



Ore-Based Metallurgy for iron & steel

AN INTRODUCTION

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- **What are ore-based metallics (OBM's)?**
- **How are they used?**
- **How and where are they produced?**
- **What are their principal markets?**
- **Analysis of cross-border trade**
- **Market structure and dynamics**
- **Price information**

What are ore-based metallics?

They are various forms of iron, manufactured principally by the reduction of iron ore in blast furnaces and direct reduction plants, also from the smelting of titanium-bearing mineral sands, and used as feedstock in the iron & steel and iron casting industries:

pig iron, hot briquetted iron (HBI), direct reduced iron (DRI), granulated pig iron



How are they used?

- In the steel industry, the principal application is as ferrous feedstock for steel produced in electric arc furnaces (EAF) as a supplement to steel scrap, the principal feedstock material.
- Outside China, EAF share of steel production shows a gradual upward trend.
- Being manufactured from iron ore, ore-based metallics have a very low content of residual metallic and other impurities such as copper, tin, zinc, etc. This is the principal, but not the only benefit of OBM's.
- As such, they enable production of higher quality steels, such as flat products, via the EAF route by dilution of the impurities in the scrap.
- Pig iron is an essential feedstock material for production of certain grades of cast iron in foundries, due to its clean analysis.

Residual impurities in scrap and OBM's

EU steel scrap specifications				
Category	Grade	Cu %	Sn %	Cr, Ni, Mo %
Old scrap	E3	≤ 0.250	≤ 0.010	Σ ≤ 0.250
	E1	≤ 0.400	≤ 0.020	Σ ≤ 0.300
New scrap, low residuals, uncoated	E2	Σ ≤ 0.300		
	E8	Σ ≤ 0.300		
	E6	Σ ≤ 0.300		
Shredded	E40	Σ ≤ 0.250	Σ ≤ 0.020	
Steel turnings	E5M	≤ 0.400	Σ ≤ 0.030	Σ ≤ 1.0
High residual scrap	EHRB	≤ 0.450	Σ ≤ 0.030	Σ ≤ 0.350
	EHRM	≤ 0.400	Σ ≤ 0.030	Σ ≤ 1.0
Fragmented scrap from incineration	E46	≤ 0.500	≤ 0.070	
Ore-based metallics *	pig iron, DRI, HBI	0.002	trace	Σ ≤ 0.015
* Dependent on source iron ore				

How is pig iron produced?

- **Pig iron is produced principally by the reduction of iron ore in a blast furnace, using coke or charcoal as reductant. In integrated steel mills, liquid iron (hot metal) is transferred directly to the steel plant for refining into steel.**
- **For the merchant market, liquid iron is cast into ingots which when cooled can be delivered to customers. Merchant pig iron is produced:**
 - by dedicated merchant plants selling only cold pig iron
 - by integrated steel mills which sell surplus iron to the merchant market in the form of cold pig iron
- **High Purity Pig Iron (HPPI) is produced by smelting ilmenite, a titanium-bearing mineral, in electric furnaces. This is a niche form of pig iron, used for production of ductile iron castings.**
- **Granulated pig iron is manufactured by the rapid solidification of liquid blast furnace iron in water to form granules.**

Where is merchant pig iron produced?

- **The principal producing countries outside China are Russia, Ukraine and Brazil which account for at least 75% of market supply. Others include Japan, India, Germany and Italy.**
- **China is by far the world's largest producer of merchant pig iron, but exports very little and then only to nearby markets.**
- **HPPI is produced in South Africa, Canada and Norway.**
- **Granulated iron is currently produced in Sweden and India for the merchant market.**

How are DRI and HBI produced?

- **Direct Reduced Iron is produced by the reduction of iron ore:**
 - in shaft furnaces using natural gas as reductant ([Midrex](#) and [Energon](#) are the principal processes) – about 80% of global production
 - in rotary kiln furnaces using coal as reductant (various proprietary processes), mainly in India where the product is known as “sponge iron” – about 20% of global production
- **As a highly reduced form of iron, DRI is very reactive and requires special measures for safe transportation and handling.**
- **Hot Briquetted Iron is a form of DRI which is briquetted at elevated temperature to form dense briquettes which can be transported and handled easily and safely.**

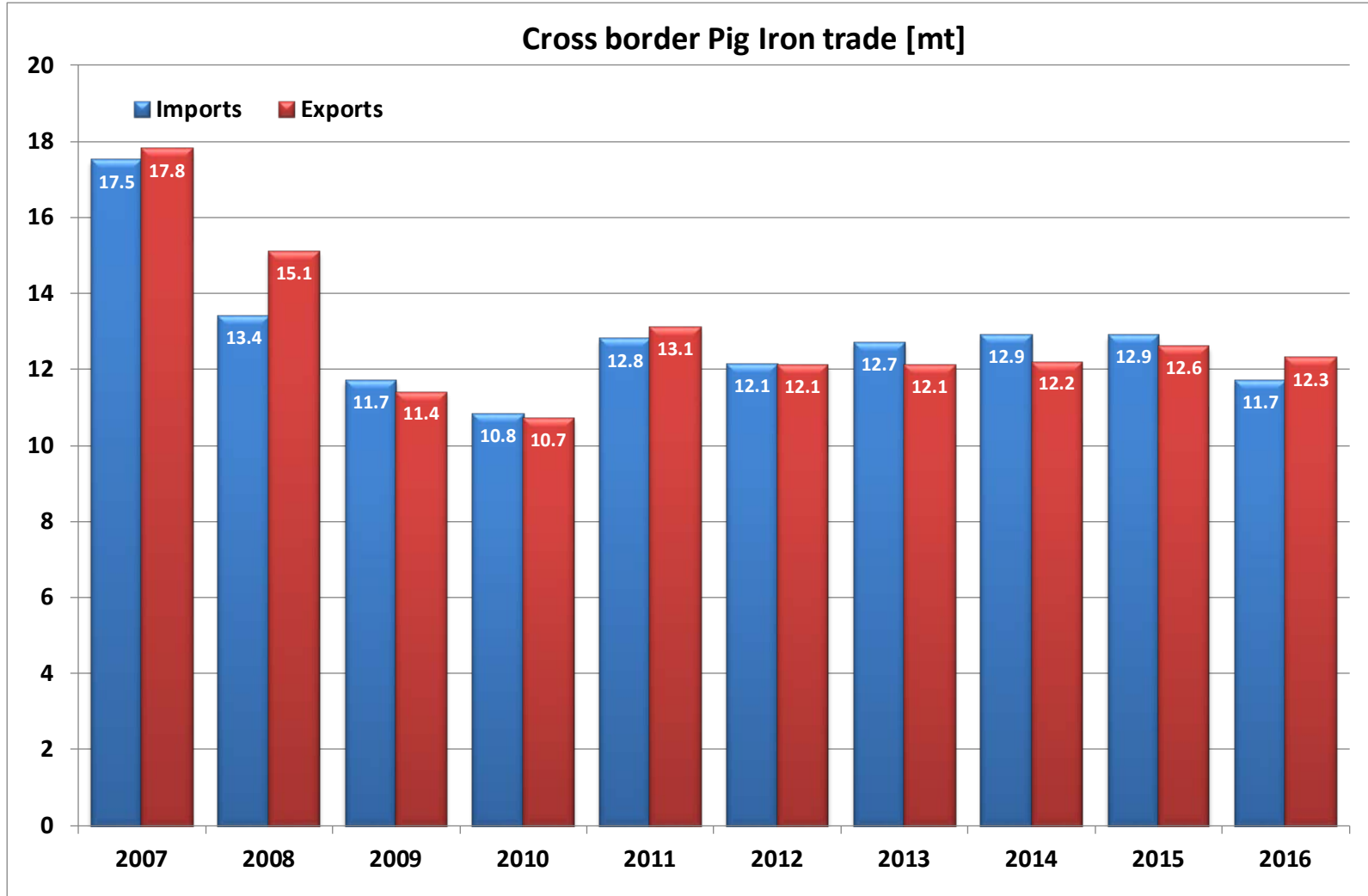
Where are DRI and HBI produced?

- **Apart from coal-based sponge iron production in India, gas-based production of DRI occurs where there is plentiful supply of low cost natural gas:**
 - Middle East (Iran, Saudi Arabia, Qatar, UAE, Bahrain, Oman) and North Africa (Egypt, Libya)
 - The Americas (Venezuela, Argentina, Trinidad, Mexico, USA and Canada)
 - Russia (there are also plants in Canada, Germany, South Africa and Indonesia)
- **Due to its nature, DRI is consumed mainly in steel mills where DRI production is integrated with EAF steel production. There is a very limited merchant market for DRI.**
 - Steel producer Nucor produces DRI at its plants in Trinidad and Louisiana and ships about 3 millions tonnes per year to its various steel mills in the USA
- **HBI is produced principally in Russia, USA and Venezuela, the main suppliers, but also in Malaysia, Qatar and Libya.**

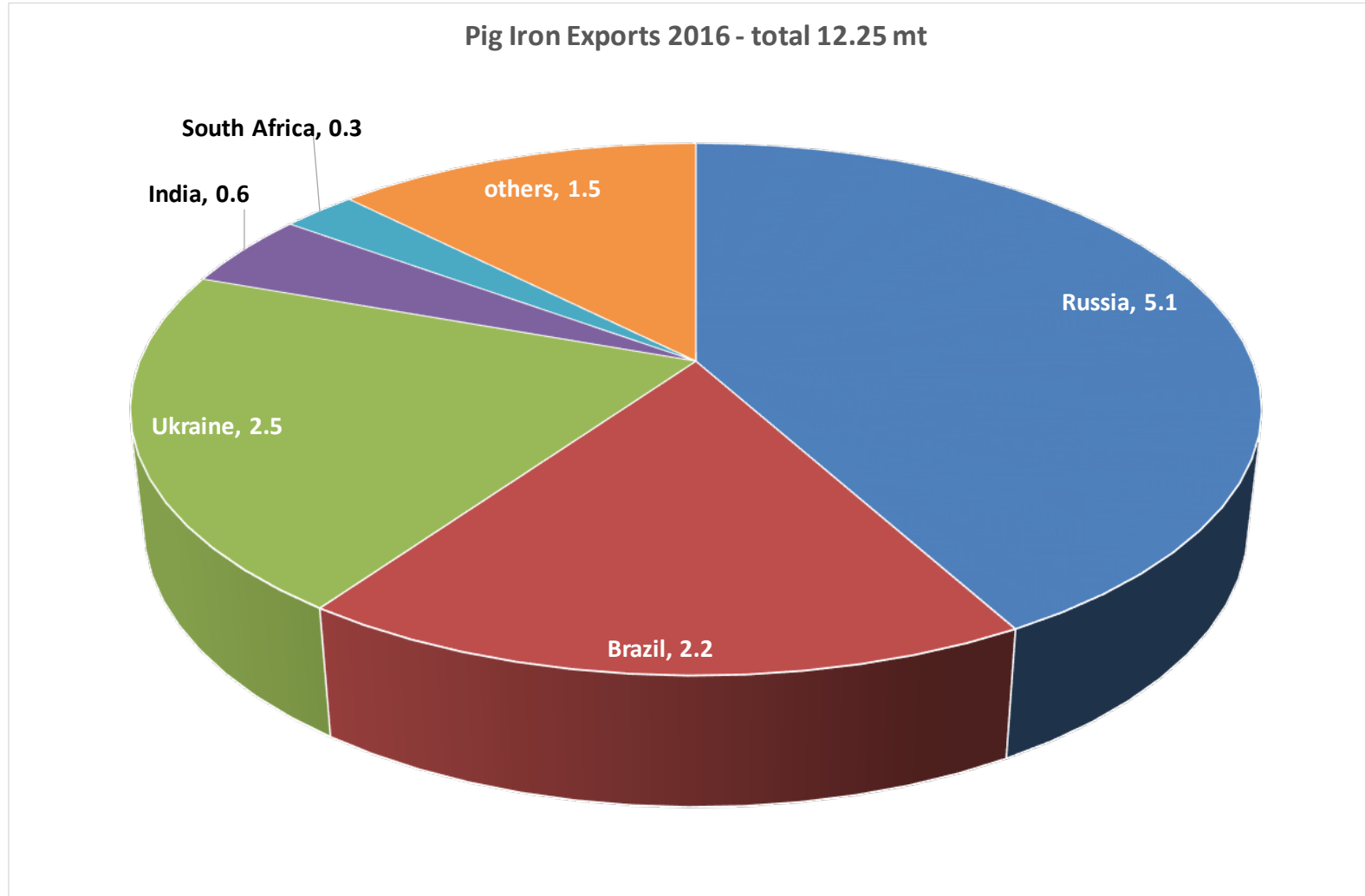
What are the principal markets for OBM's?

- **Outside China, the principal EAF steel markets for OBM's are:**
 - the USA, Mexico
 - in Europe: Turkey, Italy and Spain
 - in Asia: India, South Korea, Taiwan
 - the Middle East
- **The principal foundry markets for pig iron are the major iron casting nations of China, USA, India, Germany, Japan, Russia, South Korea, Mexico, Brazil and Italy.**

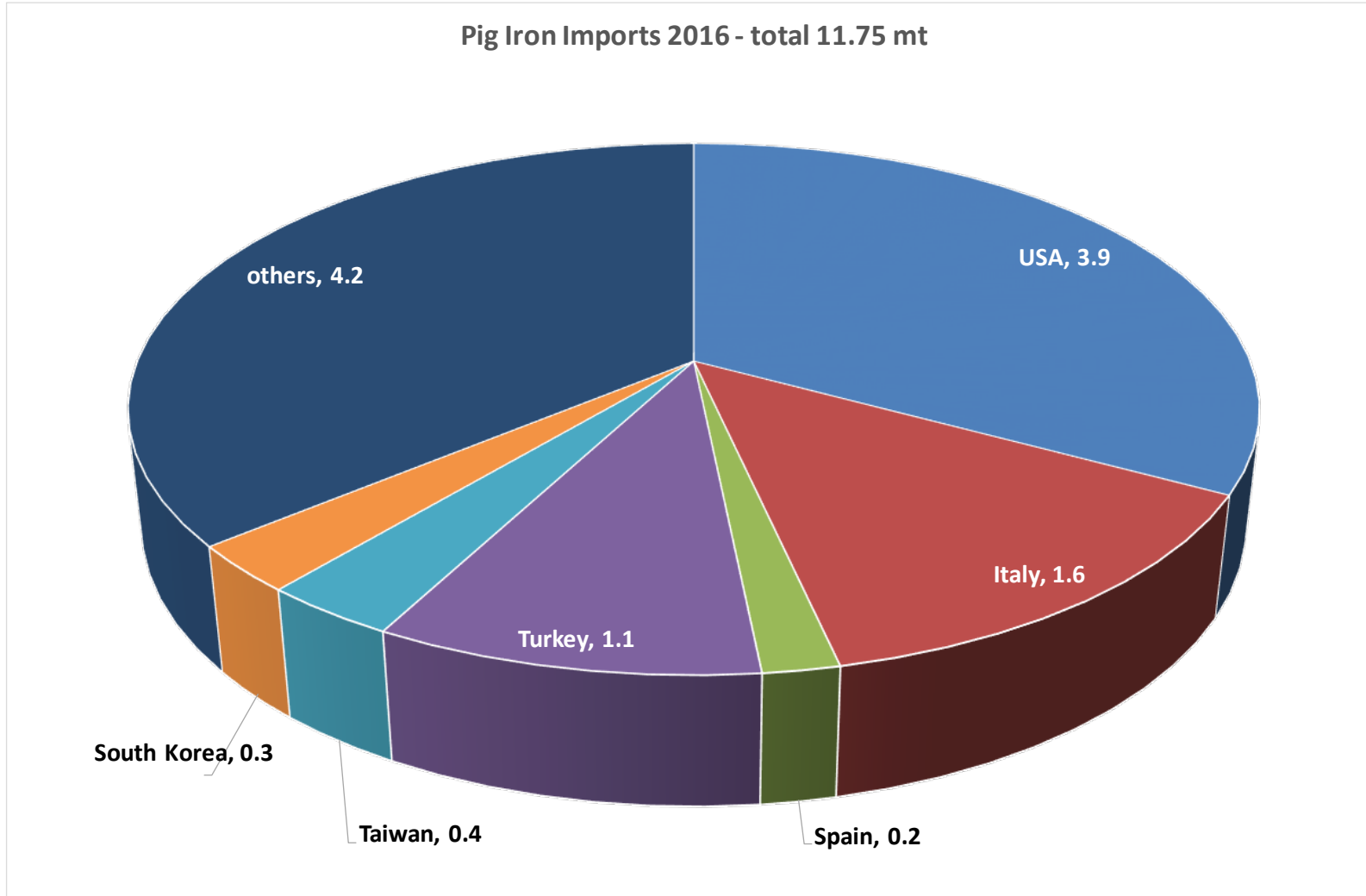
Cross border trade in pig iron



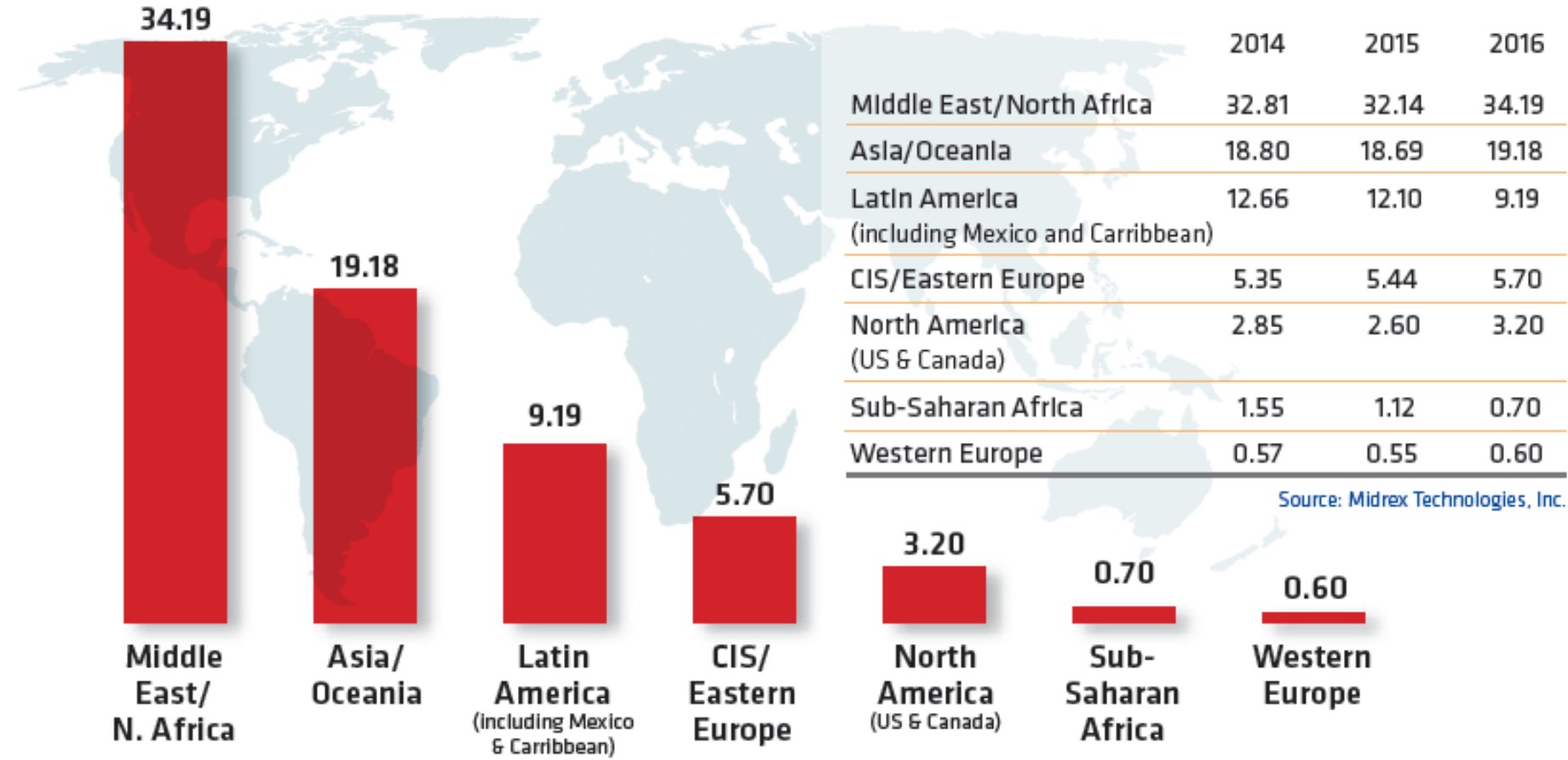
Distribution of pig iron exports in 2016



Distribution of pig iron imports in 2016



2016 World DRI Production by Region (Mt)

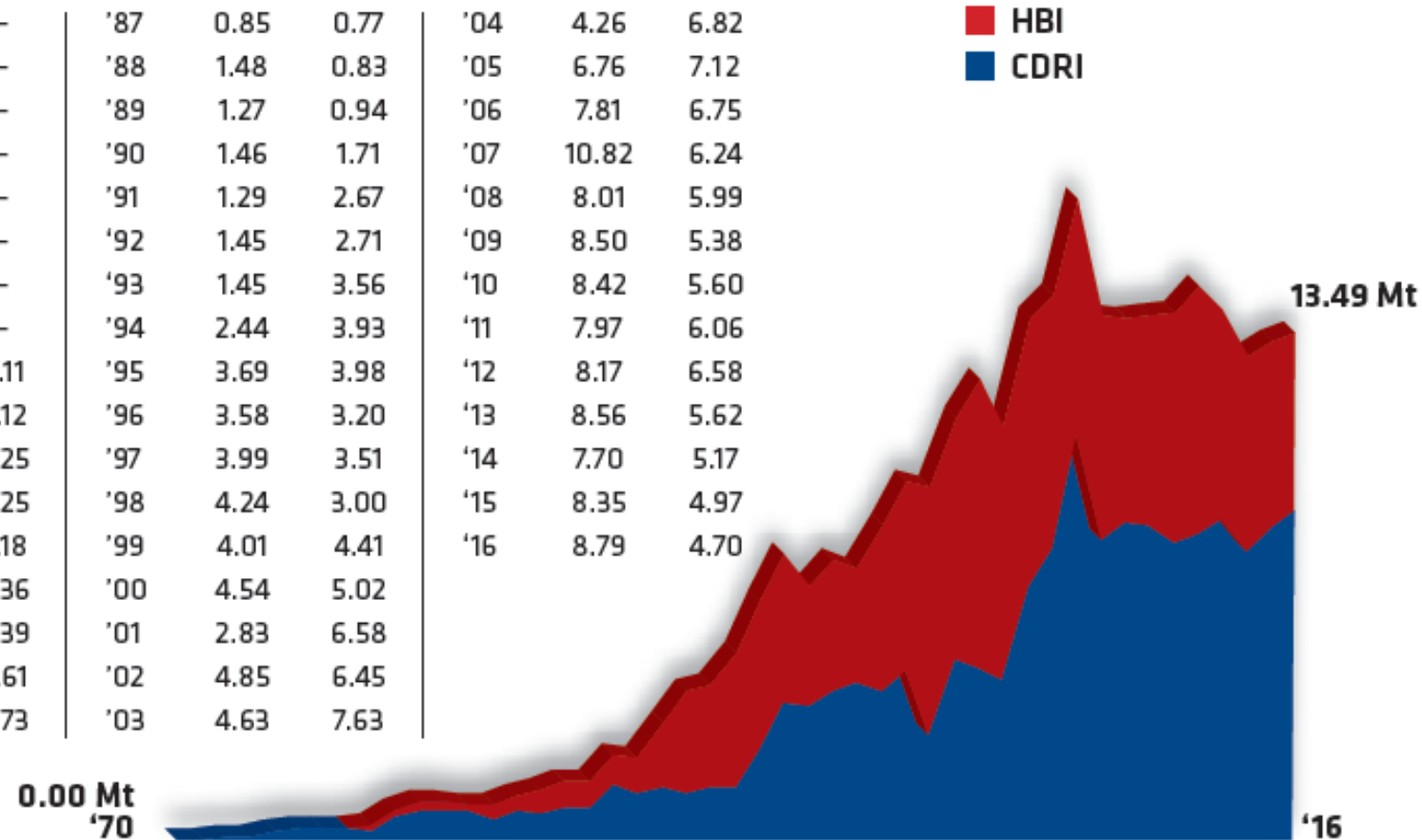


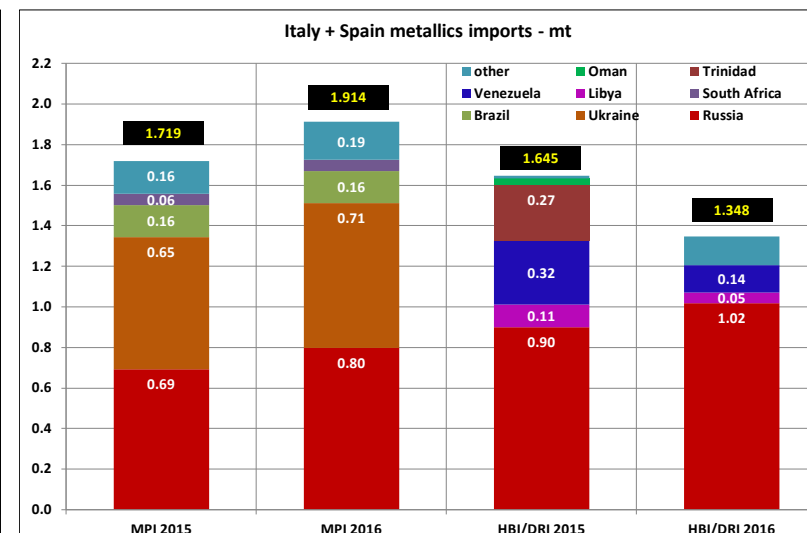
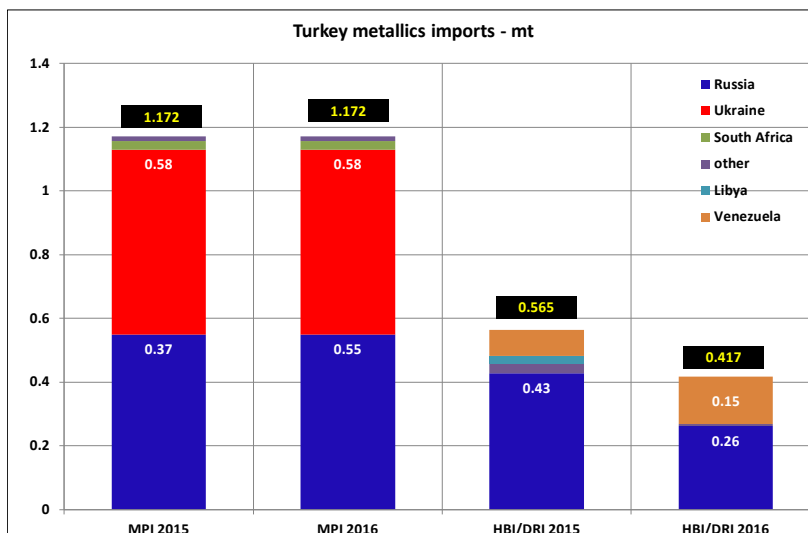
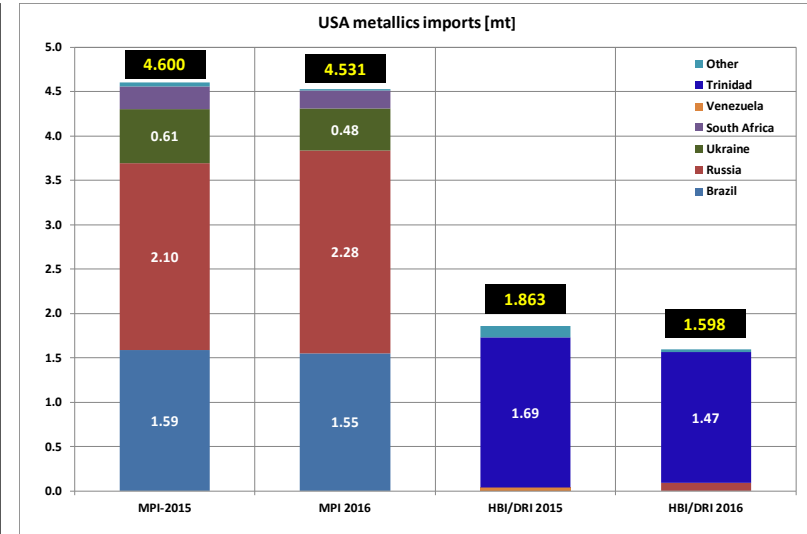
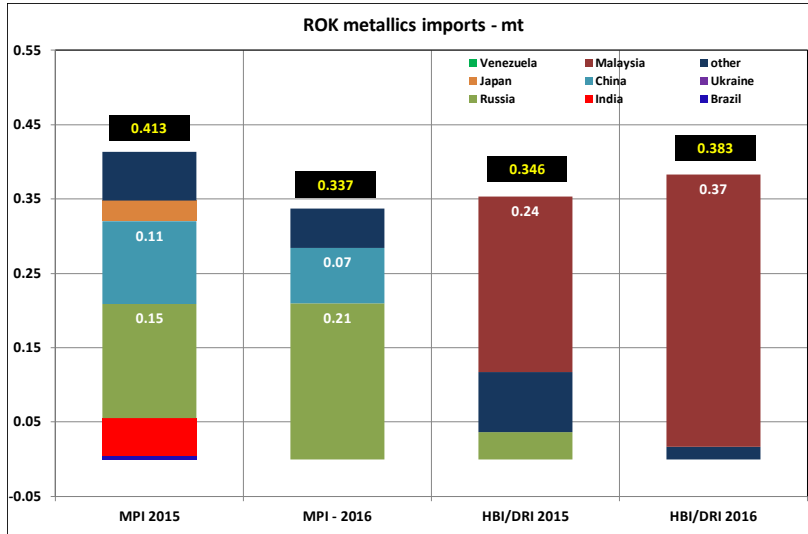
World DRI shipments

World DRI Shipments (Mt)

Source: Midrex Technologies, Inc.

Year	CDRI	HBI	Year	CDRI	HBI	Year	CDRI	HBI
'70	0.00	-	'87	0.85	0.77	'04	4.26	6.82
'71	0.04	-	'88	1.48	0.83	'05	6.76	7.12
'72	0.08	-	'89	1.27	0.94	'06	7.81	6.75
'73	0.13	-	'90	1.46	1.71	'07	10.82	6.24
'74	0.26	-	'91	1.29	2.67	'08	8.01	5.99
'75	0.34	-	'92	1.45	2.71	'09	8.50	5.38
'76	0.37	-	'93	1.45	3.56	'10	8.42	5.60
'77	0.32	-	'94	2.44	3.93	'11	7.97	6.06
'78	0.28	0.11	'95	3.69	3.98	'12	8.17	6.58
'79	0.66	0.12	'96	3.58	3.20	'13	8.56	5.62
'80	0.81	0.25	'97	3.99	3.51	'14	7.70	5.17
'81	0.83	0.25	'98	4.24	3.00	'15	8.35	4.97
'82	0.80	0.18	'99	4.01	4.41	'16	8.79	4.70
'83	0.59	0.36	'00	4.54	5.02			
'84	0.83	0.39	'01	2.83	6.58			
'85	0.71	0.61	'02	4.85	6.45			
'86	0.89	0.73	'03	4.63	7.63			





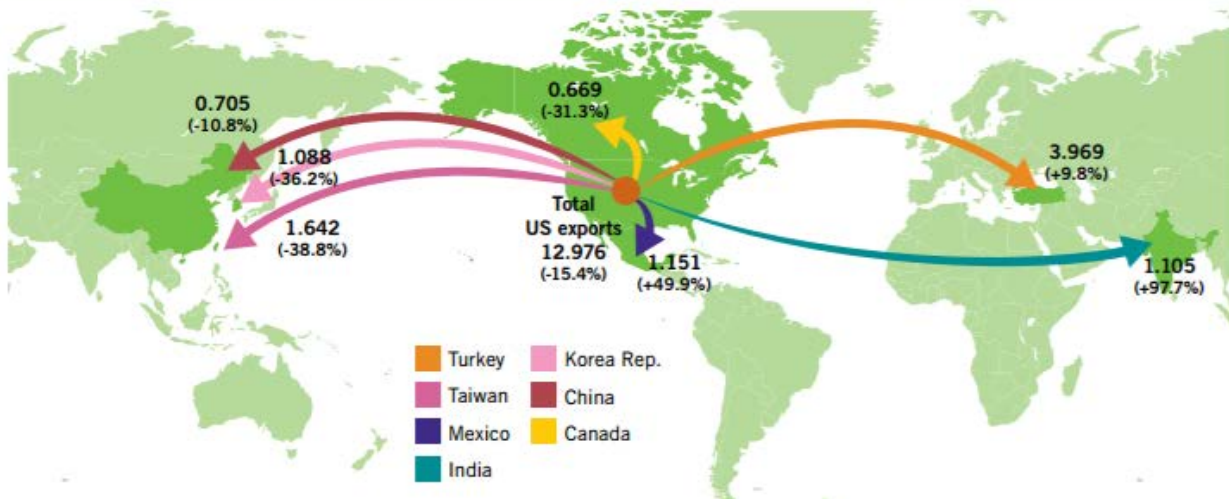
- **The market can be divided into two parts logistically:**
 - full ship or barge loads delivered directly to steel companies or large foundries
 - truckloads delivered from intermediate stockpiles to foundries
- **In terms of supply chain, there are two principal mechanisms:**
 - direct sales by producers to end users, either by direct shipment or via producer-owned stockpiles
 - sales to end users via traders and distributors, either by direct shipment or via their own stockpiles
- **In practice, most business is done by traders and distributors which provide financing to the supply chain.**

- **Full shipload business is generally concluded on a shipment-by-shipment basis with the price being negotiated against the background of then current market circumstances.**
- **Distributor business is generally done either on a truckload-by-truckload basis or against a weekly, monthly or quarterly offtake schedule with the price being fixed on a monthly or quarterly basis.**
- **Payment terms vary from pre-shipment financing to letter of credit payment on loading of vessels to monthly credit terms for truckload business.**
- **Sales contracts cover delivery schedule and shipping conditions, price and payment terms, payable weight and product specifications, etc.**

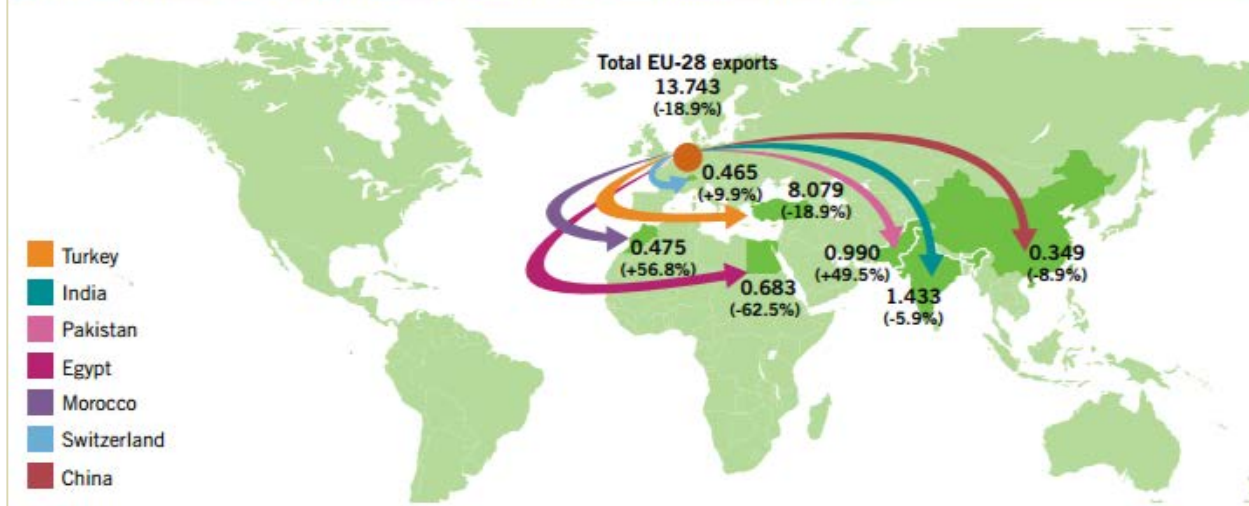
- **There are several drivers of OBM prices**
 - First and foremost, OBM prices are driven by steel scrap prices which can vary from region to region (e.g. North America, Europe, Far East) and within regions (in USA, mid-west, south, etc.). Scrap prices are themselves driven by supply-demand factors, steel production and price levels, etc.
- **By virtue of their high value-in-use, OBM's predominantly sell at a premium to scrap, but not always.**
- **Commodity prices along the steel value chain tend to follow the same general trend over the longer term**
 - iron ore, coal/coke, OBM's, scrap, steel semis, steel products
- **In the short term, supply-side and demand-side issues can distort traditional pricing relationships and lead to temporary changes in the main price drivers**

Main scrap trade flows

MAIN FLOWS OF US STEEL SCRAP EXPORTS 2015 (MILLION TONNES)

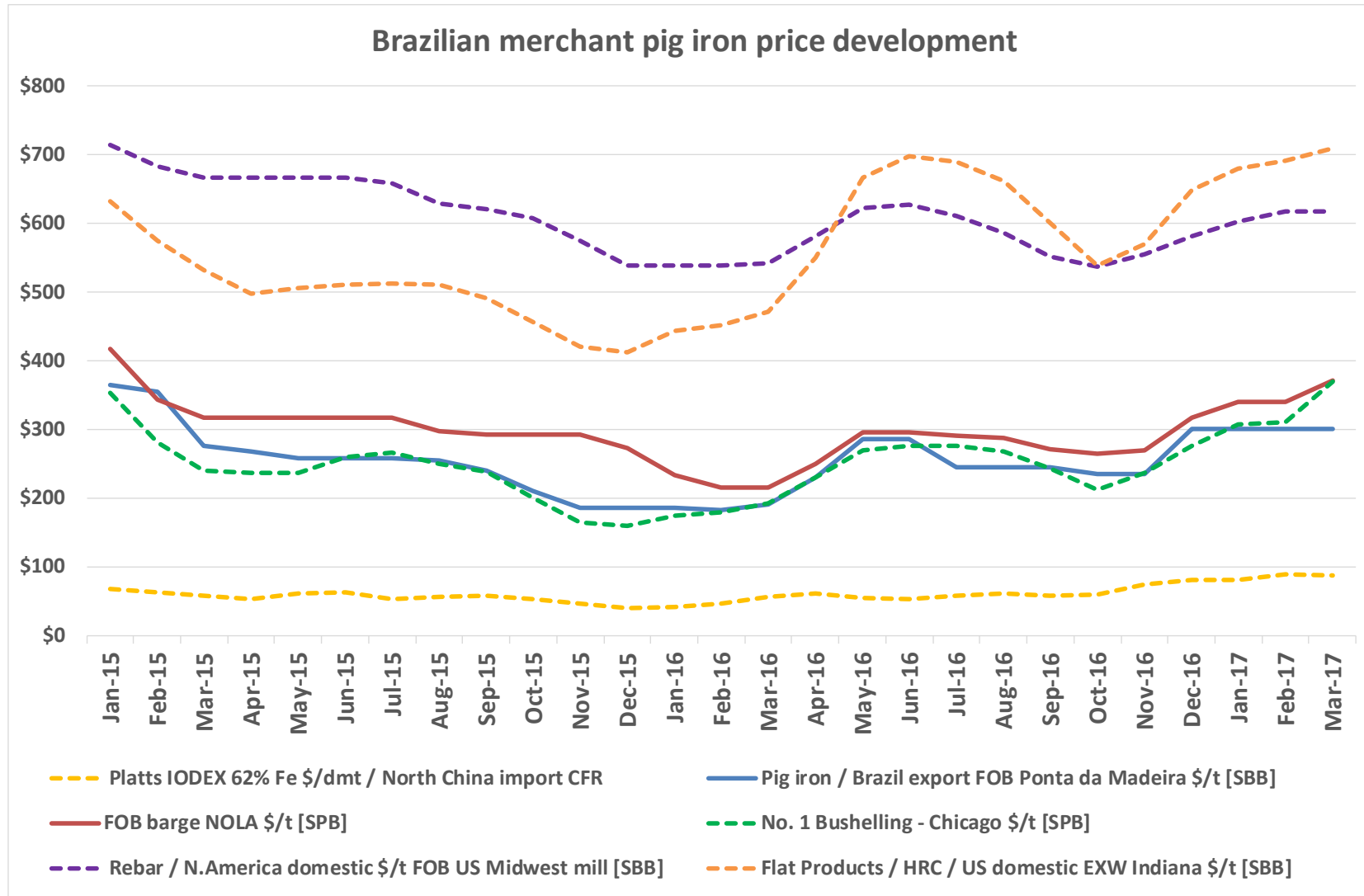


MAIN FLOWS OF EU-28 STEEL SCRAP EXPORTS 2015 (MILLION TONNES)

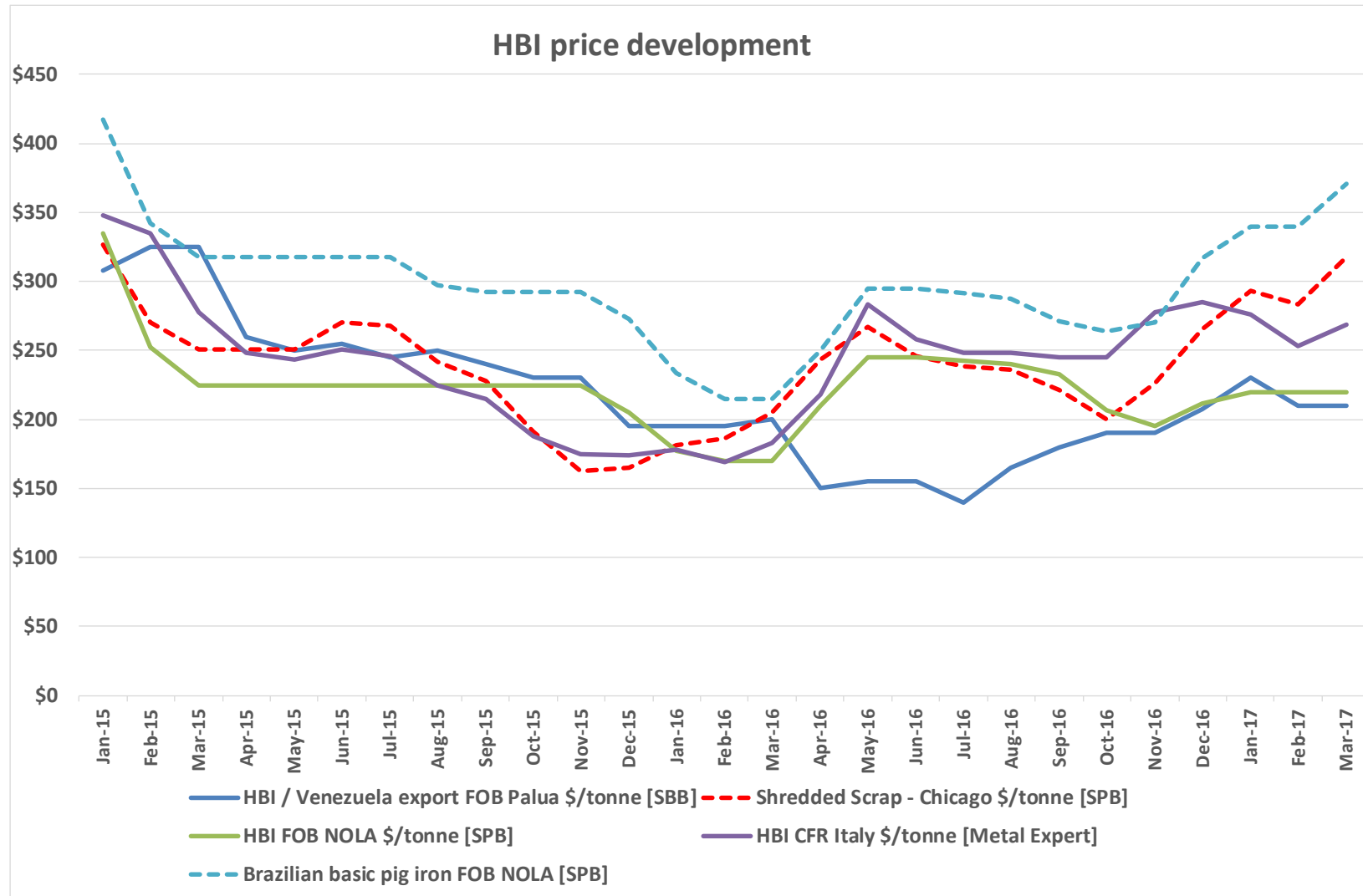


Information source: BIR

Price development along the steel value chain



Price development along the steel value chain



Price references for OBM's

- **There are several reference price series published by media companies, based mainly on contacts with trade players:**
 - Platts/SBB, Metal Bulletin/AMM, CRU, SteelHome, Mysteel, umetal
 - it is important to understand the basis on which prices are quoted in order to compare “apples with apples”
- **There is no “scientifically” calculated index for OBM prices as for iron ore. The issue is that there is probably not sufficient trade volume and liquidity to justify the cost of creating one.**
- **There is a degree of correlation between OBM prices and, say iron ore and scrap prices, but are the latter suitable proxies for OBM's?**
 - IODEX, Metal Bulletin and The Steel Index for iron ore
 - LME and Steel Benchmarker for steel scrap

Further information

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IIMA member contact details available on website