 and 2020 will double annual greenhouse gas emissions from 18 million to 36 million MT (Baete, 2009). In Australia, it is estimated that 15 MT of carbon emissions are produced for every metric tonne of copper (Mudd et al., 2012).
• The greenhouse gas intensity of copper can become a supply hazard to Chinese enterprises if these environmental costs are reflected in the price of copper, or by brand and reputational effects from public concerns.</td></tr>
<tr><td rowspan="2">Pollution</td><td>Medium (1)</td><td>High (2)</td><td>Medium (1)</td><td>Medium (1)</td><td>Low (0)</td><td>Low (0)</td><td>Low (0)</td><td>Low (0)</td></tr>
<tr><td colspan="8">• Water pollution from copper mining operations is a significant concern, and occurs when there is the dissolution and transportation of metals and heavy metals by runoff and groundwater if proper protective measures are not taken (USEPA, 1995).
• Some chemicals like arsenic, sulphuric acid and mercury can also accumulate in unusually high concentrations due to copper production.</td></tr>
<tr><td rowspan="2">Biodiversity</td><td>High (2)</td><td>Medium (1)</td><td>Medium (1)</td><td>High (2)</td><td>Low (0)</td><td>Medium (1)</td><td>Medium (1)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Many copper deposits are located in ecologically sensitive areas, including the location of many mining sites in Peru, Madagascar and Indonesia (ICMM, 2010). Mining companies need to be very strategic when deciding whether and how to exploit areas that are rich in biodiversity (Rio Tinto, 2008). Any severe demarcation from local and global expectations of appropriate mining behaviour could severely damage their social license to operate, leading to a reduction in its opportunity set and increased costs (Miningfacts, 2012).</td></tr>
<tr><td rowspan="2">Deforestation</td><td>Medium (1)</td><td>Low (0)</td><td>Medium (1)</td><td>High (2)</td><td>Low (0)</td><td>Medium (1)</td><td>Medium (1)</td><td>Low (0)</td></tr>
<tr><td colspan="8">• Although mining does not cause deforestation on the same scale as logging and agriculture, it can be a significant concern at a select number of sites. In Brazil's Carajas Mineral Province, which may be the world's largest copper reserves, wood is being cut for charcoal to fuel pig iron plants, resulting in annual deforestation of 6,100 square kilometres (WWF Global, n.d.a).</td></tr>
<tr><td rowspan="2">Energy Efficiency</td><td>Very High (3)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td><td>Very High (3)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• The energy used to produce metals is expected to approach 40 per cent of global energy supply by 2050, and copper will be an important part of this energy consumption (MacLean, et al., 2010).
• Currently, energy costs can represent 15 per cent of a mining companies' cost of production, while they represent 20–40 per cent of production costs in the metals industry (Accenture, 2012).</td></tr>
<tr><td rowspan="2">Labour and Human Rights</td><td>High (2)</td><td>Medium (1)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Some mining sites have been accused of using child labour and denying workers' right to organize. In a 122-page report by Human Rights Watch, Chining copper mining companies in Zambia are accused of significant human rights abuses (Human Rights Watch, 2011). These claimed abuses were covered across various media outlets including the BBC (2011), the Guardian (Smith, 2011) and TIME Magazine (Tharoor, 2011).</td></tr>
<tr><td rowspan="2">Society and Communities</td><td>High (2)</td><td>High (2)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td><td>Medium (1)</td><td>Medium (1)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Various competing claims over land use and land rights can lead to conflicts when mining companies displace agriculture, livestock farming or other traditional land users (Apoyo Consultoria, 2009). These conflicts can lead to damages to equipment, and disruptions to operations.
• Community consultation and early engagement can help establish good relationships between government, mining companies and local communities (ICMM, 2013). Such an approach is especially important in countries with a history of colonialism, or where there is already a distrust of government or other groups in society. If local communities perceive that projects have been imposed on them without sufficient consultation, there may be significant opposition to mining operations (Clark & Clark, 1999).</td></tr>
<tr><td rowspan="2">Maintenance and Safety</td><td>Very High (3)</td><td>Medium (1)</td><td>High (2)</td><td>Very High (3)</td><td>Medium (1)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Maintenance and safety is especially important for the mining sector. Mining accidents, although they rarely occur, are high impact events with significant human, productivity and financial consequences. Mining collapse, explosions and machinery accidents are significant causes of fatalities and operation disruptions. Corporate leadership is necessary to help minimize these risks (ICMM, n.d.a; ICMM n.d.b).
• In Chile, an average of 34 people have died annually in mining accidents since 2000, with a high of 43 fatalities in 2008 (Long, 2010). The 2010 Copiago mining accident that trapped 33 gold-copper miners underground for 69 days was allegedly the result of managerial negligence (Govan, Laing & Allen, 2010) and the mine is now considering bankruptcy and has remained closed in the aftermath of this incident (Agencia Venezolana de Noticias, 2010).</td></tr>
<tr><td rowspan="2">Corruption</td><td>High (2)</td><td>Medium (1)</td><td>Medium (1)</td><td>High (2)</td><td>Low (0)</td><td>Medium (1)</td><td>High (2)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Processes for awarding mining rights to companies are often mired in corruption. As a result, many mineral rich countries are stuck in poverty because public revenues that would have otherwise been gained from selling these resources are squandered through corrupt practices or lack of government accountability (Global Witness, n.d.).
• When corrupt practices are uncovered, these can reduce the producer's ability to access new projects, and can result in class action suits that reduce its financial return to investors.</td></tr>
<tr><td rowspan="2">Litigation and Compliance Risks</td><td>High (2)</td><td>Low (0)</td><td>Medium (1)</td><td>High (2)</td><td>Medium (1)</td><td>Medium (1)</td><td>Medium (1)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Mining companies often operate in areas with lax regulations or enforcement. However, litigation risks from negative environmental practices, human rights violations and corruption are still a concern.
• Due to the strong salience of environmental practices, human rights and corruption to the mining sector, litigation and compliance risks are significant.</td></tr>
<tr><td rowspan="2">Transparency</td><td>Very High (3)</td><td>High (2)</td><td>High (2)</td><td>Medium (1)</td><td>Medium (1)</td><td>Medium (1)</td><td>Low (0)</td><td>Medium (1)</td></tr>
<tr><td colspan="8">• Corporate transparency is associated with responsible business activities. The companies that are more transparent also tend to be more responsible. Therefore, transparency mitigates litigation and compliance risks as well as various irresponsible, unsustainable and illegal practices.</td></tr>
</table>

Copper Country Environment Assessment



	Fixed analysis		Micro-level assessment			Macro-level assessment		
	Relevance to the sector	Share of supply	Hazard loss exposure	Prospective Impact	Likelihood	Hazard loss exposure	Prospective Impact	Likelihood
Aggregate Producer Supply Hazards Score			**Medium (1)**			**Medium (1)**		
	• Both at the micro and macro levels, the aggregate hazard loss exposure is assessed to be medium. The risks of resource nationalism and natural disasters and environmental degradation are most relevant at both levels. Enterprise level risks are believed to be marginally smaller because of the possibility of substituting one supplier country for another, a luxury not enjoyed at the national level.							
Climate change policy	Medium (1)	Low (0)	**Medium (1)**	Medium (1)	Low (0)	**Medium (1)**	Medium (1)	Low (0)
	• Australia's recent decision to abolish its carbon tax has made it seem relatively less progressive on climate policy; the decision has been unpopular, and regional partners have taken notice (Radio Australia, 2013). Further, Germanwatch and the Climate Action Network's Climate Change Performance Index (CCPI) rates the country's emissions profile development, renewable energy policy, energy efficiency and especially its emissions level as poor (Germanwatch, 2013). • This hazard is pronounced only for Australia (Chile and Peru's climate policies are rated more favourably), and with copper production being less associated with carbon emissions than other more carbon intensive sectors such as energy production, the loss exposure is believed to be low (at present) at both macro and micro levels.							
Resource nationalism	Very high (3)	Very high (3)	**High (2)**	Medium (1)	Medium (1)	**High (2)**	High (2)	Medium (1)
	• Maplecroft's Resource Nationalism Index (RNI) investigates factors such as risk of outright nationalization and expropriation, export freezes or restrictions, and increases in taxes on revenues and places the risk associated with resource nationalism at medium for Chile, Peru and Australia, noting Australia's Mineral Resources Rent Tax (Maplecroft, 2012). • Supply restrictions associated with resource nationalism are more pronounced at the macro level, since the potential for using new suppliers is greater for individual firms; whereas at the country level substitution is more difficult.							
Natural disasters and negative environmental events	Medium (1)	High (2)	**Medium (1)**	Low (0)	High (2)	**High (2)**	Medium (1)	High (2)
	• Chile is assessed to be highly risk exposed with respect to natural disasters and environmental degradation because of its high degree of exposure; however, this is counter-balanced with a relatively low vulnerability with respect to coping and adaptive capacities. Peru is assessed as having a medium degree of risk on the same scale; less exposed than Chile, but more vulnerable (Alliance Development, 2012). • Natural disasters and environmental factors would affect supply lines and infrastructure but wouldn't affect production as directly as, for example, agricultural commodities.							
Strength of governance	Medium (1)	Low (0)	**Medium (1)**	Medium (1)	Low (0)	**Low (0)**	Low (0)	Low (0)
	• Peru presents governance-associated risks, particularly with respect to political stability, government effectiveness, rule of law, and corruption (World Bank, 2013). • The risk associated with sourcing copper from nations with poor governance records is more strongly impacted by high-profile events such as human rights abuses, which are less likely for Peru since the country scores relatively well on voice and accountability dimensions of governance.							
Trade and interconnectivity	Very high (3)	Low (0)	**Medium (1)**	High (2)	Low (0)	**Medium (1)**	High (2)	Low (0)
	• All main supplier nations were found in the International Chamber of Commerce's Open Markets Index (2013) were found to have average levels of trade openness, and scored favourably with respect to their trade policy and trade-enabling.							
Competition and markets	Medium (1)	Low (0)	**Medium (1)**	Medium (1)	Low (0)	**Medium (1)**	Medium (1)	Low (0)
	• All main supplier nations are found to be stable or favourable with respect to their competeiveness. Australia is regarded as having efficient, competitive markets; Chile has well-functioning markets with high levels of domestic competition; and Peru, although facing challenges with respect to innovation and skills gaps, has been moving steadily up the index rankings in recent years (World Economic Forum).							
Knowledge and access to information	Low (0)	Low (0)	**Low (0)**	Low (0)	Low (0)	**Low (0)**	Low (0)	Low (0)
	• All three main supplier countries are relatively well developed, with strong Internet penetration and intergration into global institutions and networks. Access to information is not believed to be an issue. • Although Peru has challenges with respect to its education sector, its mining sector is well developed and is able to attract the human capital it requires.							

Appendix 2: Copper economic actors

State-owned enterprises and foreign investment enterprises are the leading importers of copper ore. Between 2007 and 2011, imports of state-owned enterprises represented 41–56 per cent of total, while foreign investment enterprises represented 33–47 per cent and the share of private enterprise imports rose from 11 per cent to 23 per cent (Global Environmental Institute, 2013).

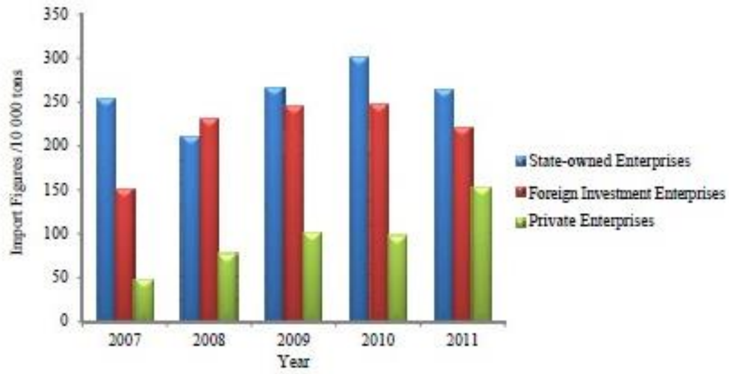


FIGURE 9. IMPORTS OF COPPER ORE BY ENTERPRISE TYPE

Source: Global Environmental Institute (2013)

The top 10 largest importers of copper ore represented 70–80 per cent of total imports between 2007 and 2011, indicating a highly concentrated market (Global Environmental Institute, 2013) .

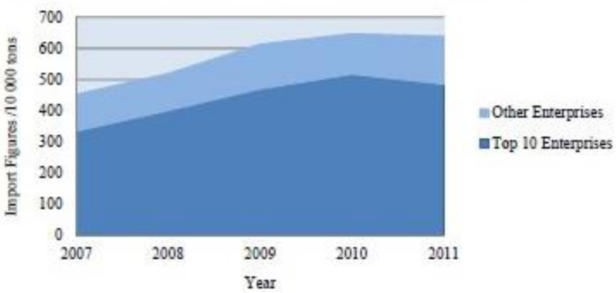


FIGURE 10. COPPER ORE IMPORT VOLUMES OF TOP TEN IMPORTING ENTERPRISES, 2007-2011.

Source: Global Environmental Institute (2013)

The top 15 copper smelters in China have a processing capacity of 2.6 million tonnes per year and represent over 90 per cent of China's total smelting capacity (Streicher-Porte and Althaus, 2010). These smelters are all equipped with modern environmental technology including emission coolers, fabric filters, hot electrostatic precipitators and cyclones (Streicher-Porte and Althaus, 2010). In addition, sulfuric acid plants recover sulfur dioxide emissions from the smelting and conversion process (Streicher-Porte and Althaus, 2010). However, some older smelters lack the wet or semi-dry scrubbers for the off gases (Streicher-Porte and Althaus, 2010). China has been relatively successful in phasing out reverberatory furnaces compared to the rest of the world, and both the composite smelter technology and the SKS processes used in China are considered "state of the art" (Streicher-Porte and Althaus, 2010). The top 15 smelters in China are the following:

- Baiyin (smelter)
- Daye/ Hubei
- Feishang
- Fuchunjiang
- Guixi (smelter)
- Huludao
- Jinchang (Tongling II)
- Jinchuan (smelter)
- Jinfeng
- Jinlong (Tongdu)
- Kangxi (Liangshan)
- Shandong Fengxiang (smelter)
- Yantai Penghui
- Yunnan Copper
- Zhongtiaoshan (Houma)

The top 15 copper refineries in China have a refining capacity around 4 million tonnes per year and represent approximately 80 per cent of total refining capacity in China. These refiners mainly apply startsheet refining with stainless steel cathodes, and are equipped with wet or semi-dry scrubbers to prevent acid mist emission (Streicher-Porte & Althaus, 2010). The top five refined copper producers (Jiangxi Copper Group Corporation, Tongling Nonferrous Metals Group Holdings Co., Ltd, Yunnan Copper Corporation, Jinchuan Nonferrous Metals Company, Daye Nonferrous Metals Company) alone represent 60 per cent of refined copper output (Shang, Zhao, Duan & Zhou, 2011). The top 15 refineries in China are the following:

The production of copper semis in China is more widely distributed and diversified than copper smelting and refining, and copper semis enterprises feature large amounts and a wide variety of locations across China, and most of them are private enterprises (Shang, Zhao, Duan $ Zhou, 2011). China produces approximately 8 million tonnes of semis annually, occupying 50 per cent of global production (Shang, Zhao, Duan & Zhou, 2011). The output of the top five copper fabricators represent 9.4 per cent of all copper fabricators in China (Shang, Zhao, Duan & Zhou, 2011).

- Baiyin
- Chifeng
- Daye/ Hubei (refinery)
- Fuchunjiang (refinery)
- Guixi
- Huludao (refinery)
- Jinchang (Tongling II) (refinery)
- Jinchuan
- Jinlong (Tongdu) (refinery)
- Jintian
- Shandong Fengxiang
- Yantai Penghui (refinery)
- Yunnan Copper
- Zhangjiagang
- Zhongtiaoshan (Houma) (refinery)

The production of copper semis in China is more widely distributed and diversified than copper smelting and refining, and copper semis enterprises feature large amounts and a wide variety of locations across China, and most of them are private enterprises (Shang, Zhao, Duan $ Zhou, 2011). China produces approximately 8 million tonnes of semis annually, occupying 50 per cent of global production (Shang, Zhao, Duan & Zhou, 2011). The output of the top five copper fabricators represent 9.4 per cent of all copper fabricators in China (Shang, Zhao, Duan & Zhou, 2011).

TABLE 3. TOP COPPER FABRICATORS

	Copper fabricator output (tonnes, 2008)
Ningbo Jintian Copper (Group) Co., Ltd	24,000
Golden Dragon Group Co., Ltd	21,000
China Hailiang Group Co., Ltd	14,700
Chalco Luoyang Copper Co., Ltd	10,400
Jiangxi Copper Group Corporation (Jiangxi Copper)*	43,900
Jiangxi Copper's copper wire rods*	-35,000
Top five companies: percentage of national total*	9.4%
Total of all Chinese companies	836,000

** Jiangxi Copper Group Corporation's production includes fabricators and wire rods; however, the top five companies' percentage of national total does not include Jiangxi Copper's wire rods production (which is why the wire rods' row appears as a subtraction).*
Source: Shang, Zhao, Duan and Zhou (2011)

The top consumers of copper are the electric power industry, electronics and communication technologies, machinery and equipment, transportation, and construction industries (Shang, Zhao, Duan & Zhou, 2011). The electric power industry accounts for 42 per cent of copper consumption, while the electronics and consumer goods industries each represent 15 per cent of consumption (Shang, Zhao, Duan & Zhou, 2011).

TABLE 4. REFINED COPPER CONSUMPTION BY SECTOR

	Copper consumption (kilotonnes, 2008)	Copper consumption share
Electric power	2,500	42%
Consumer goods	900	15%
Transportation	400	7%
Electronics	900	15%
Construction	200	3%
Machinery and equipment	600	10%
Others	500	8%

Source: Shang, Zhao, Duan and Zhou (2011)

Authoring Team

Jason Potts, International Lead

Jason Potts manages the Sustainable Markets and Responsible Trade (SMART) Program at the IISD. Prior to joining IISD, Mr. Potts worked with the Trade, Employment and Competitiveness Program at the International Development Research Centre, as well as the North American Commission for Environmental Cooperation's Trade and Environment Branch on issues at the nexus of trade, environment and international development.

potts.jason@gmail.com

Gabriel A. Huppé, Project Researcher

Gabriel Huppé works across the IISD with the Natural and Social Capital program, the Sustainable Finance program, the Trade and Investment program, and the Impact Network. His work focuses on governance and policy innovations, international food production and trade system, and the role of the private sector in sustainable development.

ghuppe@iisd.ca

Jason Dion, Project Researcher

Jason Dion's work at IISD focuses on Greenhouse Gas mitigation, environmental impact analysis, the green economy, and Nationally Appropriate Mitigation Actions (NAMAs). He is a graduate of York University focusing on ecological economics, and holds a certificate from Laval University's Partnership for Economic Policy (PEP) in development policy modeling using Computable General Equilibrium (CGE) economic models.

jdion@iisd.ca

Vivek Voora, Project Researcher

Vivek Voora works with the Natural and Social Capital Program, Trade and Investment Program and Water Innovation Centre at IISD. He works broadly on projects related to natural capital, ecosystem services, sustainable agriculture and water management as well as ecosystem markets, greening supply chains and sustainability standards.

vvoora@iisd.ca

Maya Forstater, Lead Writer

Maya Forstater is a researcher and writer with 15 years experience in the field of sustainable development and business, leading research with multilateral institutions, multi-sector collaborations, major corporations in the energy, ICT, apparel, mining and minerals and mobility sectors, and has written extensively on a range of issues related to sustainability and business.

maya@zadek.net

International Institute for Sustainable Development
Institut international du développement durable

Published by the International Institute for Sustainable Development.

International Institute for Sustainable Development
Head Office
161 Portage Avenue East, 6th Floor, Winnipeg, Manitoba, Canada R3B 0Y4
Tel: +1 (204) 958-7700 | Fax: +1 (204) 958-7710 | Website: www.iisd.org

www.iisd.org