FIGURES

page 5

1.1 Simplified view of the life of a mine

1.2	Productivity in the Australian and US mining industries 10		
	R&D expenditure in mining in Australia, 1993–2016 27		
	Worldwide mineral exploration expenditure (US \$ bn) by commodity,		
2.2	1994–2017 29		
2.3	Worldwide mining technologies, 1990–2015 29		
	Worldwide mining technologies as share of technologies,		
	1991–2015 31		
2.5	Patent families potentially related to mining by source 32		
2.6			
2.7	Mining technologies by subsectors, 1990–2015 34		
2.8	B Distribution of mining technologies in subsectors by period,		
	1990–2015 35		
2.9	Patents families in automation class over time 36		
2.10	Mining production and innovation by country, selected		
	countries 37		
2.11	Mining innovation by top country of origin 39		
2.12	Mining patents share by country, selected countries 40		
2.13	Mining relative specialization index (RSI), selected countries 41		
2.14	RSI by mining sub-sector, selected countries 43		
2.15	Number of mining patents families over the years by type of		
	stakeholder 45		
2.16	Mining Firms by technology, by earliest priority year 48		
2.17	Patent families of mining firms by WIPO technology field 48		
3.1	Ownership profile of (large) mining firms. Largest 100 mining companie		
based on operating revenues (distribution based on number of			
	firms) 54		
3.2	Recent trends in mining FDI 57		
3.3	Largest investors in mining FDI 59		
3.4	Development impact of mining FDI, multiple dimensions 61		
3.5	An analytical framework 65		
3.6	R&D expenditure of MNEs in UNCTAD top 100 ranking 68		

ii	LIST OF FIGURES		
3.7	The ownership profile of the top 100 applicants of mining patents Number of applications in the period 1990–2015, share to total 70		
3.8	Internationalization of patent activity: evidence from WIPO patent		
	statistics 72		
3.9	Greenfield FDI by type of activity 75		
	Policy recommendations: linking analysis and practice for		
	impact 77		
4.1	Reserves of key minerals by countries' income level (2015, %) 92		
4.2	Proportion of mineral production (%) 92		
4.3	Number of mining patent families, by country of origin (2004,		
	2014) 93		
4.4	Mining GVC firms and patents by type of firm and region (2004,		
	2014) 93		
5.1	Transport in the international mining supply chain 120		
5.2.	Coal and lignite imports and exports 2014 122		
5.3	Average commodity and transportation costs for US coal		
	(2008–14) 123		
5.4	Historical change in transport-related innovation		
	(1900–2015) 127		
5.5	Country of origin of mining transport patents (1990–2015) 130		
5.6	Mining transport patents by transport mode (1970–2015) 131		
5.7	Transport patents in automation 135		
5.8	Transport automation innovation per country 136		
	Where does MTI source technology? 137		
	Which sectors make use of mining transport technologies? 138		
6.1	Number of clean mining patents over time in total sample (left panel) and		
	share of clean patents among all mining patents (right panel) 149		
6.2	Decomposition of the OECD EPS index 151		

- d
- 6.3 Market and nonmarket EPS 153
- 6.4 Mining patenting and lagged EPS 159
- 6.5 Mineral price index (MPI) 159
- 7.1 Private R&D expenditure in mining and quarrying in EU countries and World Bank Metals and Minerals Price Index
- 7.2 Mineral exploration expenditure by commodity and nonferrous metals price index
- 7.3 De-trended Metals and Minerals Price Index and different cycles components
- 7.4 Number of patent families and R&D expenditure in the mining
- 7.5 Country exposure to mining sector rents 184
- 7.6 Mining and METS firms innovation relative specialization, by country and mining technology 185

	LIST OF FIGURES			
7.7	Mining price, quantity and innovation co-evolution			
	(1960–2015) 185			
7.8	Mining price, quantity and innovation cycle decomposition (1960–2015) 186			
7.9	.9 Average marginal effect of long cycle component of price index on			
	innovation with 95% confidence intervals 195			
7.10	Average marginal effect of medium cycle component of price index on			
	innovation with 95% confidence intervals 196			
7.11	11 Average marginal effect of short cycle component of price index on			
	innovation with 95% confidence intervals 196			
	Leading producing companies in Brazil (2015) 203			
8.2	2 Innovative activities developed by extractive companies and degree of			
	importance 208			
	Mining patents, by type of applicant (2000–15) 215			
	Mining patent applicants, by mining technology groups 215			
	Mining patents filed by METS, by country of origin (2000–15) 216			
	Leading METS applicants (2000–15) 217			
	Leading applicants among mining firms (2000–15) 218			
	Leading contractors (2000–15) 222			
8.9	Leading suppliers, by country of provision of the contract (2000–15) 223			
9.1	Types of firms surveyed by products supplied 242			
	Sales (frequency distribution, excluding the largest four firms) 244			
	3 Employees (frequency distribution, excluding the largest four			
	firms) 244			
9.4	Type of innovation 245			
9.5	Do IP registration costs affect protection decisions in Chile? 248			
9.6	Does your firm have trade secrets? 249			
9.7	IP instruments of apparent interest to potential exporters 250			
10.1	US mining employment (1900–2017) 259			
10.2	Fatalities in US mining (1900–2017) 260			
10.3	USPTO-granted patents in mineral mining (three-year moving average by			
	filing year) 265			
10.4	USPTO-granted patents in mineral mining separated into safety-related			
	and non-safety-related groups (three-year moving average by			
	filing year) 266			
10.5	USPTO-granted patents in mineral mining for refuge chambers and TTE			
	communications 268			
10.6	Schematic diagram of a wall-to-wall barrier in a passageway of			
	a mine 271			

10.7 Through-the-earth (TTE) emergency tracking and communication

system

272

- 10.8 Distributions of similarity scores for NIOSH granted patents in four mutually exclusive groups (mineral mining, safety-related mineral mining, TTE communications and refuge chambers) 273
- 11.1 Canadian patenting activity in the mining sector between 1990 and 2015 286
- 11.2 Top Canadian mining firms and METS and their associated mining sector category, 1990–2015 288
- 11.3 Priority country share for top Canadian mining firms and METS 289
- 11.4 Priority country share for all Canadian mining firms and METS 290
- 11.5 All mining patent families assigned to Canadian mining firms and METS 291
- 11.6 Canadian patenting activity by mining category between 1990 and 2015 293
- 11.7 Relative Specialization Index (RSI) 294
- 11.8 Patent families assigned to Canadian assignees in the exploration category 296
- 11.9 Collaborations and their distribution by mining sector category between 1990 and 2015 297
- 11.10 Collaboration map involving mining firms and METS 299
- 11.11 Canadian mining industry clusters 301
- 11.12 Geographical clusters of inventive activity in Canada 302
- 12.1 Patent families of Australian origin, by priority year,1997–2015 311
- 12.2 Top Australian patent filers 313
- 12.3 Australian entities who file patents, by entity type 313
- 12.4 Patent filings by Australians, by mining technology 314
- 12.5 Patent filings by Australians, by mining technology, by priority year, 1997–2015 315
- 12.6 Jurisdictions in which Australian innovators seek patent protection 319
- 12.7 Australian patent filing collaboration by entity type 320
- 12.8 Top Australian collaborators in patent filings 321
- 12.9 Australian patent filings by CRCs 321
- 12.10 Mining sector expenditure in the R&D Tax Incentive, 2000–1 to 2015–16 324
- 12.11 Mining sector companies by entity size, 2000–01 to 2015–16 325
- 12.12 Comparison of mining sector industry subdivision trends under the R&D Tax Incentive by industry subdivision, 2000–1 to 2015–16 326
- 12.13. Mining sector R&D expenditure and patent filings for R&D Tax Incentive companies, 2000–01 to 2015–16 327

12.14	Mining sector performance under	the R&D Tax Incentive by State and
	Territory, 2000-1 to 2015-16	328

- 12.15 Patent filings into Australia, by priority year, 1997–2015 330
- 12.16 RBA Index of Commodity Prices, 1997–2015 333
- 12.17 Mining sector profits as a share of nominal GDP, 1997–2015 331
- 12.18 Australian investment in mining as a percentage of GDP, 1997–2015 332
- 12.19 Patent filings into Australia by mining technology 332
- 12.20 Patent filings into Australia by applicant origin 333
- 12.21 Top applicants filing patents into Australia in the mining sector 335
- 12.22 International collaboration on patent filings into Australia in the mining sector 336
- 12.23 Collaboration on patent filings into Australia in the mining sector by technology 337
- 12.24 Collaboration on patent filings into Australia by technology by country 337