



Comisión
Nacional de
Productividad

Copper Industry Productivity in Chile

Copper to the World Conference

Adelaide, SA

June 27, 2017

Agenda

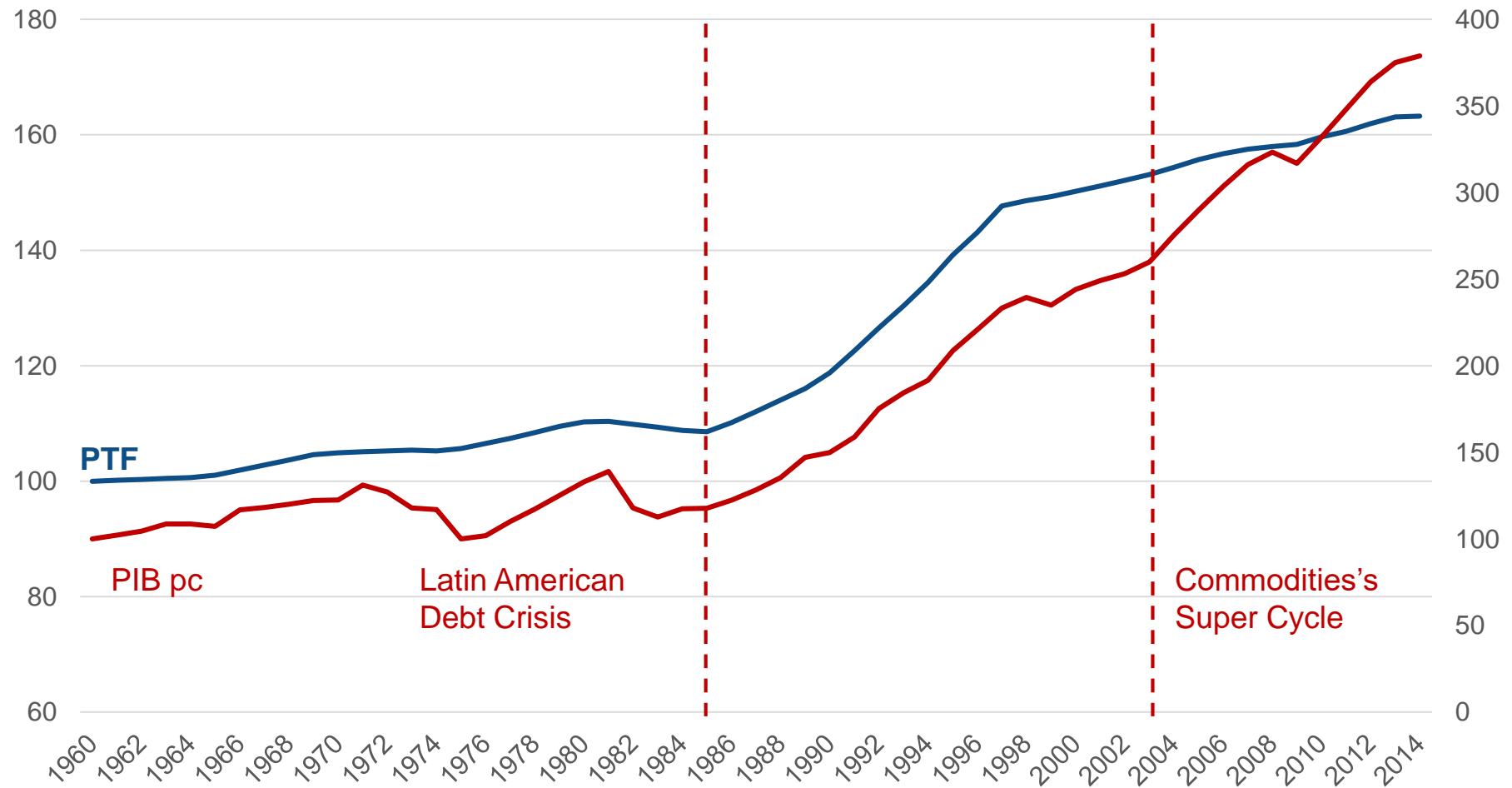
- Introduction
- The Productivity in Copper Mining inquiry
- Evolution and level of Copper Mining Productivity (2000-2014)
- International Benchmarking (2015)
- Report Results: A 3-pillar Mining Strategy

Chilean Productivity Commission

- Created in July 2015, aspires to be **permanent**
- 8 independent commissioners; with small technical staff
- Mission: make evidence-based **recommendations**

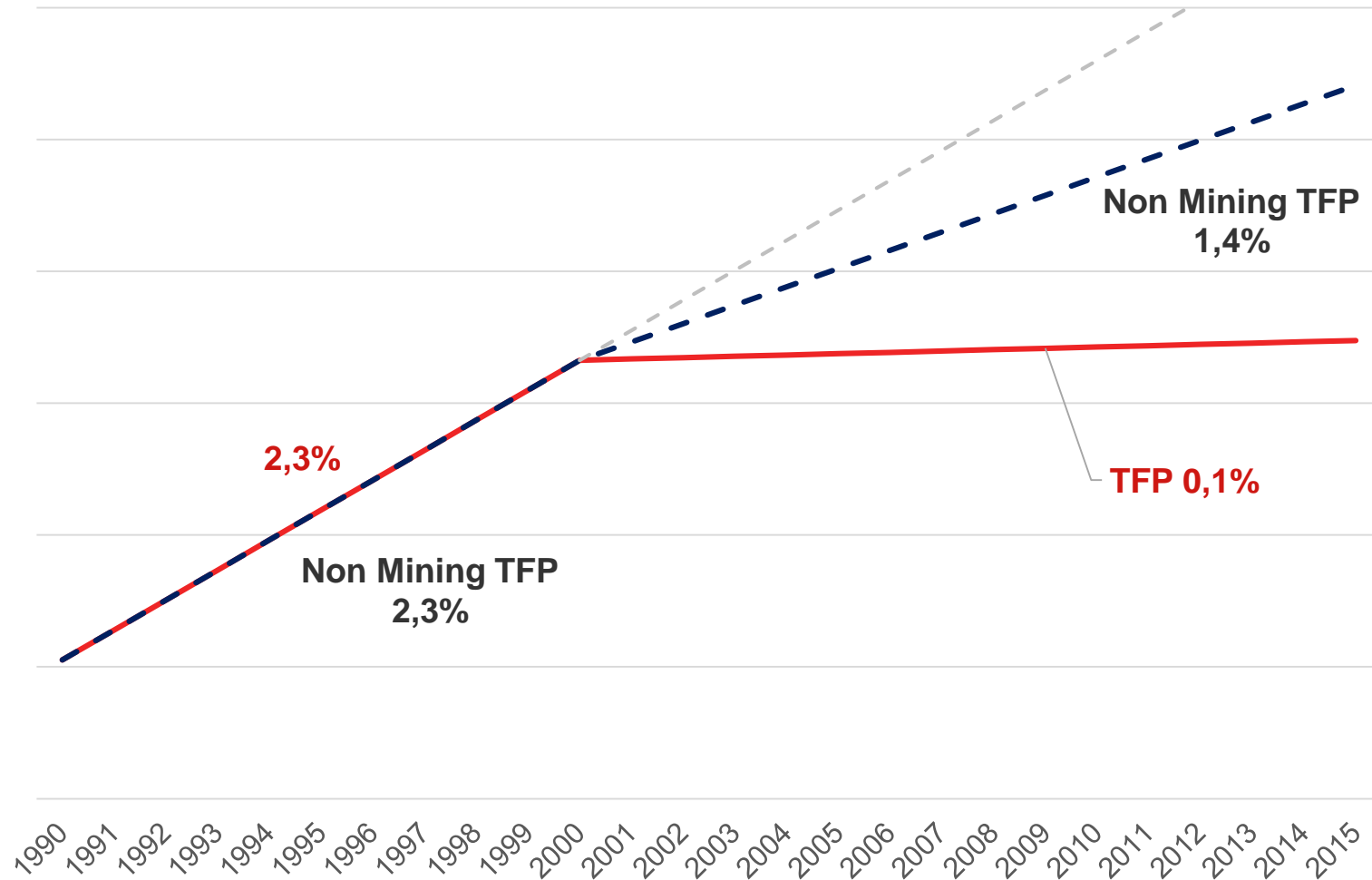
- Completed government inquiries and research:
 - “Agenda of Productivity Agendas”
 - Annual Productivity Report 2017
 - **Mining**
- Current government inquiries and research:
 - Labor skills
 - Disruptive Technologies and Sharing Economy
 - Annual Productivity Report 2017

Productivity is behind Chile's success in the last 30 years



Source: The Conference Board. 2016. The Conference Board Total Economy Database
<http://www.conference-board.org/data/economydatabase/>

Aggregate TFP slowdown since 2000 with Mining being one of the leading lagging sectors



Source: Chilean Productivity Commission
[Comisión Nacional de Productividad (2016) Informe Anual de Productividad 2016: Una mirada de largo plazo]

Objective: Make Chile not only a world leader on copper production but also in productivity

➤ **Government inquiry**

- Collaborative report between CNP, Mining Ministry, Cochilco, Mining Council, Fundación Chile, Matrix Consulting and many others.
- Benchmark analysis comparing 12 Chilean operations from large scale copper mining with best practice operations from Australia, Canada, United States, Peru and Sweden (our sample is 30% of world production)
- Over 500 interviews in 12 Chilean mines, 7 international best practice mines (1 Australian), suppliers, contractors, institutions and experts.
- 20MM observations used for developing benchmark analysis

Teck

Highland Valley 133

Taseko

Gibraltar 73



Copper Mountain 46

**Escondida 1.145****GLENCORE****Collahuasi 449****El Teniente 434****Los Bronces 377****Los Pelambres 357****Radomiro Tomic 322****Chuquicamata 311****Centinela 263****Andina 209****Spence 156****Candelaria 137****Gabriela Mistral 120**

Kiruna 26

26

Morenci 409

Safford 91

Bagdad 80

Antamina 390

Cerro Verde 277



Prominent Hill 126



Olympic Dam 114



Iron Ore Business 233



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Visitas a operaciones chilenas



Visitas a operaciones en el exterior



Producción 2015 en miles de toneladas de cobre fino

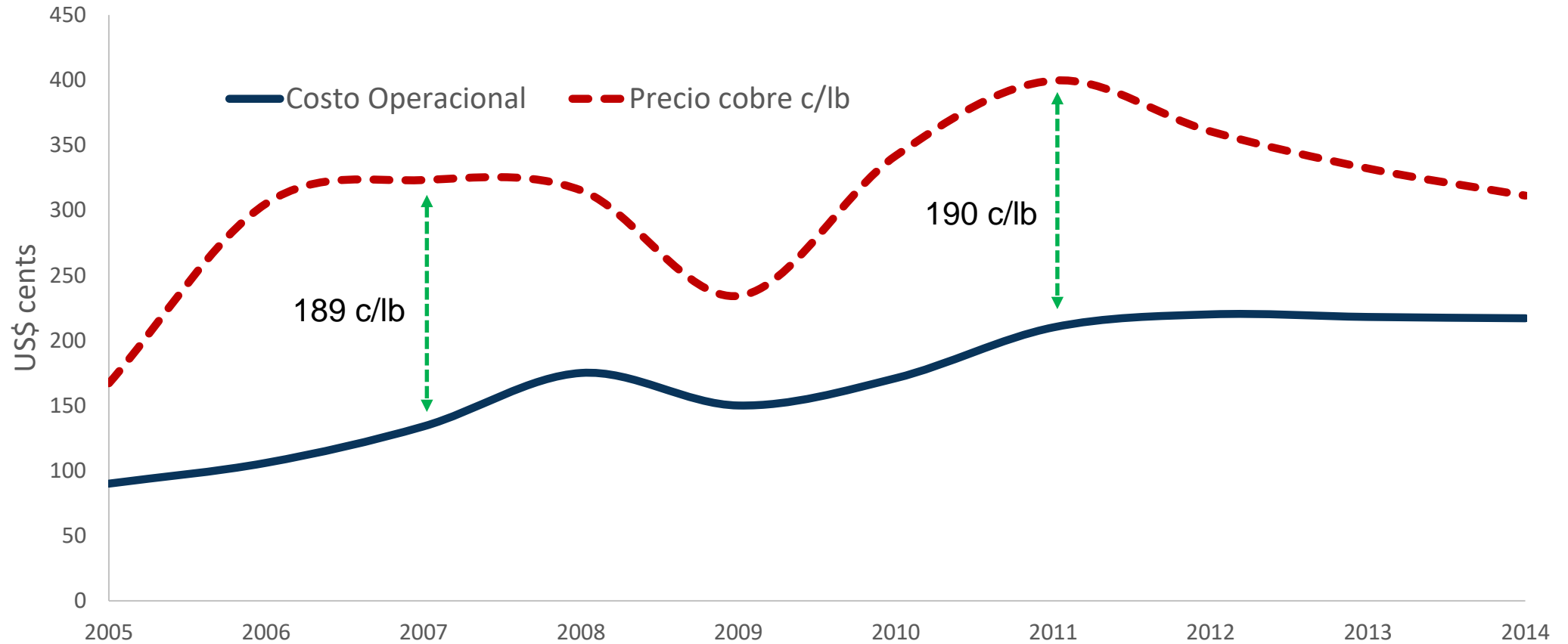


Producción 2015 en millones de toneladas de hierro

Productivity in Copper Mining

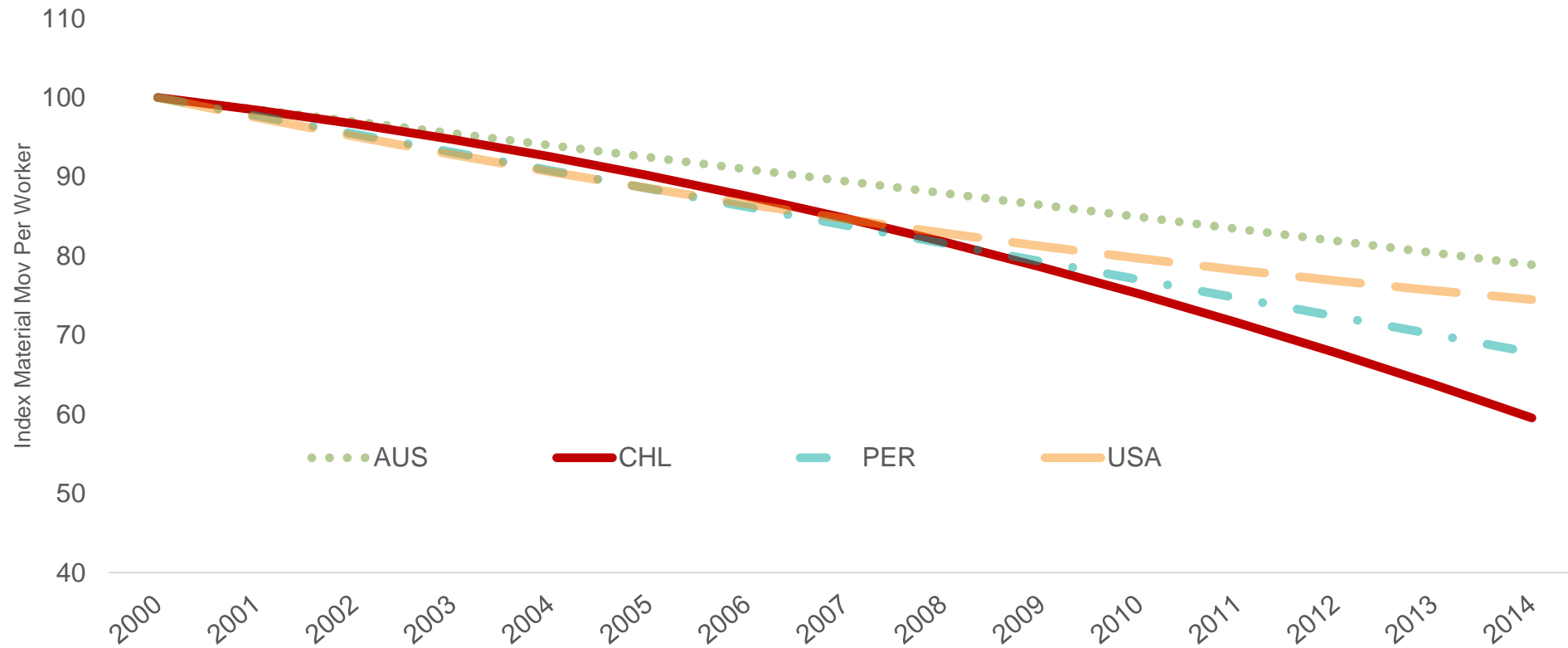
- The final report index (released to the public 22 June 2017):
 - Primera Parte: Characterization of Great Copper Mining
 - Capítulo 1: Great Copper Mining in Copper
 - **Capítulo 2: Productivity in Copper Mining (2000-2014)**
 - **Capítulo 3: Benchmark Large Scale Copper Mining (2015)**
 - Capítulo 4: Suppliers – Characterization and Productivity
 - Segunda Parte: Productivity Analysis
 - Chapter 5: Water and Energy Resources in Mining
 - Chapter 6: Mining and Communities
 - Chapter 7: Labor Market and Workers Security
 - Chapter 8: Mining Exploration
 - Chapter 9: Medium-scale Mining
 - Chapter 10: Suppliers: Barriers to Productivity and Recommendations
 - Chapter 11: A Mining Strategy for Chile

Copper Price super-cycle



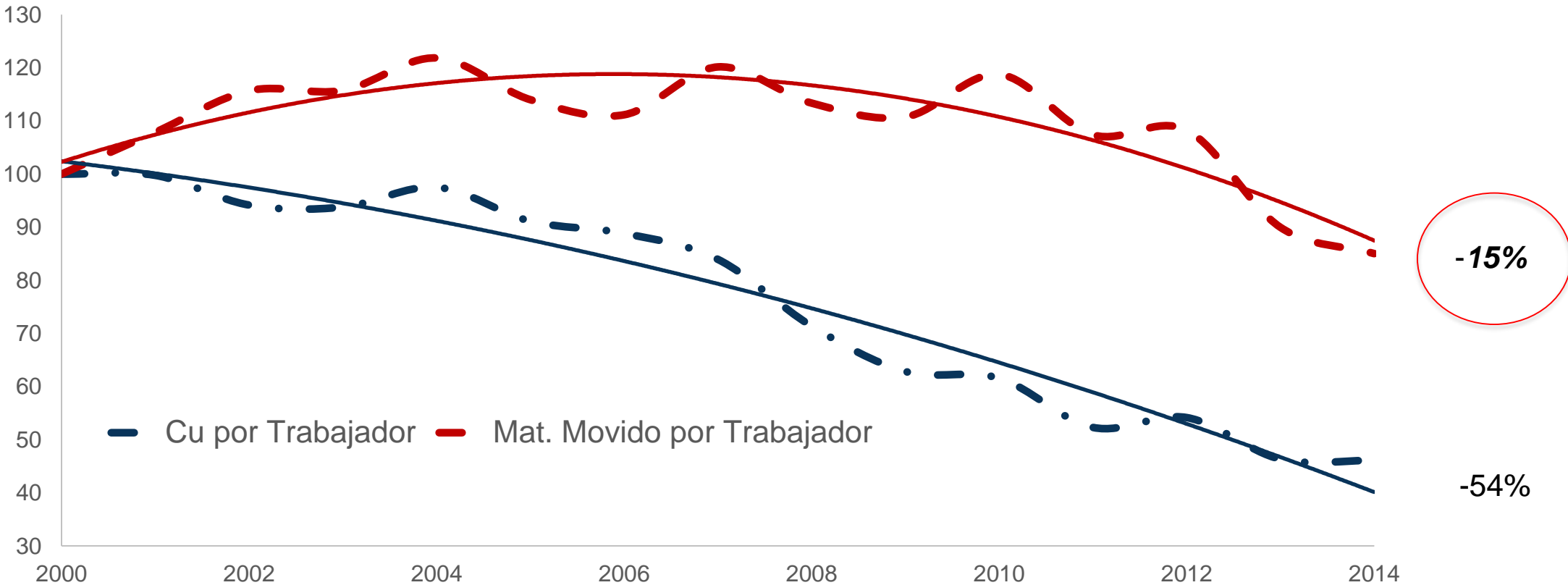
Source: Cochilco (2015)

The super-cycle had negative productivity effects on most mining countries



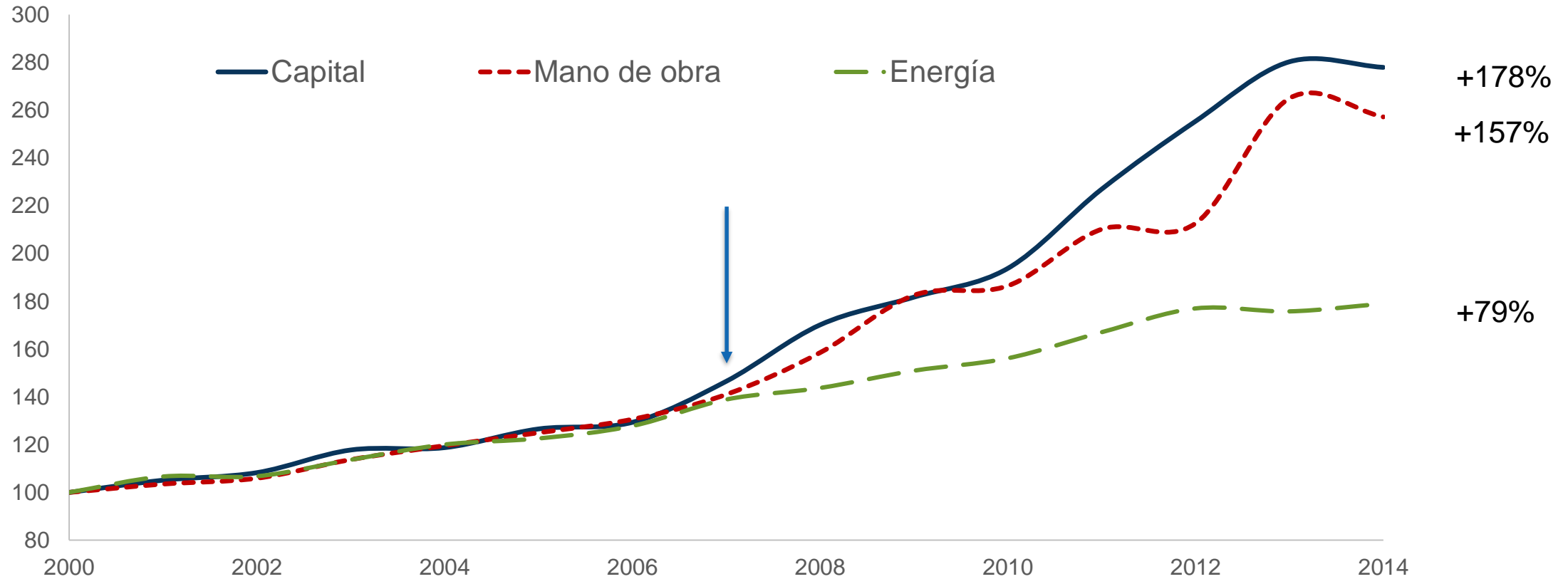
Source: Cochilco based on Wood Mackenzie.

Labor Productivity and Ore grade effects (Chile)



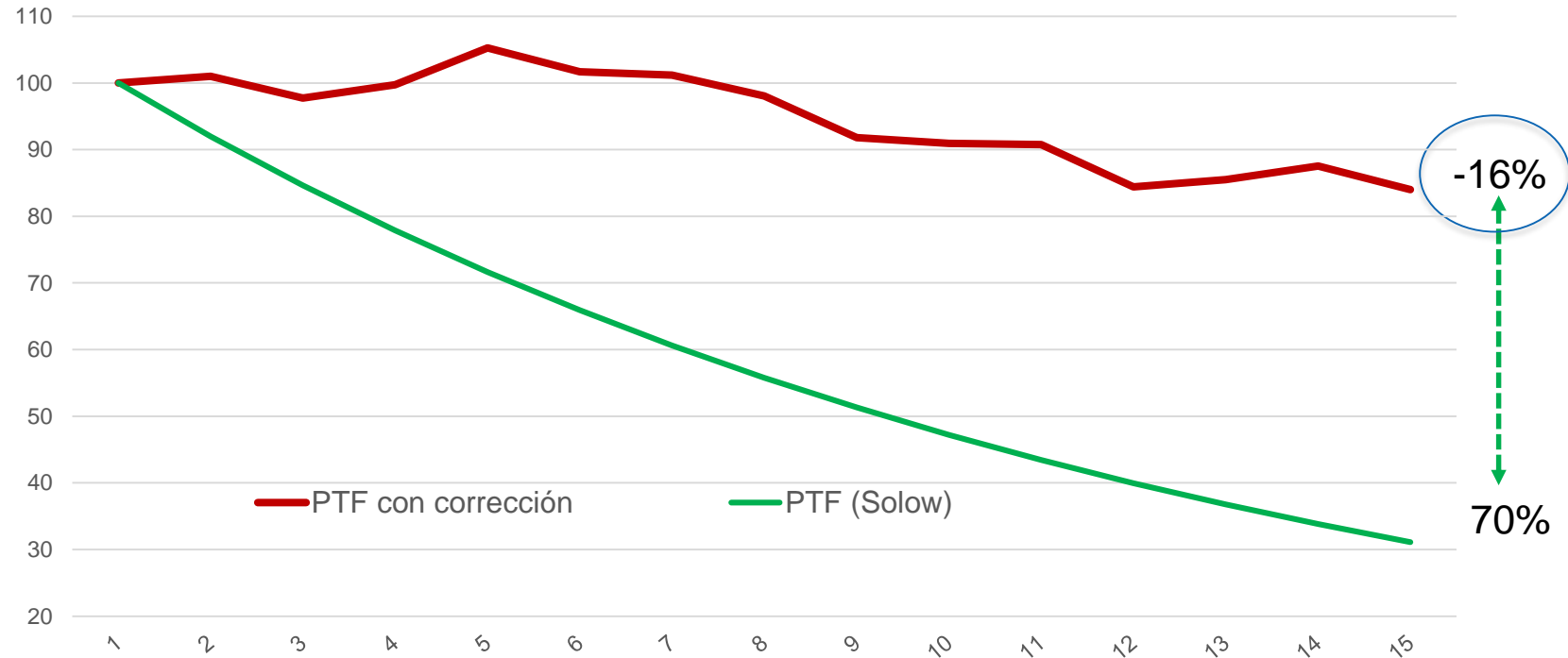
Source: Own elaboration based on Cochilco data.

Producing 19% more copper required to move 119% more material, 178% more equipment, 157% more labor and 79% more energy



Source: Own elaboration based on Cochilco data.

Total Factor Productivity evolution in Chile decreased at 1% per year after accounting for ore grades, investment lags, etc (2000-2014)



Source: Own elaboration based on Cochilco data and CNP (2016)

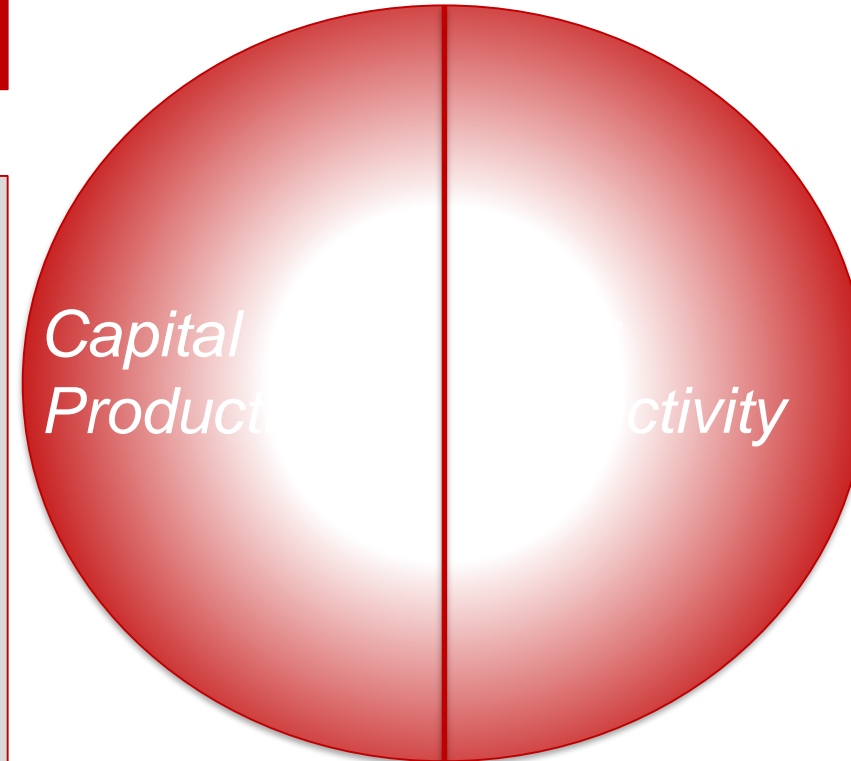
Note: Normal Total Factor Productivity estimations accounts for K and L.

Chapter 3: International Benchmark

Capital productivity variables (tool in use)

OEE: % efficiency in equipment use:

- Availability: % time available / total time
- Efficiency: % time being used / available time
- Performance: Material moved / movement capacity



Labor productivity variables (tool in hand)

- kTon material moved per worked hour.
- kTon mineral processed per worked hour
- kTon fine copper produced per worked hour.
- % effective working time (drivers and mechanics).

Capital Productivity – in Chile equipment are used 10-15% less time that best practice operations – and there is great variance

Mining Sub-process	Availability ¹ (hours per day ²)		Efficiency ¹ (hours per day ²)	
	Chile	International	Chile	International
Loading	18,5 (20,4 – 17,3)	21,6	13,4 (16,1 – 9,2)	16,6
Hauling	19,4 (21,7 – 17,2)	21,1	15,4 (19,2 – 11,3)	16,9
Crushing (Primary)	18,7 (22,9 – 13,8)	21,8	16,7 (21,9 – 10,0)	17,7
Grinding	22,0 (22,4 – 18,0)	23,0	20,2 (22,3 – 17,4)	22,8

Source: Chapter 3 - Productivity in the mining industry

(1) Availability in calendar time

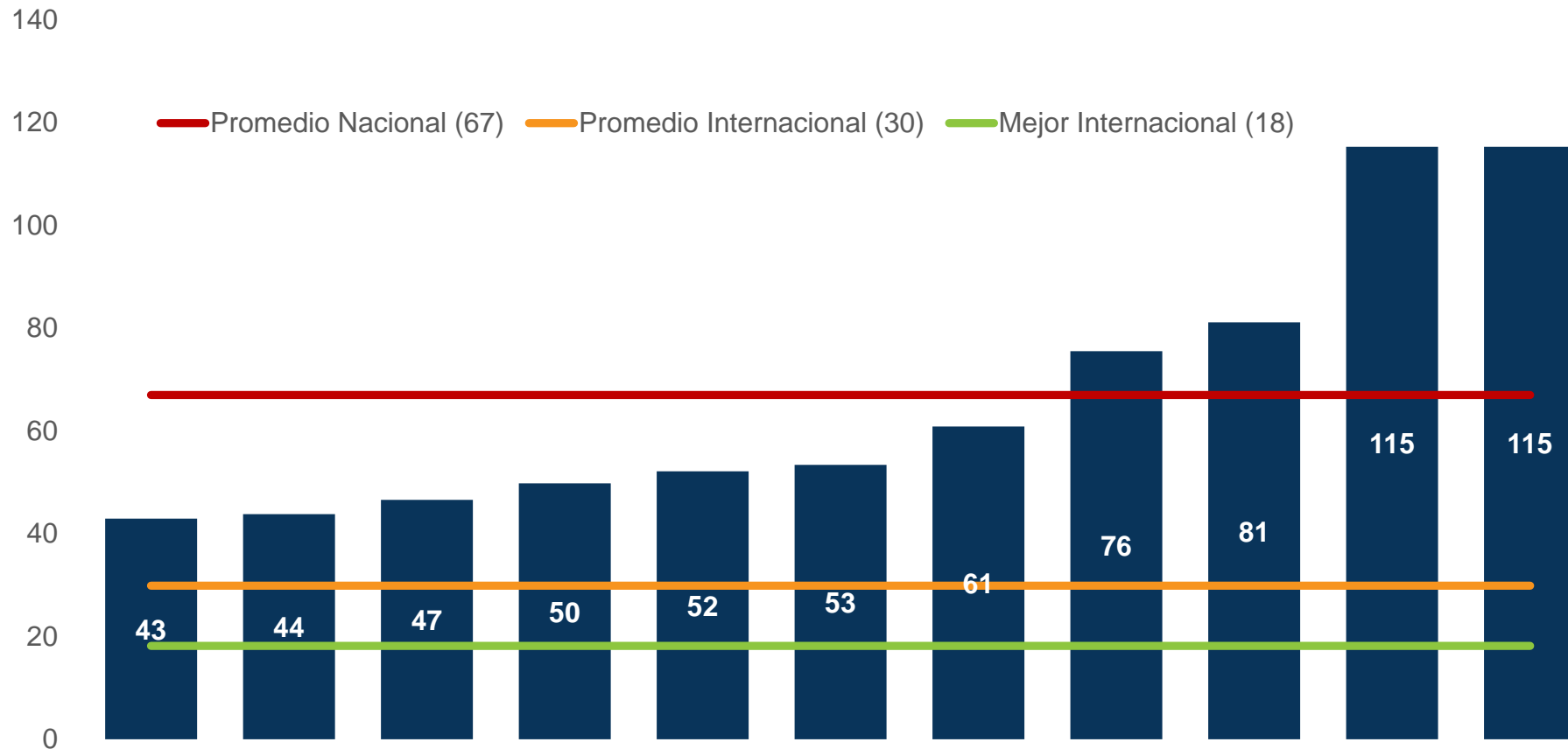
(2) Maximum is 24 hours.

Chilean operations range in parenthesis (max – min)



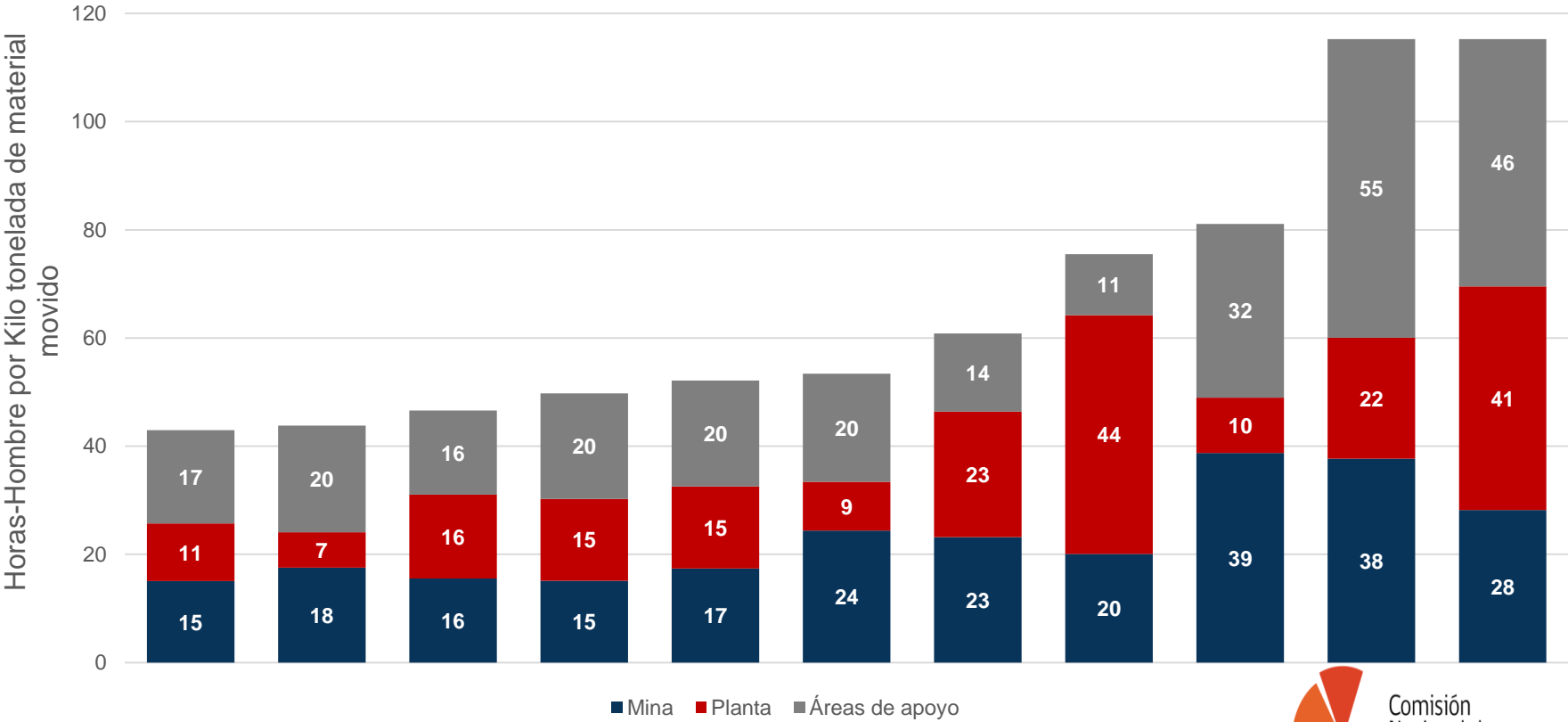
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There is high heterogeneity in Labor Productivity (2015)



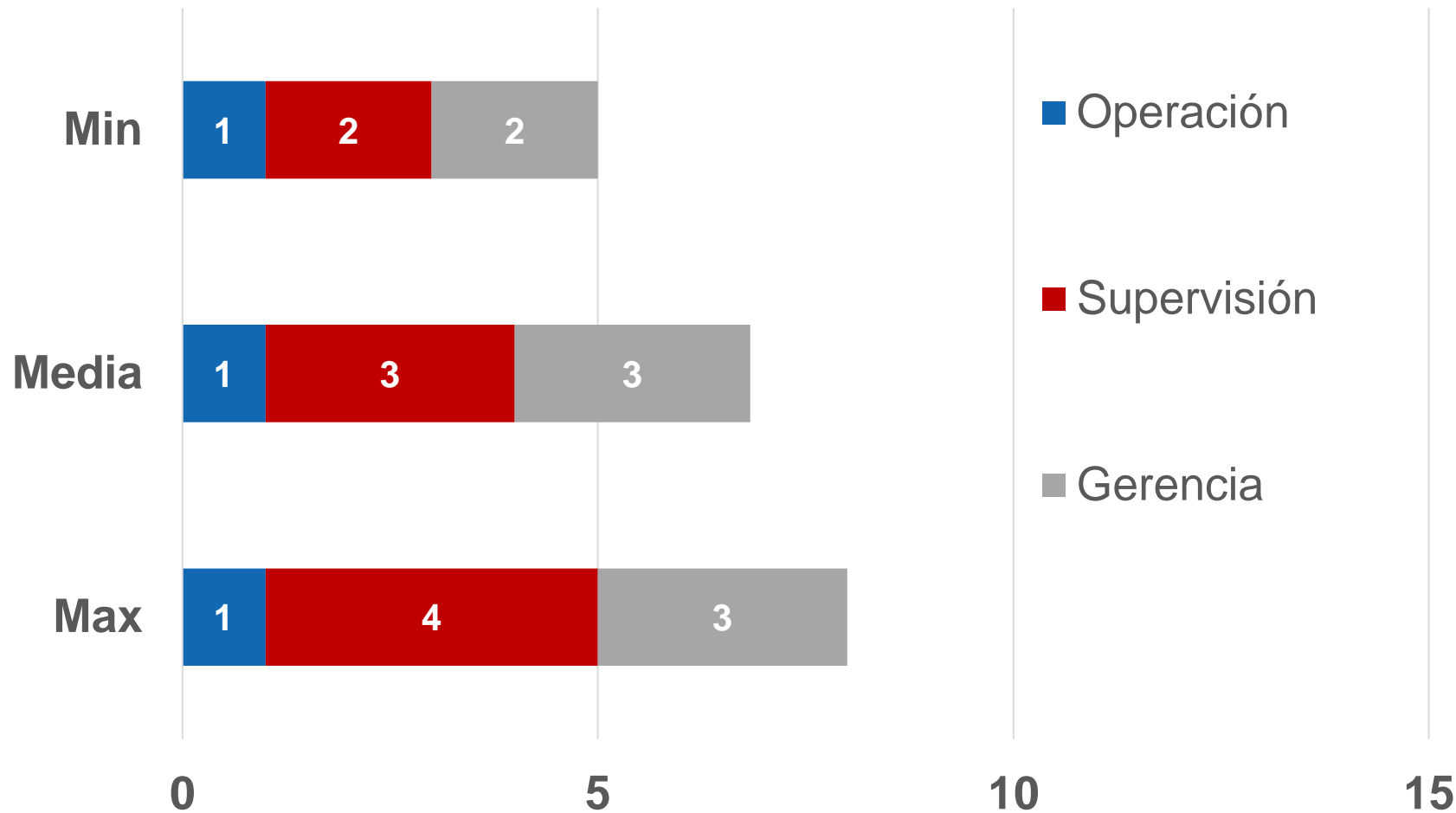
Source: Chapter 3 - Productivity in the copper mining industry

For each man-hour in Mine process there is 1,8 man-hour in other áreas versus 1,3 in best international operations



Source: Chapter 3 - Productivity in the copper mining industry

Number of hierarchical layers - Chile 2015



Source: Chapter 3 - Productivity in the copper mining industry (2017).

The result: A 3-pillar Mining Strategy

- (1) Public goods: Government efficiency and regulation quality
- (2) Club goods: higher coordination and collaboration between mining firms, suppliers and other stakeholders.
- (3) Private goods: management according to international best practice

Our 53 recommendations –unanimously voted- compose a **Mining Strategy** that on the first 2 pillars, each one with 6 action fields and time scale (short, medium and long run)

The third pillar is, arguably, the most important in productivity gains.

Selected public and club goods recommendations

- (i) Lower the time to reject or accept an Major Investment Project from 5 to 3 years (MPMO – Canada)
- (ii) Increase mining exploration by incentivizing effective use of mining concessions
- (iii) Foster operational continuity by allowing workers and mining companies to negotiate more options
- (iv) Develop a Mining Passport to enhance the mining labour market
- (v) Strengthen Human Capital (educational gaps, quantity & quality)

Private goods – Some suggestions to mining companies

1. Reduce senior executives turnover.
2. Reduce hierarchical layers
3. Change the "controlist" management culture which reduces initiative, dilutes responsibility and raises costs.
4. Focus on workers empowerment and accountability.
5. Reduce supervisors times devoted to administrative tasks in order to increase time allocated for planning and work organization tasks.
6. Improve adhesion and compliance of the plan.
7. Consider using single model equipment fleets to improve maintenance and reduce inventory of parts.
8. Raise automation and real time data management.
9. Establish a meritocratic culture increasing internal workers mobility
10. Generate incentives linked to the overall productivity of the operation and not to partial goals per phase of the process.



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Thank you
Muchas Gracias
jgana@cnp.gob.cl

Full report available (Spanish) at:

<http://www.comisiondeproductividad.cl/wp-content/uploads/2017/06/Informe-Final-Productividad-en-la-Gran-Mineria-del-Cobre-2.pdf>

English translation forthcoming this year.