

Introduction

- Energy-critical minerals (ECM) are required for emerging sustainable energy sources. Although supply networks have seen robust research activity, there are no global measurements of the illicit-illicit composition of ECM trade flows or their evolution over time.
- Our objective is to expose multiple types of inconsistencies in recent 20 years from ECM related public datasets, relying on source countries' import-export logs within a single dataset and across multiple datasets. The basic units we focus on are total export quantity (kilograms) and trade value (\$).

Research Objects

Commodity	Source Countries (SLCs indicated in blue)
Cobalt	Australia, Canada, Cuba, DRC, Finland, New Caledonia, Norway, Philippines, Russia
Lithium	Australia, Argentina, Bolivia, Brazil, Canada, Chile, China, Namibia, Portugal, Russia, US, Zimbabwe
Niobium	Brazil, Canada, China, DRC, Germany, Nigeria, Russia, Zambia
Platinum Group Metals	Belgium, Germany, Russia, South Africa, UK, US
Rare Earth Elements	Brazil, China, France, India, Japan, Malaysia, Thailand, UK, US, Vietnam, (Myanmar)
Tantalum	Australia, Bolivia, Brazil, Canada, China, DRC, Ethiopia, Mozambique, Nigeria, Russia, Rwanda, Zambia

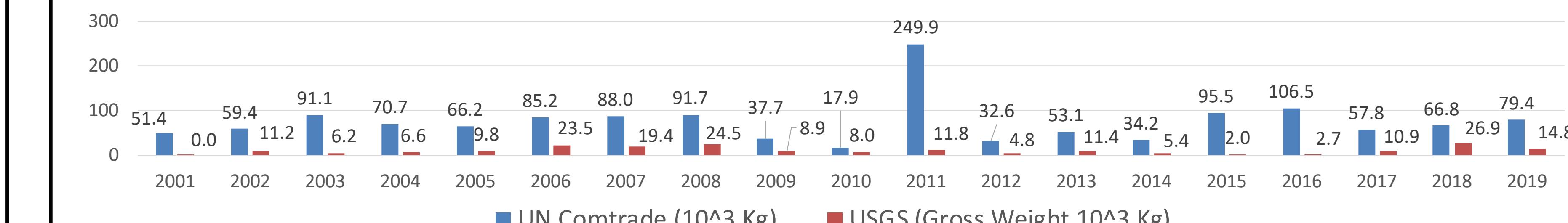
Datasets

- UN Comtrade:** a repository of official international trade statistics and relevant analytical tables. We used it to study the inconsistency in single dataset.
- USGS:** information on minerals-related issues, including minerals conservation, sustainability, availability, materials flow, and the economic health of the U.S. minerals industry. We used to study the inconsistency between multiple datasets: UN Comtrade versus USGS.

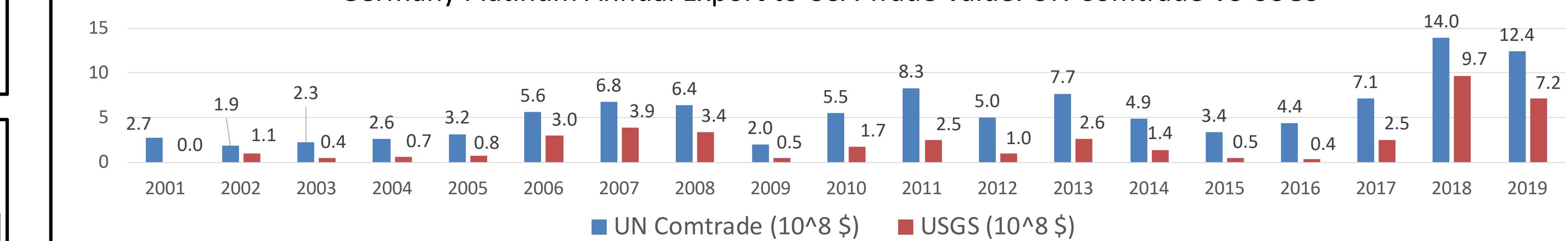
Preliminary Studies & Examples

1. Clear Inconsistency between UN Comtrade Export Log and USGS Import Log for all commodities.

Germany Platinum Annual Export to USA Quantity: UN Comtrade VS USGS



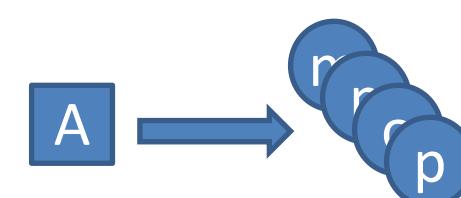
Germany Platinum Annual Export to USA Trade Value: UN Comtrade VS USGS



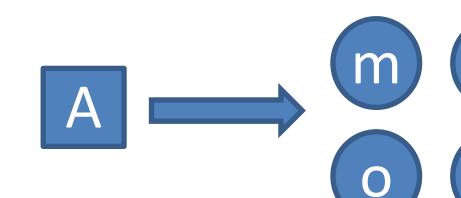
2. Clear Inconsistency in Export Log of Source Countries in UN Comtrade.

Commodity: Lithium; Niobium; Platinum; Tantalum.

Comparison between:

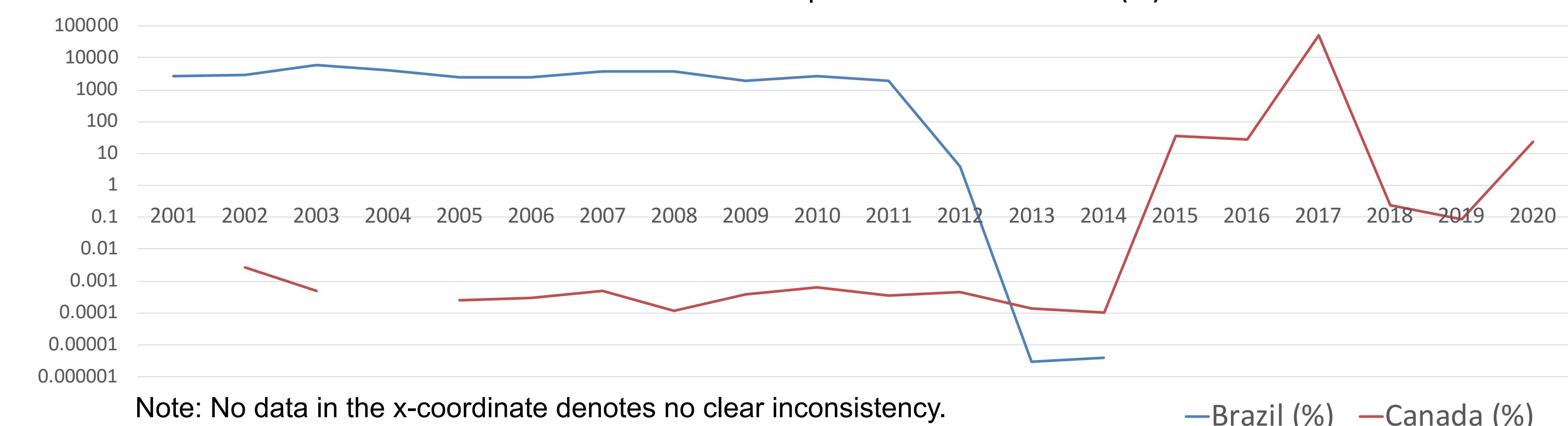


Source country, such as "A", export quantity to world.



Source country, such as "A", export quantity summarization to each country, such as "m, n, o, p".

Brazil & Canada Niobium Export Overall Difference (%)



3. For "Rare Earth Element" commodity, the quantity is unreported in UN Comtrade.

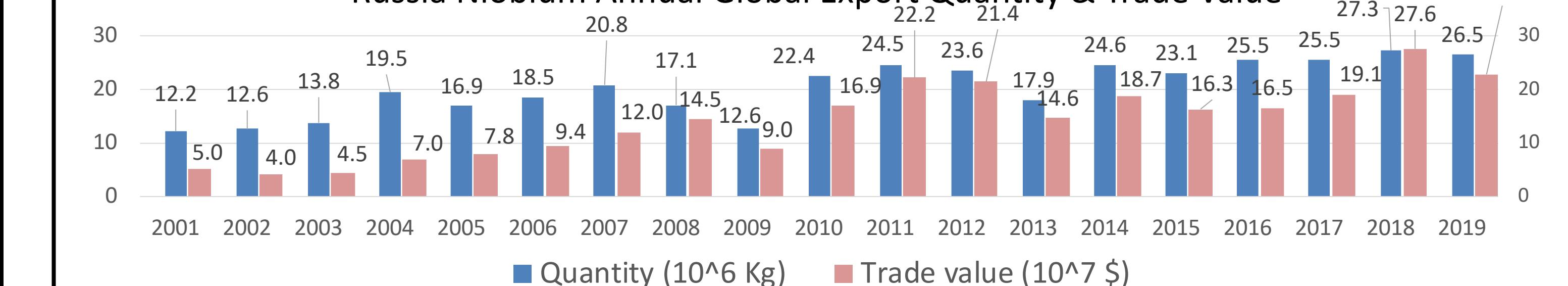
China Rare Earth Element Annual Global Export Quantity & Trade Value (2016-2020)

Year	2016	2017	2018	2019	2020
Quantity (kg)	0	0	0	0	0
Trade Value (10^10 \$)	1.2135	1.5004	2.0183	1.6908	1.5208

Preliminary Studies & Examples

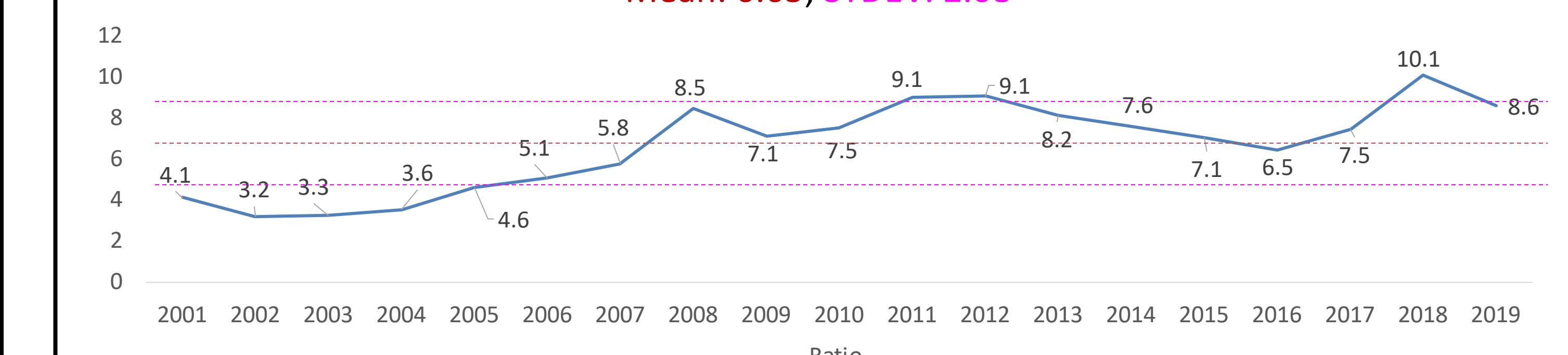
4. Mismatch between Quantity and Trade Value in UN Comtrade in all commodities.

Russia Niobium Annual Global Export Quantity & Trade Value



Russia Niobium Annual Global Export Ratio: Trade Value / Quantity

Mean: 6.65; STDEV: 2.08



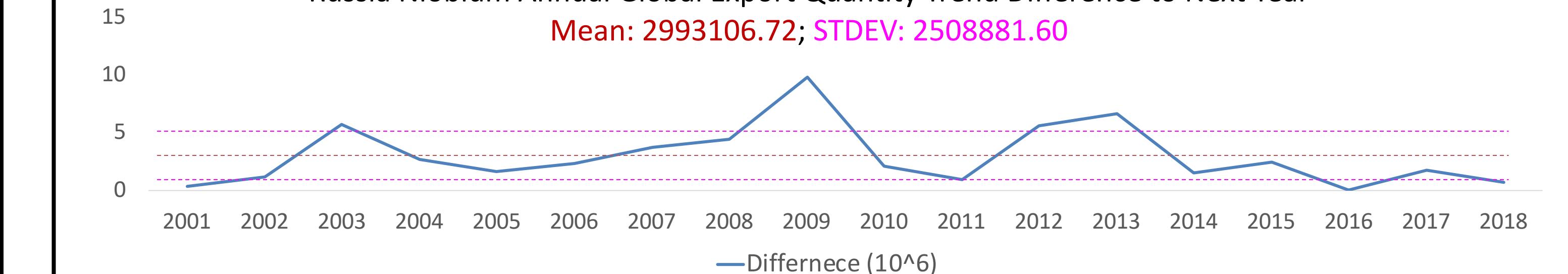
5. Missing Data in UN Comtrade.

Source Country List	Cobalt	Lithium	Niobium	Platinum	Tantalum
Source Country List	Canada; Russia; DRC; Cuba; New Caledonia	Zimbabwe; Chile	Zambia; Russian Federation; Nigeria; Dem. Rep. of the Congo	Russian Federation	Dem. Rep. of the Congo; Ethiopia; Nigeria; Mozambique; Zambia

Note: Countries in bold denote missing data more than 2 years.

6. Large Annual Fluctuations in both Quantity and Trade Value.

Russia Niobium Annual Global Export Quantity Trend Difference to Next Year



Future Work

- Exploring potential reasons which cause the inconsistencies.
- Normalizing the data for incoming machine learning research.