Vanadium Market Analysis

Terry Perles

TTP Squared, Inc.

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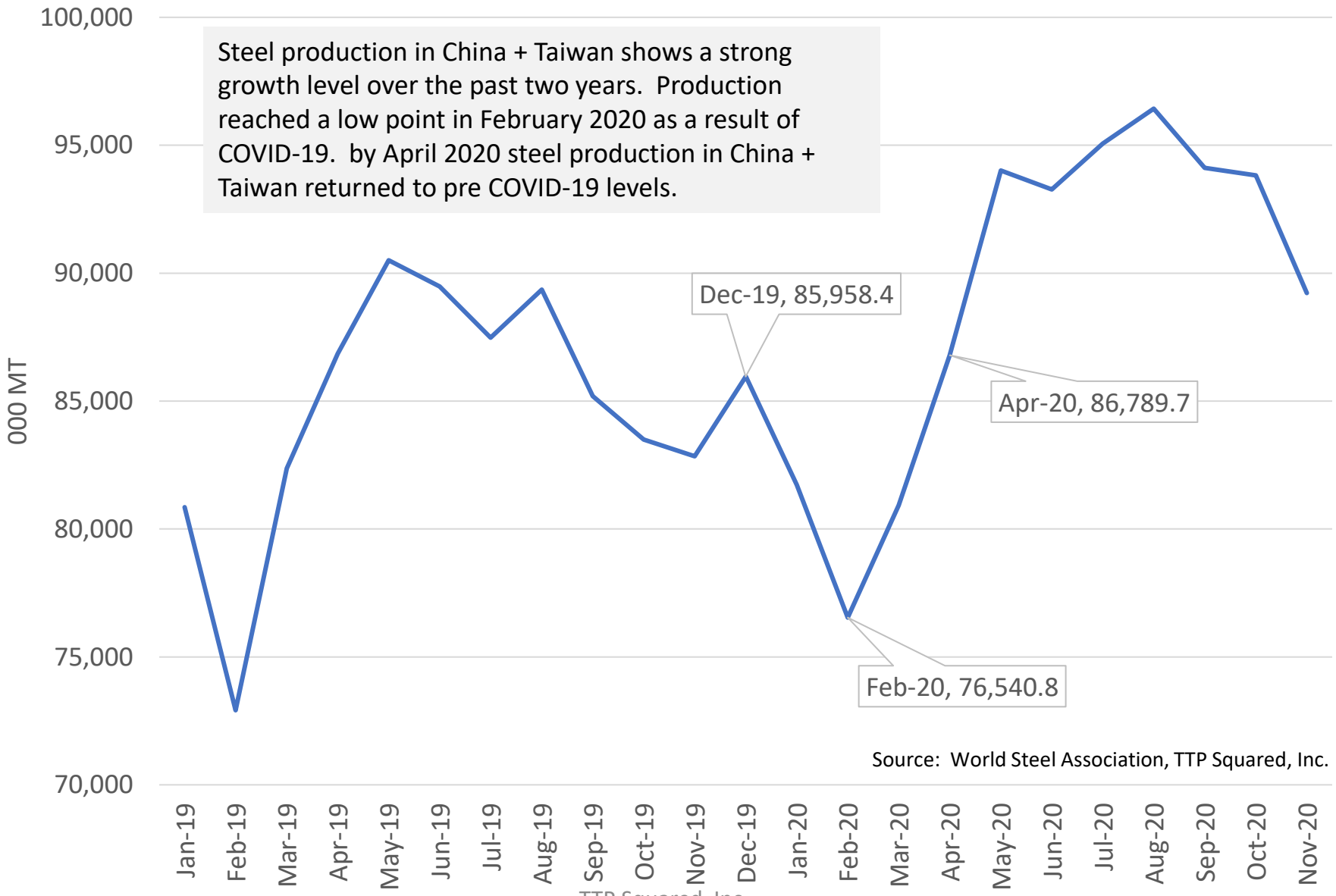
Summary

- The forecast for 2020 indicates global production of 109,187 MTV vs global consumption of 107,554 leading to a surplus of 1,633 MTV in 2020.
- As global steel production recovers following COVID-19 and the specific vanadium consumption rate in China continues to move up on the back of growing use of vanadium in rebar we expect that in 2021 global consumption will grow to 118,000 MTV.
- Global production of vanadium will grow moderately in 2021 to 113,000 MTV.
- In summary we expect global vanadium consumption to outstrip production by more than 5,000 MTV in 2021.

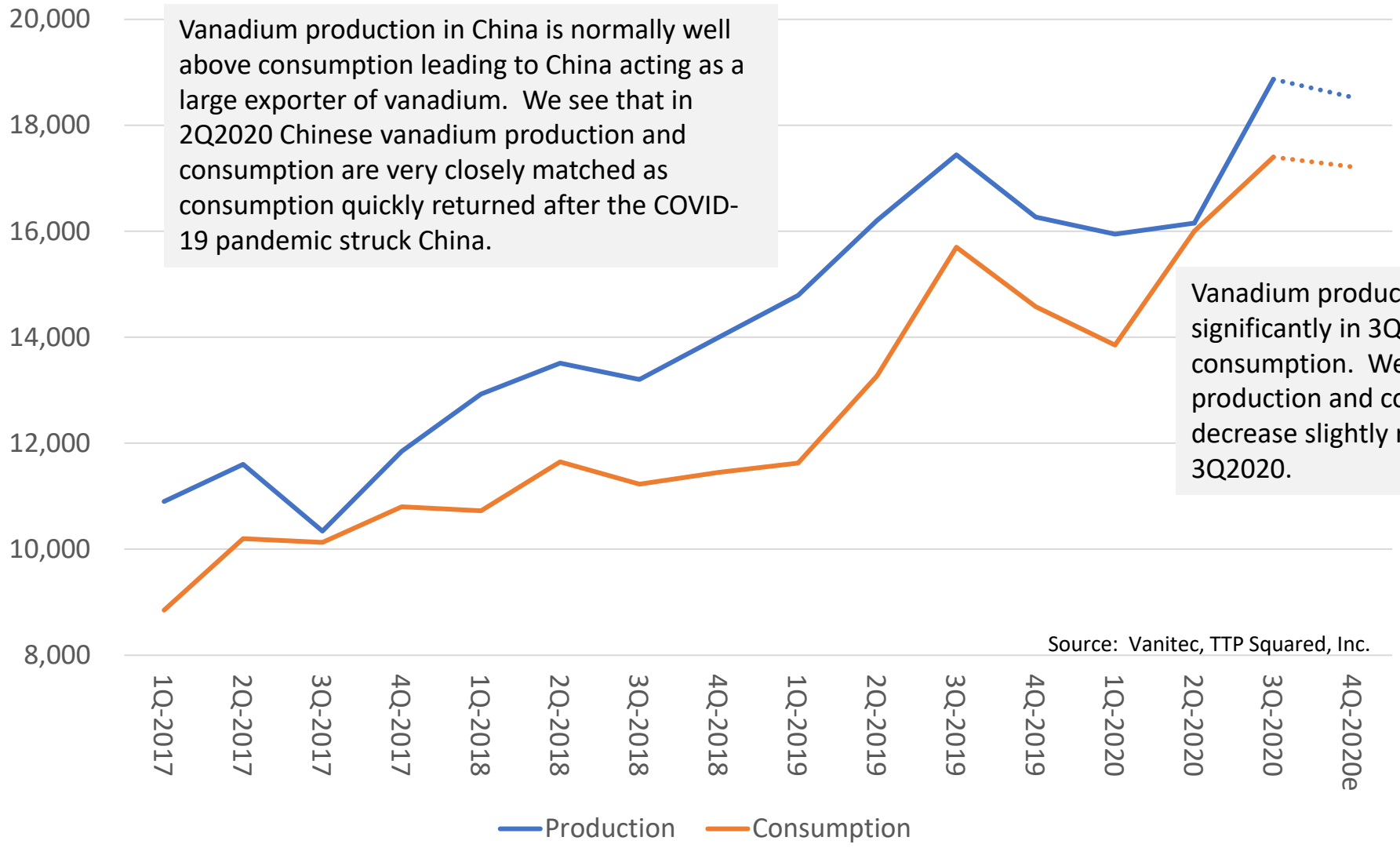
Vanadium Production and Consumption

Steel Production China + Taiwan



Source: World Steel Association, TTP Squared, Inc.

China+Taiwan Quarterly Vanadium Production and Consumption

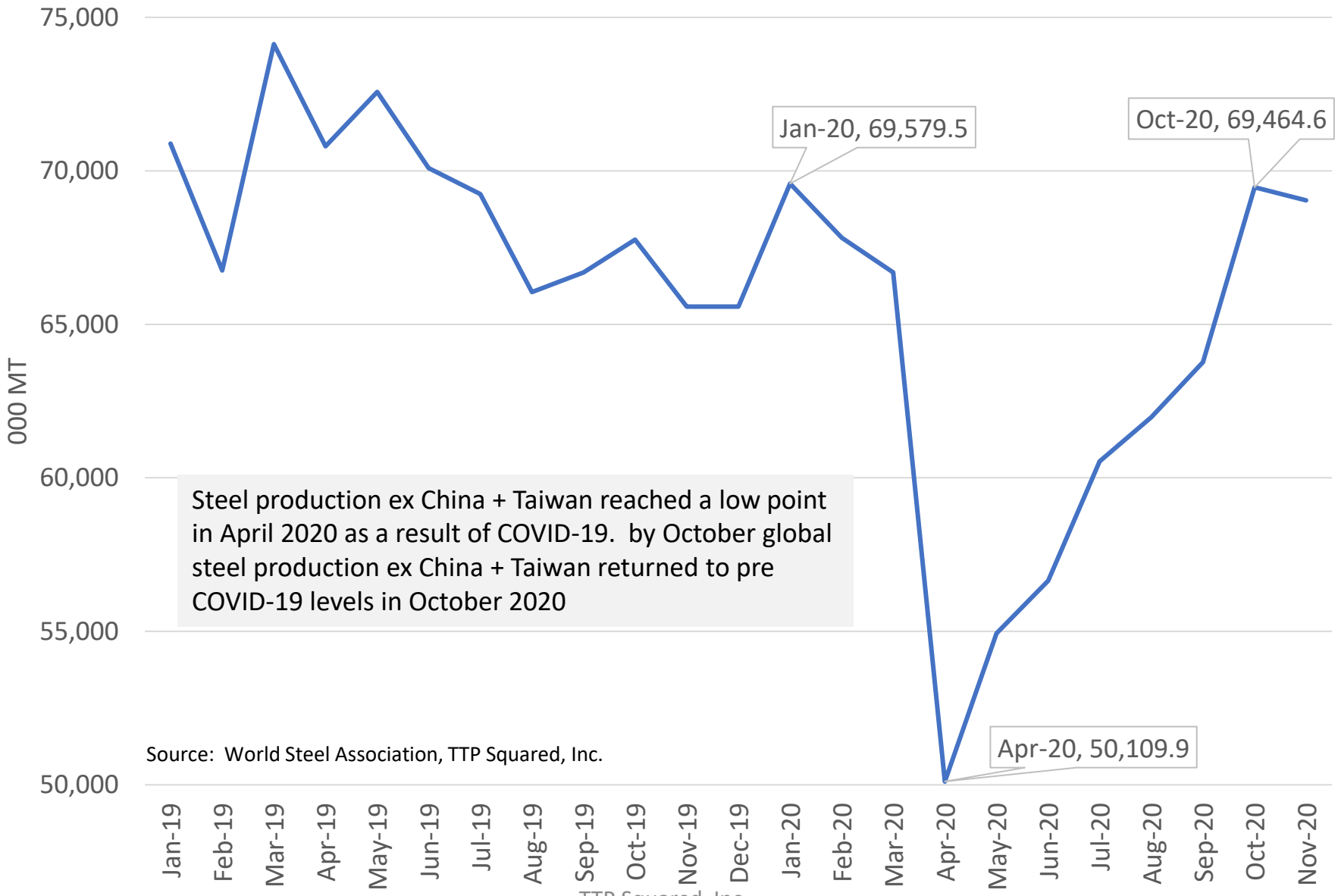


Vanadium production in China is normally well above consumption leading to China acting as a large exporter of vanadium. We see that in 2Q2020 Chinese vanadium production and consumption are very closely matched as consumption quickly returned after the COVID-19 pandemic struck China.

Vanadium production in China grew significantly in 3Q2020 as did consumption. We expect 4Q2020 production and consumption to decrease slightly relative to 3Q2020.

Source: Vanitec, TTP Squared, Inc.

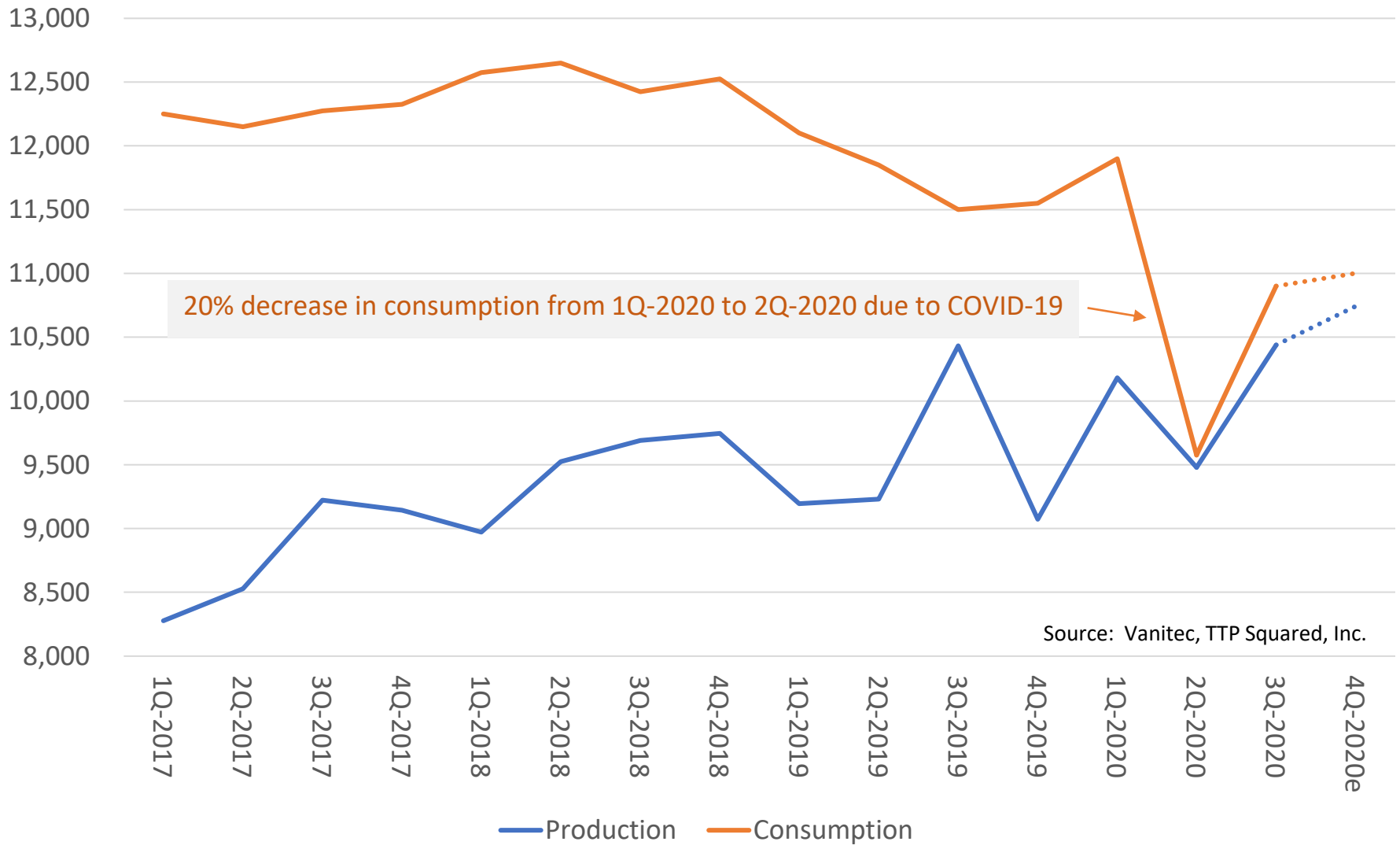
Steel Production ex China + Taiwan



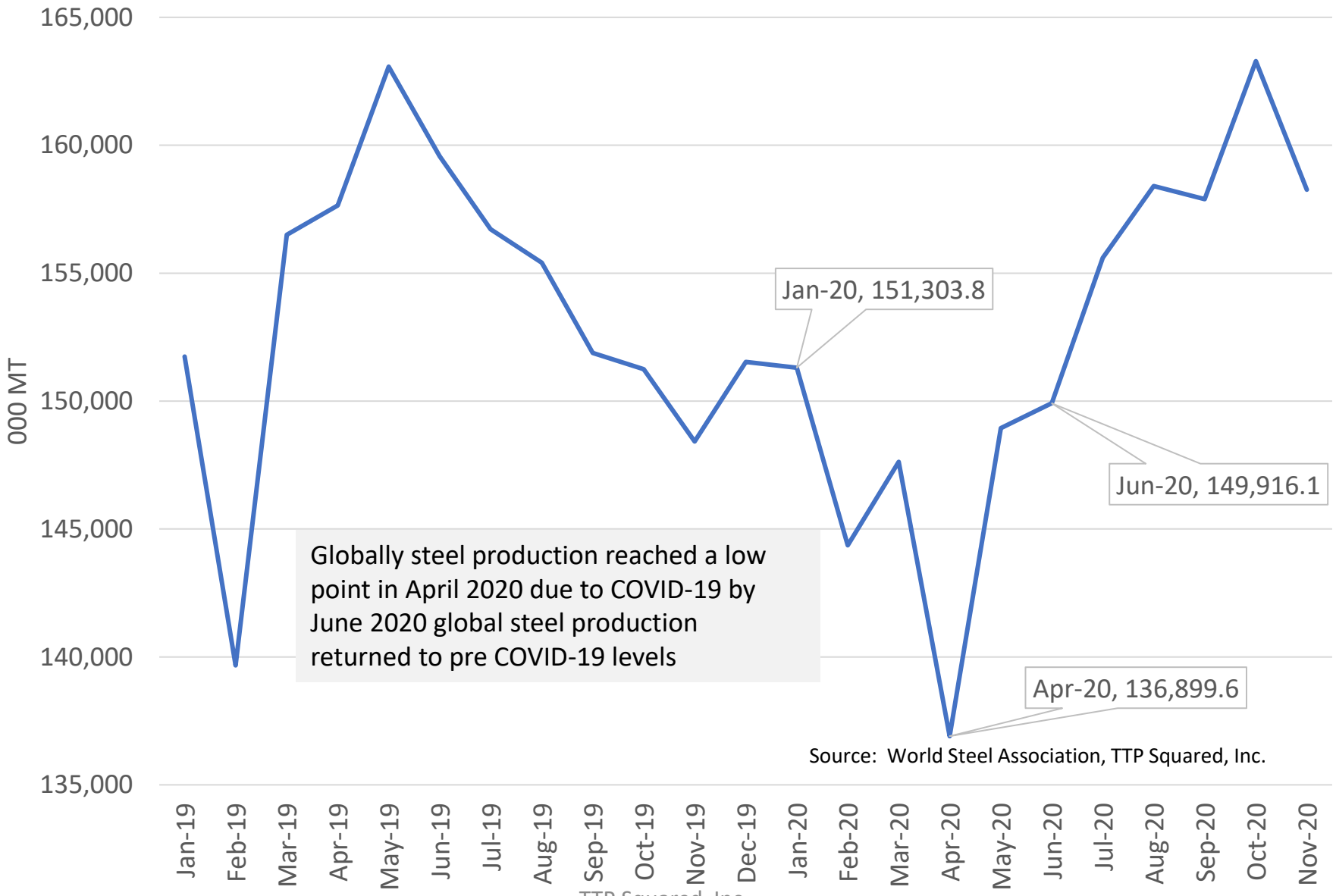
Steel production ex China + Taiwan reached a low point in April 2020 as a result of COVID-19. by October global steel production ex China + Taiwan returned to pre COVID-19 levels in October 2020

Source: World Steel Association, TTP Squared, Inc.

ex China+Taiwan Quarterly Vanadium Production and Consumption



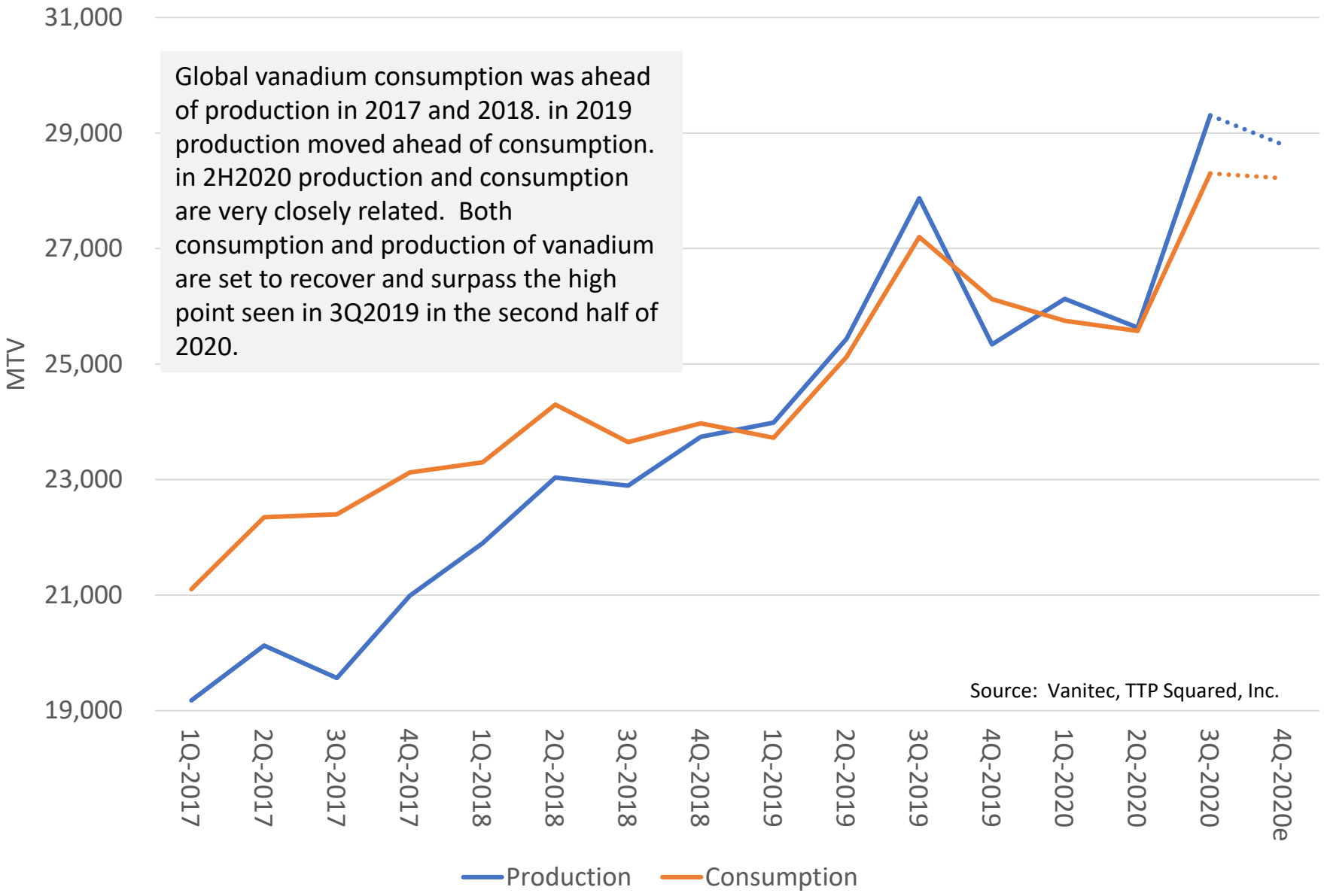
World Steel Production



Globally steel production reached a low point in April 2020 due to COVID-19 by June 2020 global steel production returned to pre COVID-19 levels

Source: World Steel Association, TTP Squared, Inc.

Global Quarterly Vanadium Production and Consumption



Global vanadium consumption was ahead of production in 2017 and 2018. in 2019 production moved ahead of consumption. in 2H2020 production and consumption are very closely related. Both consumption and production of vanadium are set to recover and surpass the high point seen in 3Q2019 in the second half of 2020.

Source: Vanitec, TTP Squared, Inc.

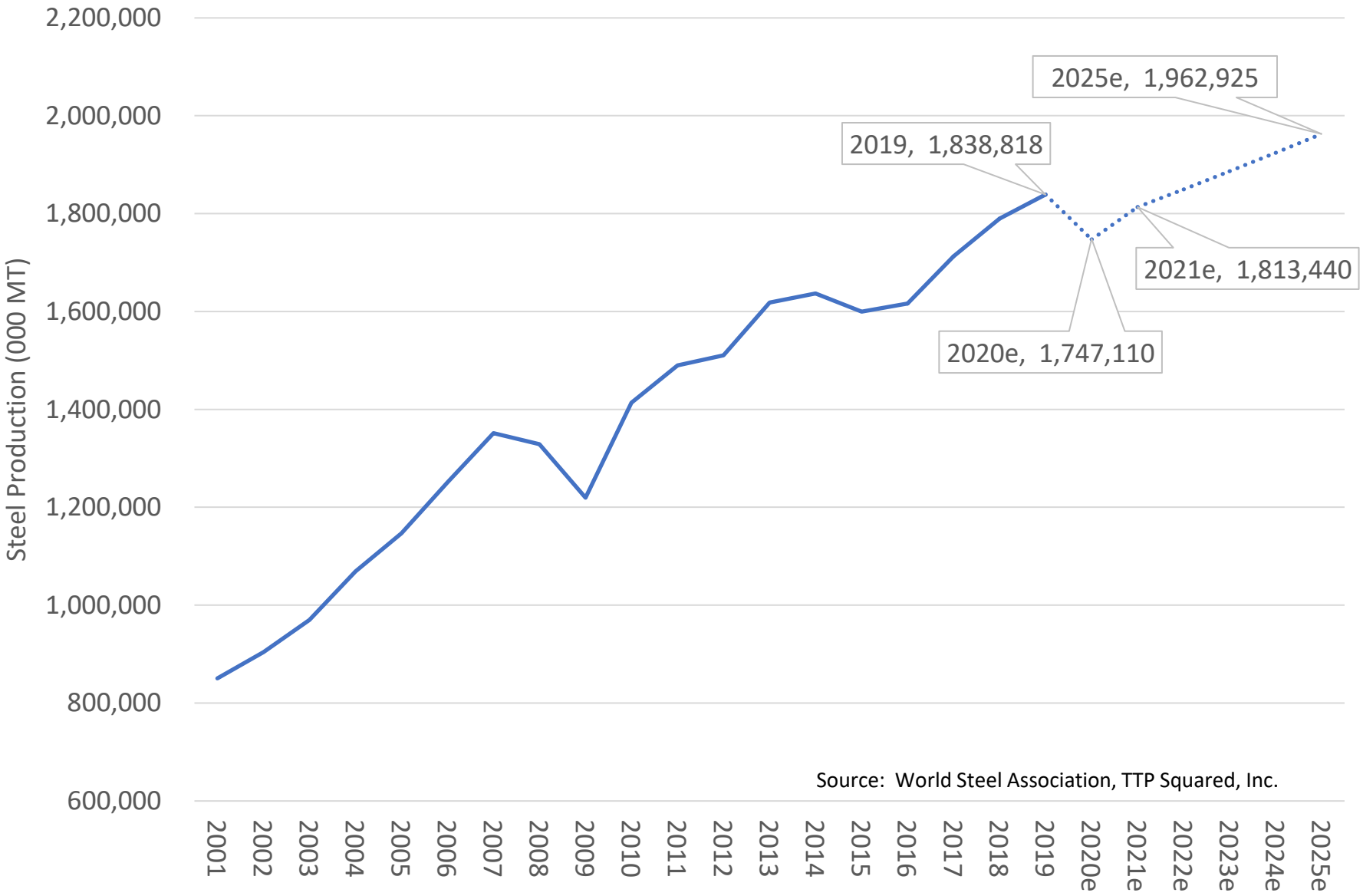
Global Vanadium Market Data

V Consumption									
Ex China	**1Q2019**	**2Q2019**	**3Q2019**	**4Q2019**	**1Q2020**	**2Q2020**	**3Q2020**	**4Q2020e**	**2020e total**
Steel Production (million MT)	217,476	219,168	207,470	203,961	209,629	166,891	189,423	191,411	**757,354**
KgV/MT Steel	0.056	0.054	0.055	0.057	0.057	0.057	0.057	0.057	**0.057**
Total Vanadium (MTV)	12,100	11,850	11,500	11,550	11,900	9,575	10,887	11,001	**43,363**
China									
Steel Production	230,434	261,115	256,544	246,072	233,677	268,879	280,759	277,666	**1,060,981**
KgV/MT Steel	0.050	0.051	0.061	0.059	0.059	0.060	0.061	0.062	**0.061**
Total Vanadium (MTV)	11,625	13,275	15,700	14,575	13,850	16,000	17,126	17,215	**64,192**
World Total									
Steel Production	447,910	480,283	464,013	450,034	443,305	435,770	470,182	469,077	**1,818,334**
KgV/MT Steel	0.053	0.052	0.059	0.058	0.058	0.059	0.060	0.060	**0.059**
Total Vanadium (MTV)	23,725	25,125	27,200	26,125	25,750	25,575	28,013	28,216	**107,554**
V Production (MTV)									
China	14,791	16,205	17,440	16,266	15,946	16,155	19,329	18,528	**69,958**
ex China	9,194	9,230	10,432	9,073	10,182	9,479	9,784	9,784	**39,229**
Total	**23,985**	**25,435**	**27,872**	**25,339**	**26,128**	**25,634**	**29,113**	**28,312**	**109,187**
Inventory Change China	**3,166**	**2,930**	**1,740**	**1,691**	**2,096**	**155**	**2,203**	**1,313**	**5,766**
Inventory Change ex China	**(2,906)**	**(2,620)**	**(1,068)**	**(2,477)**	**(1,718)**	**(96)**	**(1,103)**	**(1,217)**	**(4,134)**
Total Inventory Change	**260**	**310**	**672**	**(786)**	**378**	**59**	**1,100**	**96**	**1,633**

Source: VANITEC, TTP Squared, Inc.

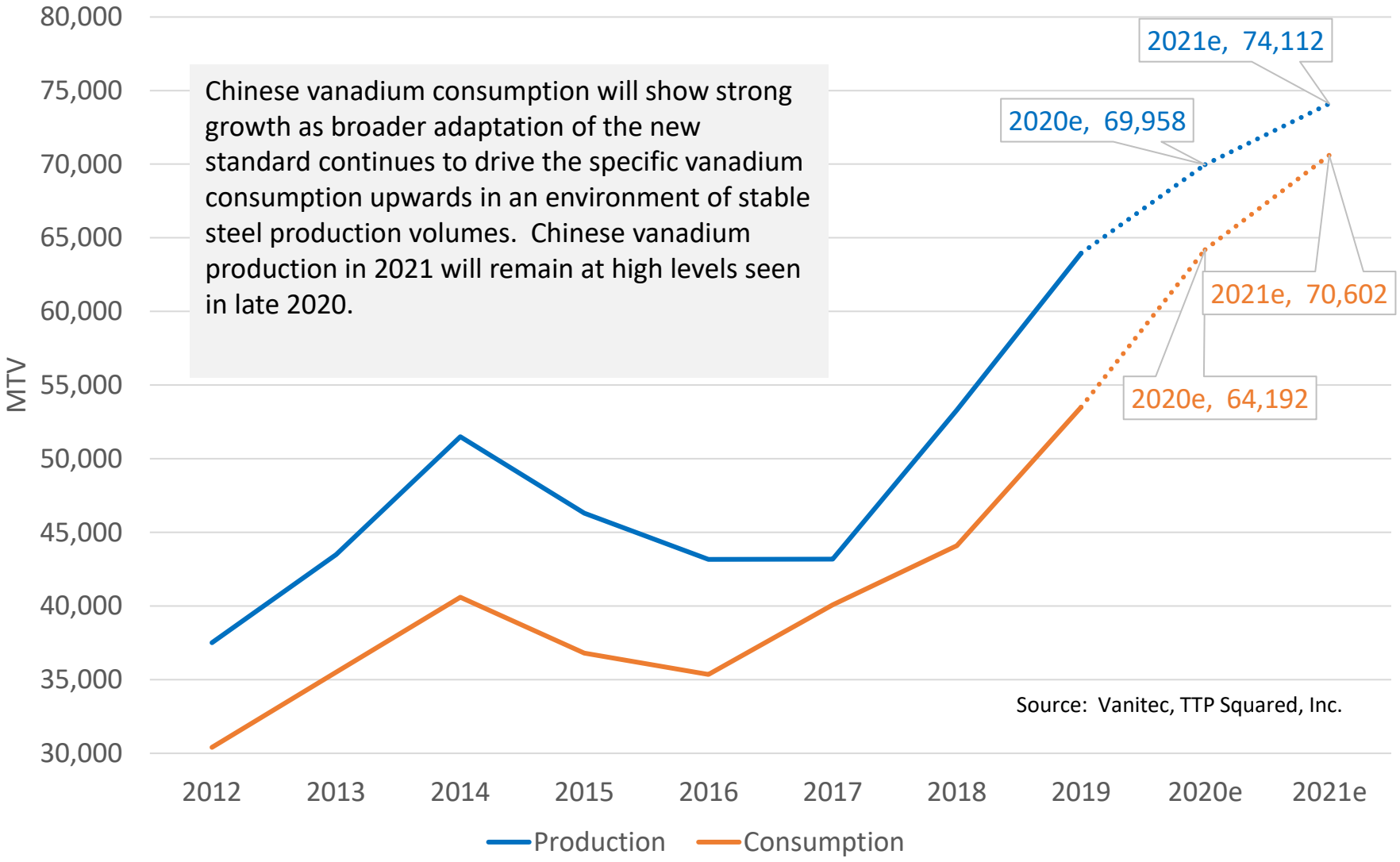
2021 Forecast

Global Annual Steel Production



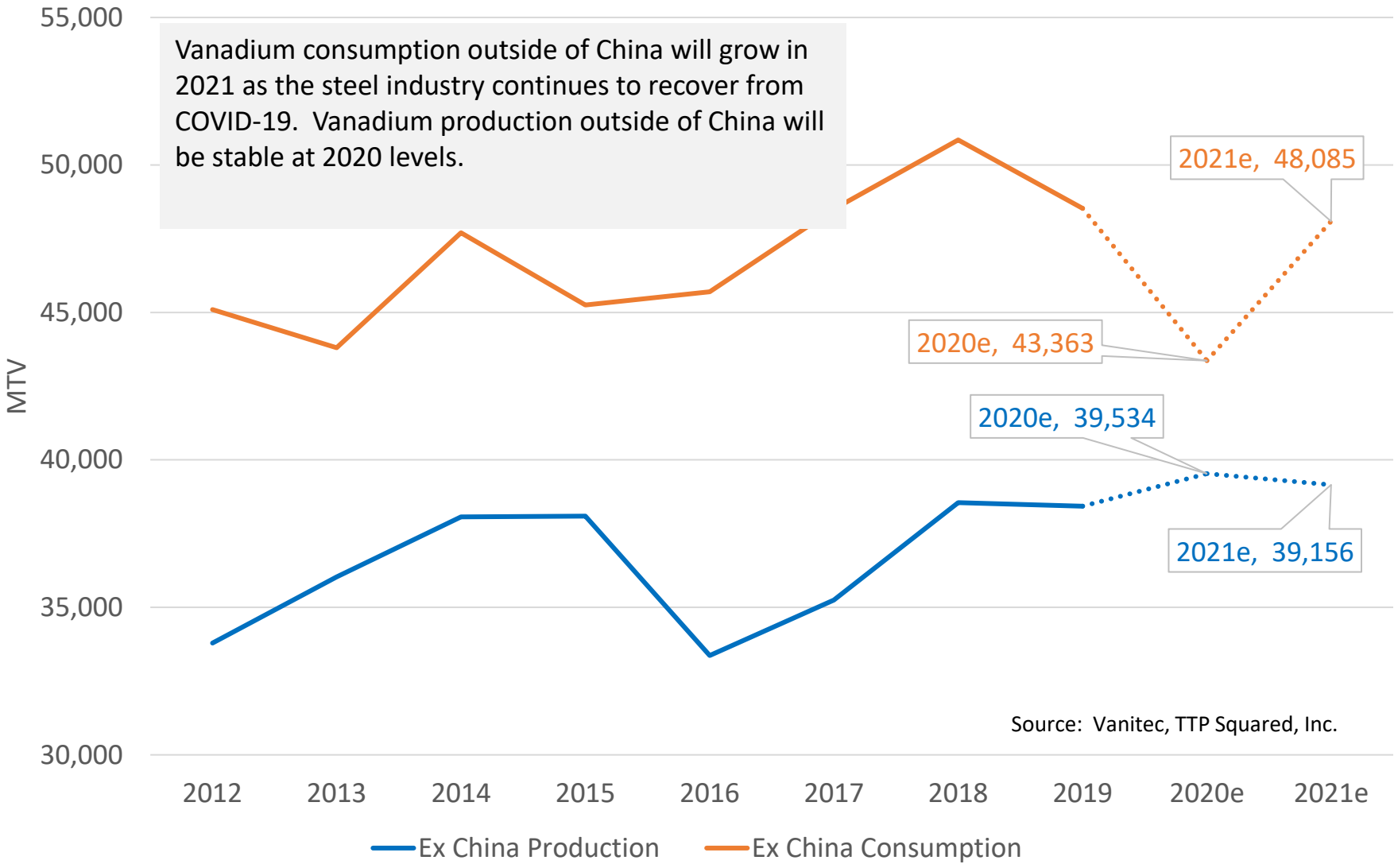
Source: World Steel Association, TTP Squared, Inc.

China + Taiwan Annual Vanadium Production and Consumption

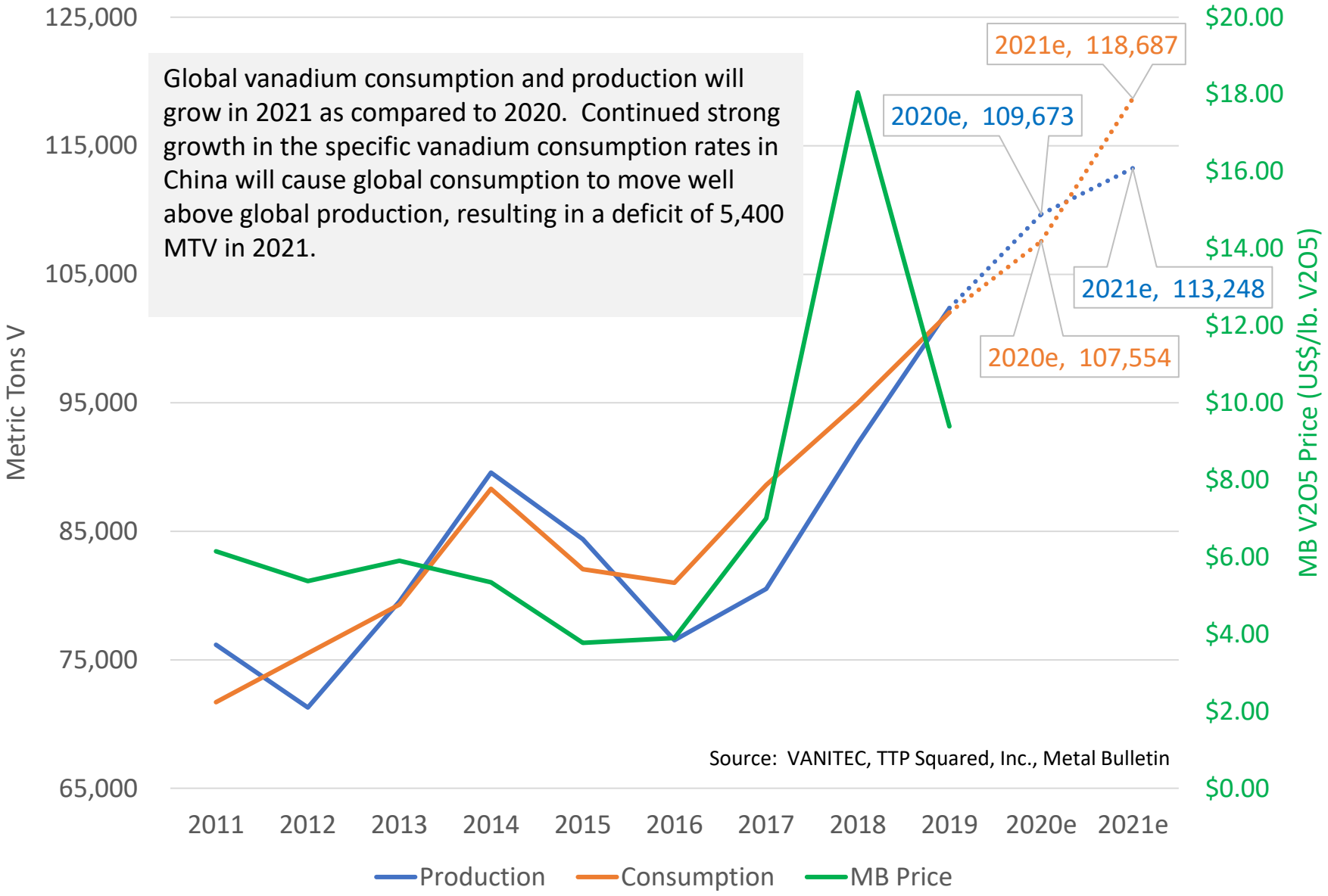


Chinese vanadium consumption will show strong growth as broader adaptation of the new standard continues to drive the specific vanadium consumption upwards in an environment of stable steel production volumes. Chinese vanadium production in 2021 will remain at high levels seen in late 2020.

Ex China Annual Vanadium Production and Consumption



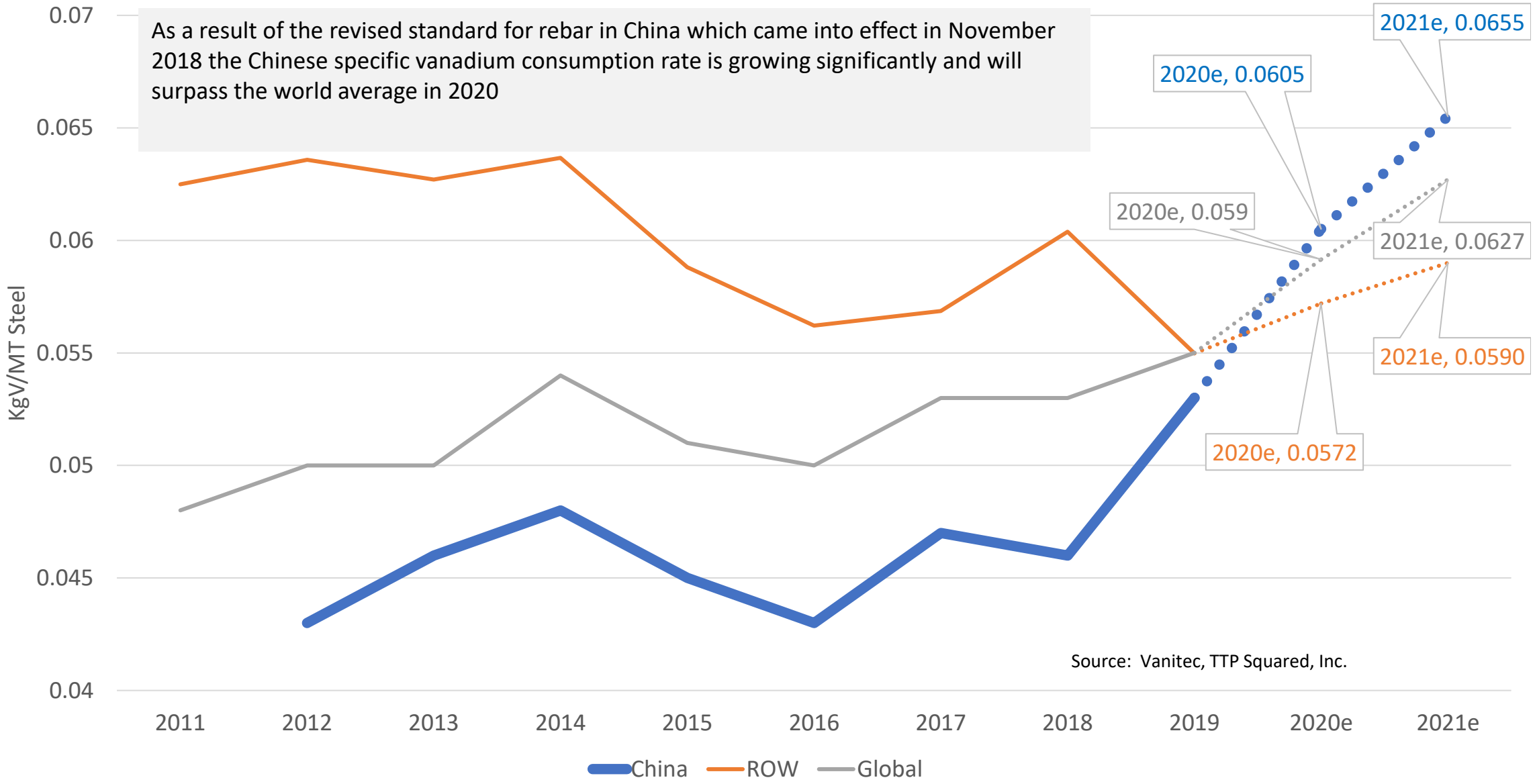
Global Annual Vanadium Production & Consumption



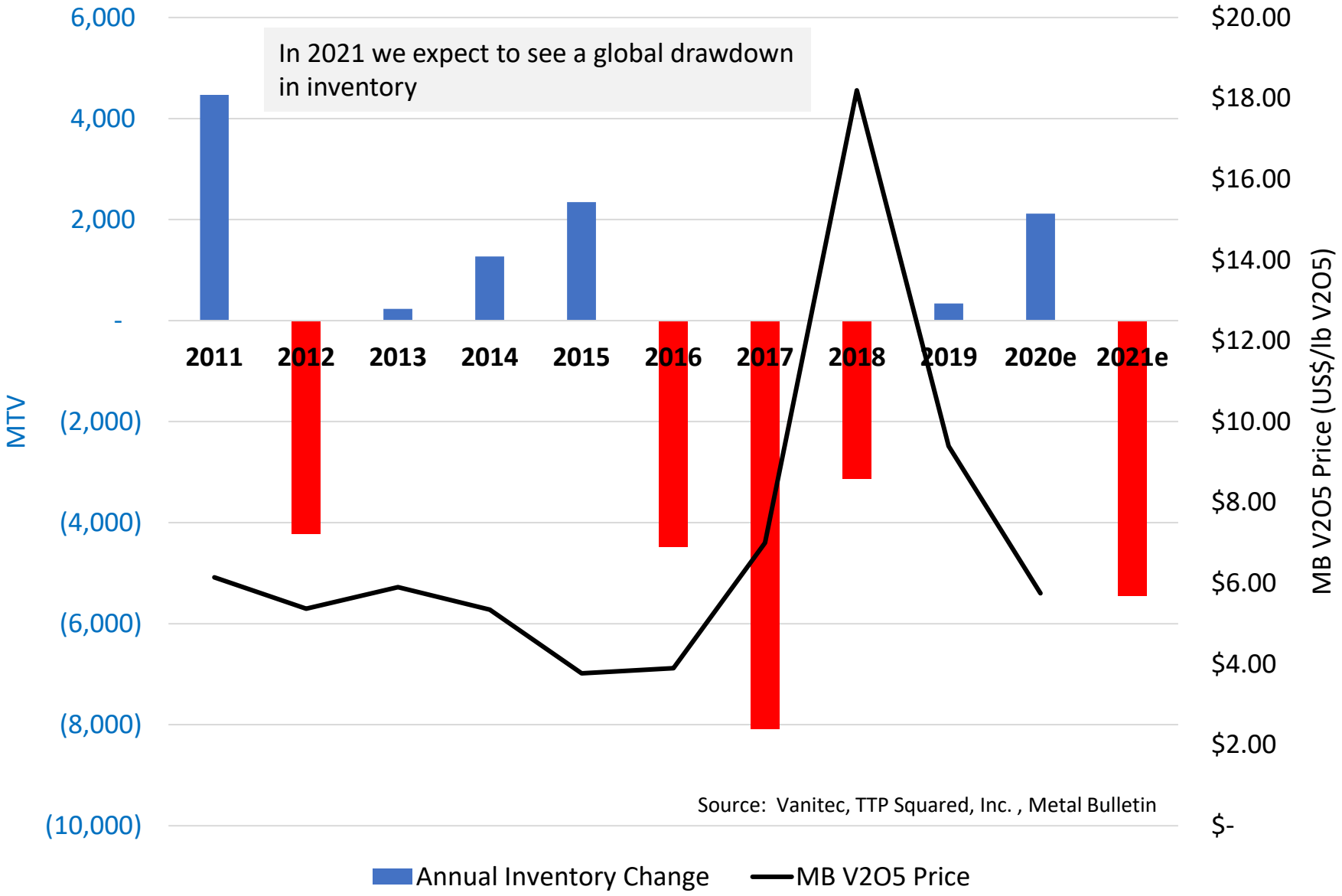
Source: VANITEC, TTP Squared, Inc., Metal Bulletin

Specific vanadium Consumption Rates

As a result of the revised standard for rebar in China which came into effect in November 2018 the Chinese specific vanadium consumption rate is growing significantly and will surpass the world average in 2020



Global Annual Vanadium Inventory Change



Vanadium Market Forecast 2021

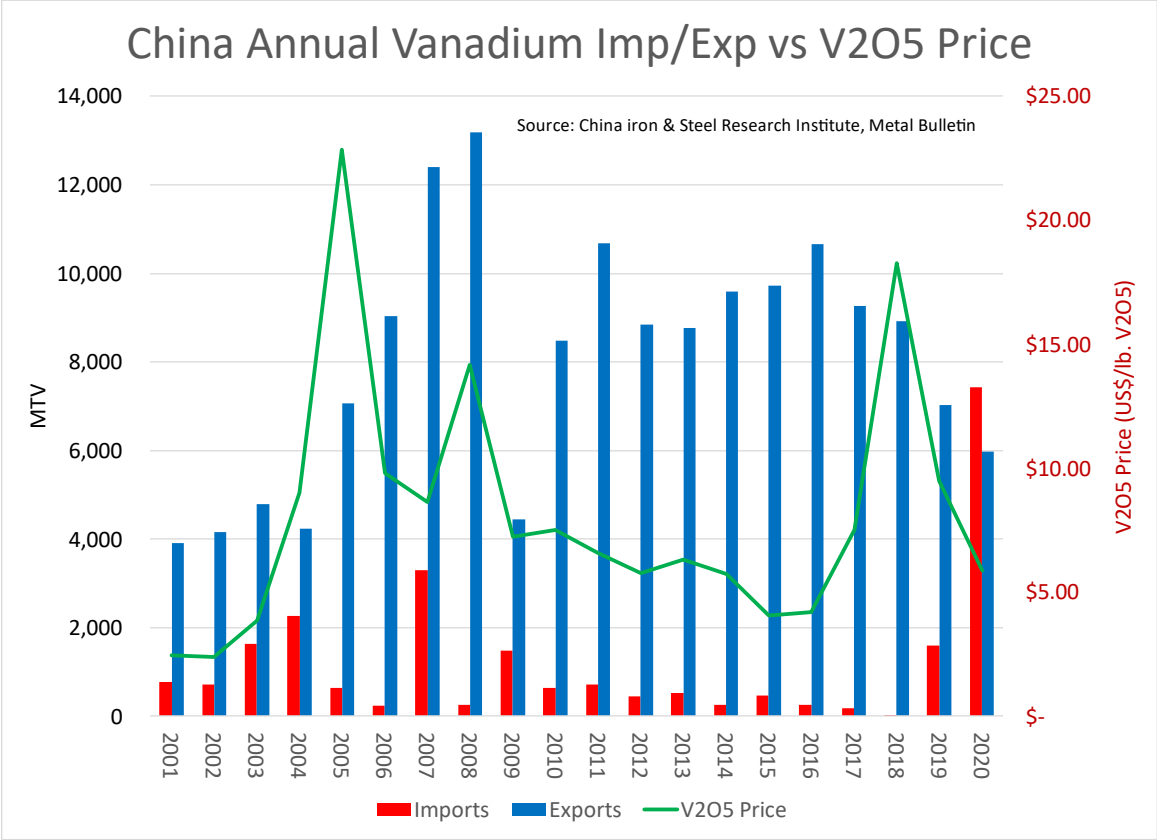
V Consumption	2019	2020e	2021e
Ex China			
Steel Production (million MT)	848,075	757,354	815,000
KgV/MT Steel	0.0554	0.0572	0.0590
Total Vanadium (MTV)	47,000	43,363	48,085
China			
Steel Production	994,166	1,060,981	1,077,886
KgV/MT Steel	0.0555	0.0605	0.0655
Total Vanadium (MTV)	55,175	64,192	70,602
World Total			
Steel Production	1,842,241	1,818,334	1,892,886
KgV/MT Steel	0.055462	0.0591	0.0627
Total Vanadium (MTV)	102,175	107,554	118,687
V Production (MTV)			
China	64,702	69,958	74,112
ex China	37,929	39,229	39,136
Total	102,631	109,187	113,248
Inventory Change China	9,527	5,766	3,510
Inventory Change ex China	(9,071)	(4,134)	(8,949)
Total Inventory Change	456	1,633	(5,439)

Source: Vanitec, TTP Squared, Inc.

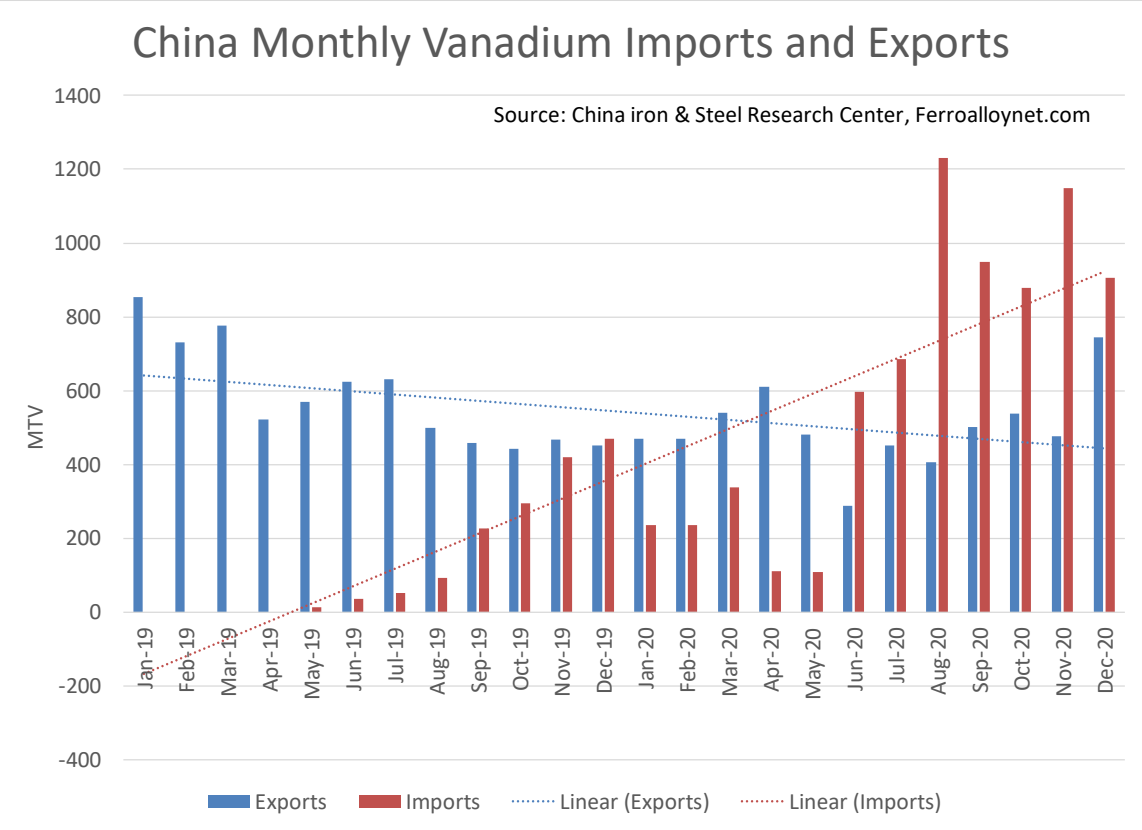
2021 Projection

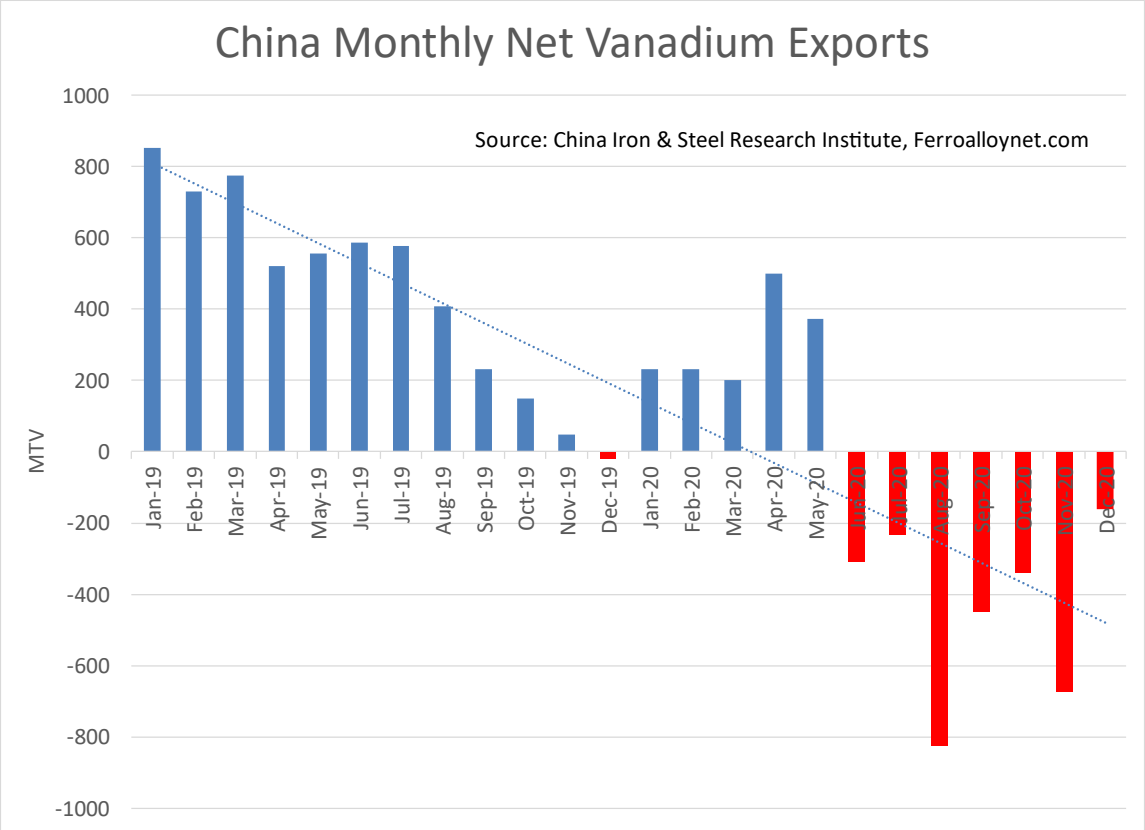
- We expect to see continued strong growth in vanadium consumption in China.
- Chinese vanadium production will remain at high levels seen in late 2020.
- Ex China vanadium consumption is expected to rebound in 2021 as steel production outside of China continues to recover from COVID-19.
- Vanadium production outside of China in 20201 is anticipated to be similar with levels seen in 4Q2020.
- On a global basis we expect consumption to outstrip production of vanadium by more than 5,000 MTV in 2021.

China Vanadium Exports



Historically China exports roughly 8,000-10,000 MTV per year. In 2020 net exports were negative.





Imports of vanadium into China surged in 2H2019 while exports decreased. Looking at net exports from China on a monthly basis we see China was a net importer of vanadium in December 2019. In early 2020 we see net exports recovering as a result of COVID-19 in China, but from June onwards net exports have turned negative.

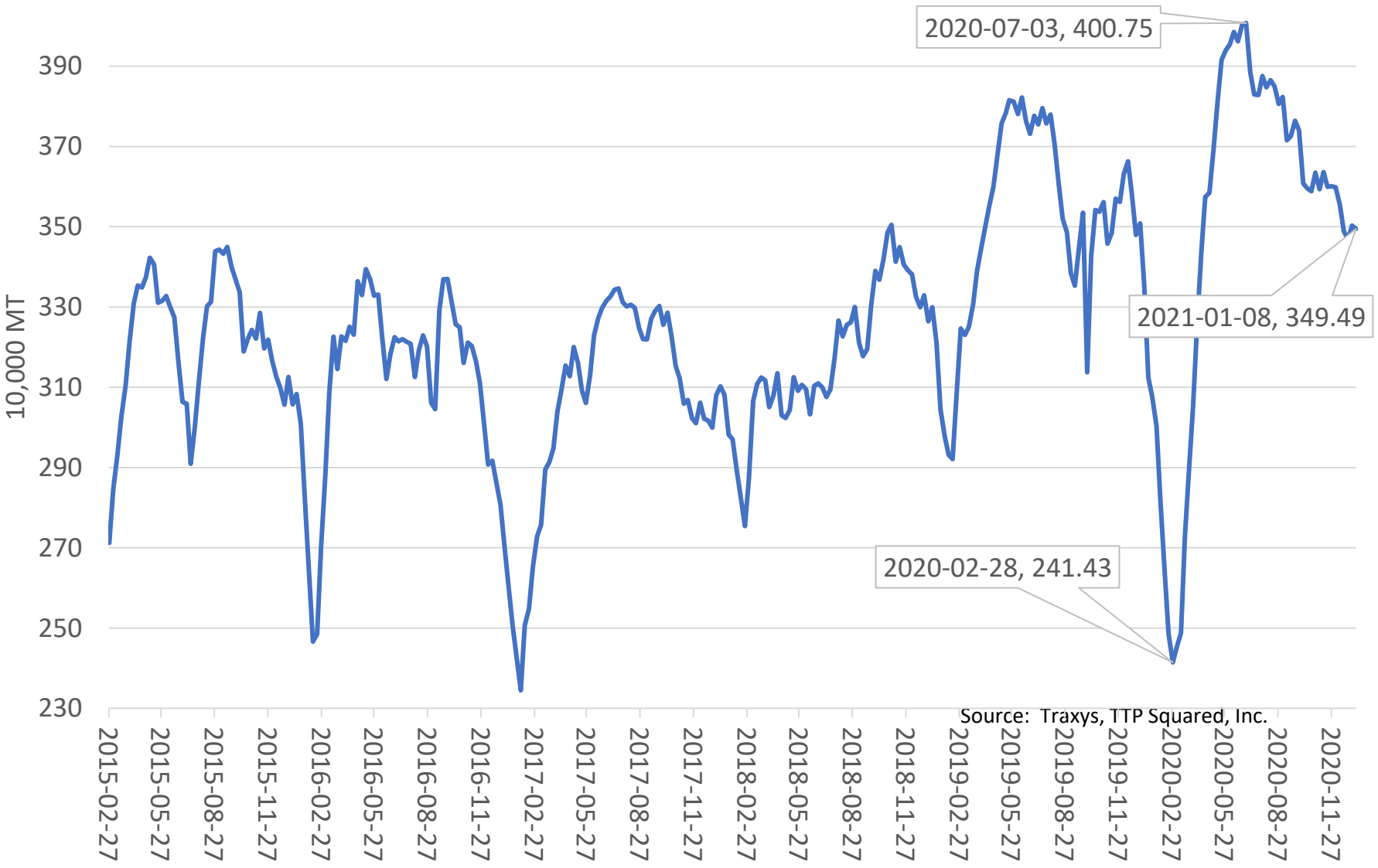
Mainland China Vanadium exports Summary

- Historically the world ex China requires 8,000-10,000 MTV per year in net exports from China to maintain balance in western markets.
- From 2Q2019 onward Chinese net exports of vanadium decreased rapidly and turned negative in June 2020.
- While demand in the west was weak through 3Q2020, in China demand is growing significantly due to the ongoing adaptation of the new rebar specification.
- With growing imports into China western inventories are now being depleted.

Source: TTP Squared, Inc.

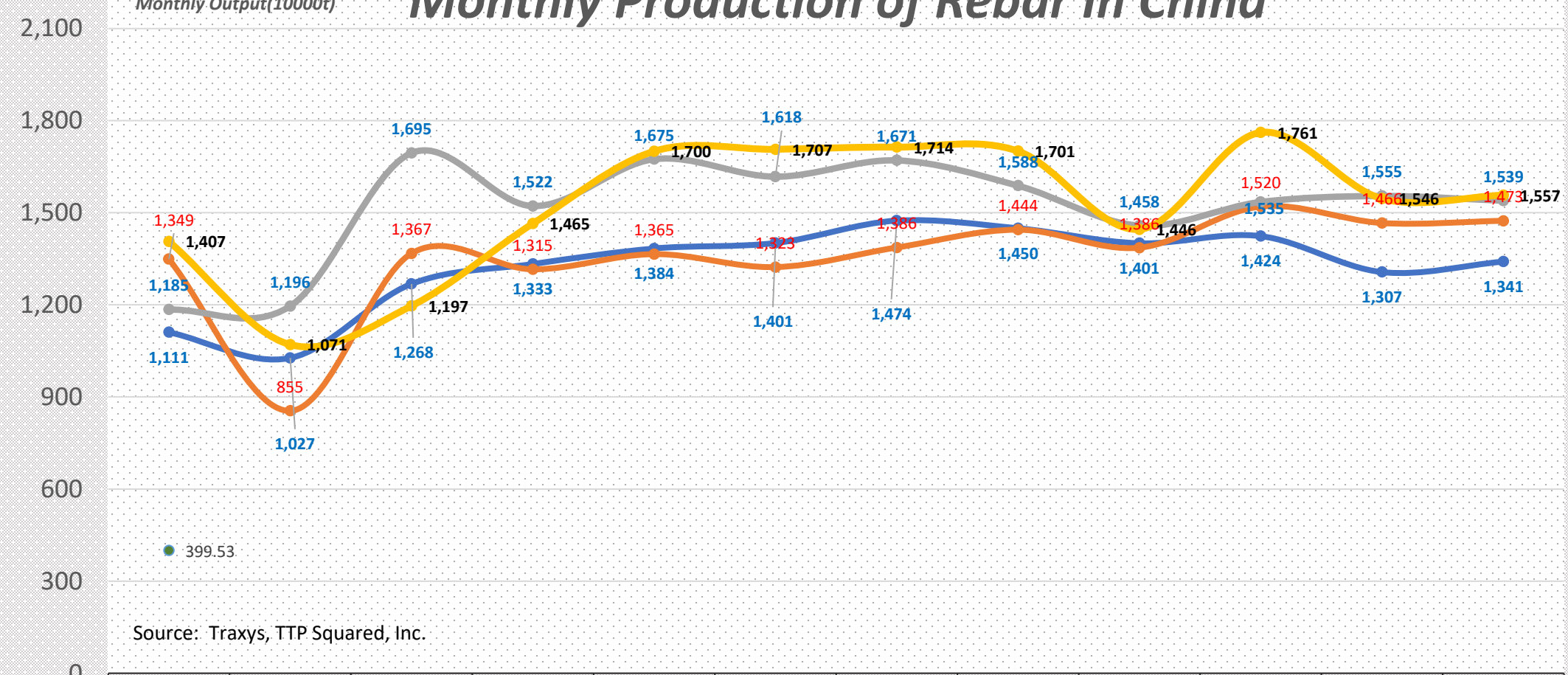
China Rebar

Weekly Rebar Production in China



Source: Traxys, TTP Squared, Inc.

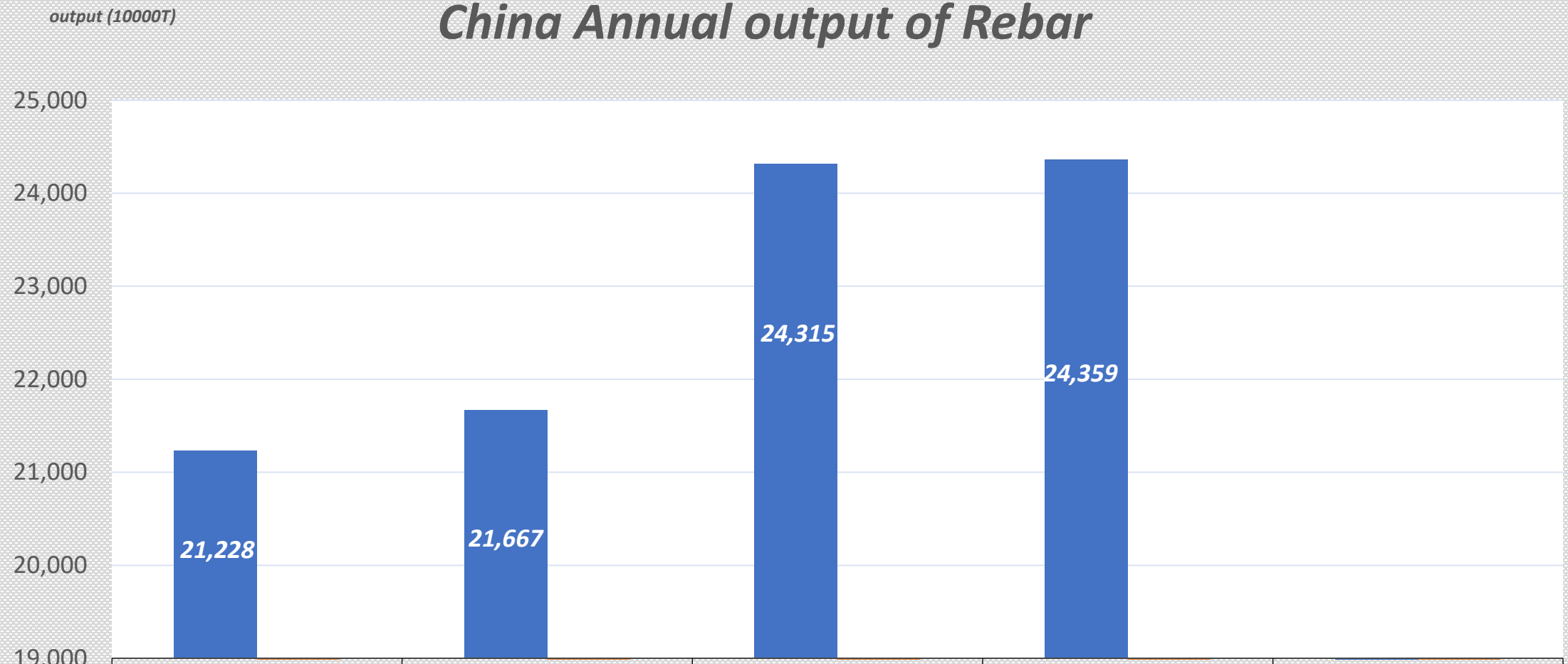
Monthly Production of Rebar In China



Source: Traxys, TTP Squared, Inc.

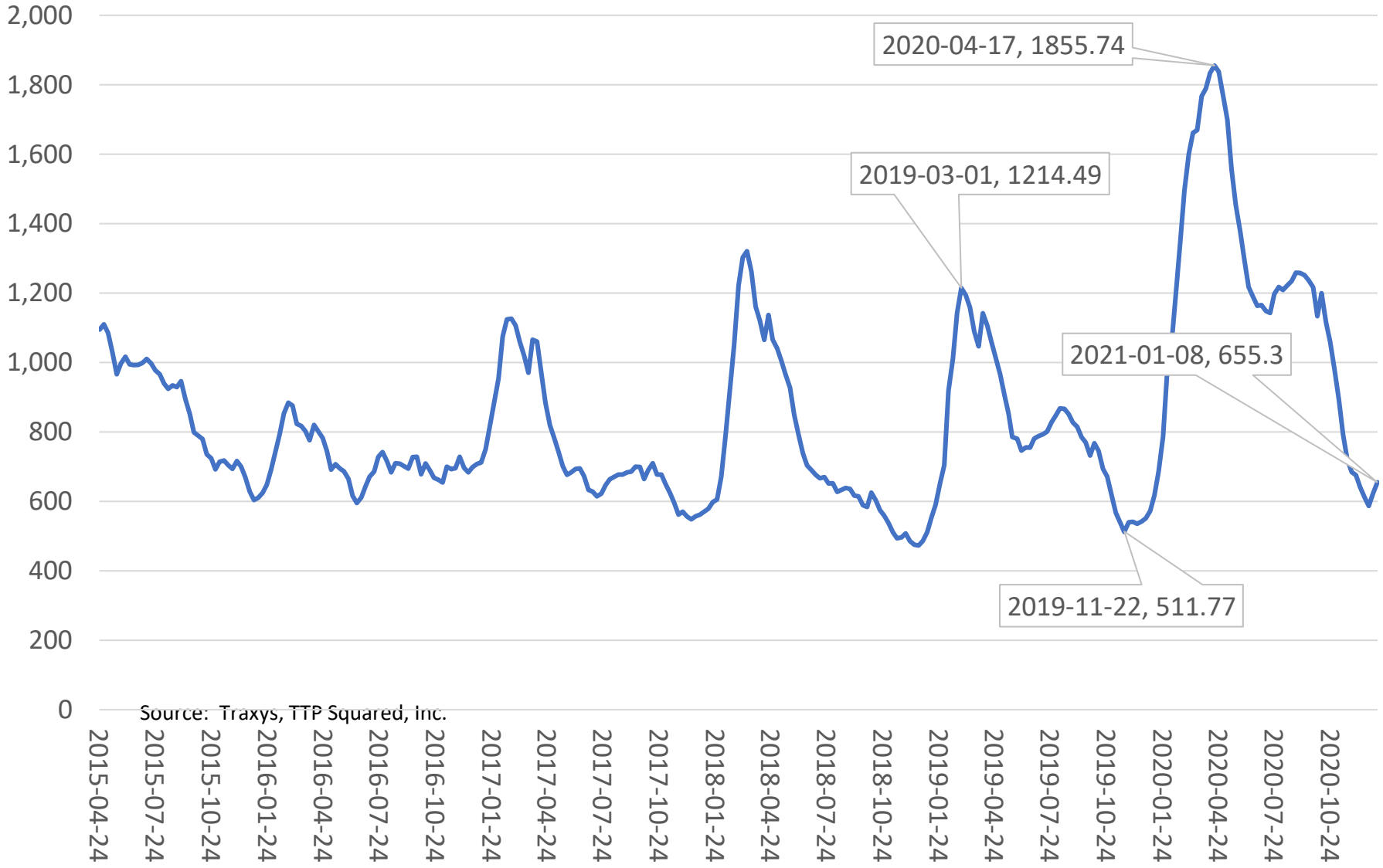
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	1110.92	1027.18	1268.29	1333.13	1383.56	1400.98	1474.24	1449.77	1400.78	1424.11	1306.88	1341.05
2018	1348.81	854.81	1367.21	1315.45	1364.95	1322.73	1386.45	1444.41	1385.80	1519.81	1466.16	1473.49
2019	1184.69	1195.98	1694.75	1522.02	1674.57	1617.72	1670.61	1588.24	1458.21	1535.13	1554.67	1539.43
2020	1406.61	1070.59	1196.54	1464.60	1700.05	1706.51	1713.56	1700.67	1445.91	1761.23	1545.90	1557.00
2021	399.53											

China Annual output of Rebar



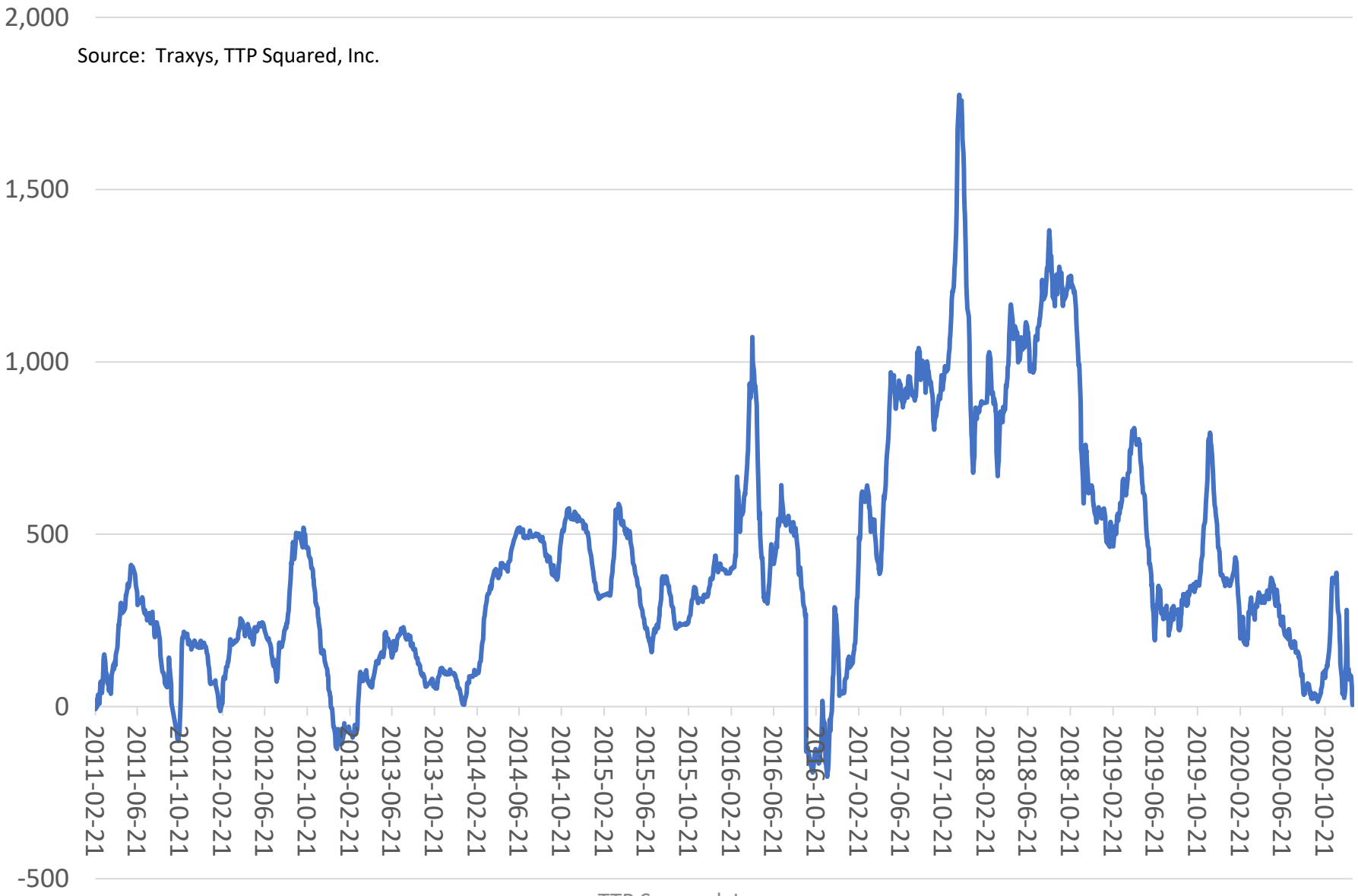
	2017	2018	2019	2020	2021
Total	21227.85	21666.77	24314.69	24358.89	532.71
V2O5_	6.80	6.94	7.79	7.80	0.17

Weekly Inventory of Rebar in China



Source: Traxys, TTP Squared, Inc.

Daily Profitability of Chinese Rebar Mills

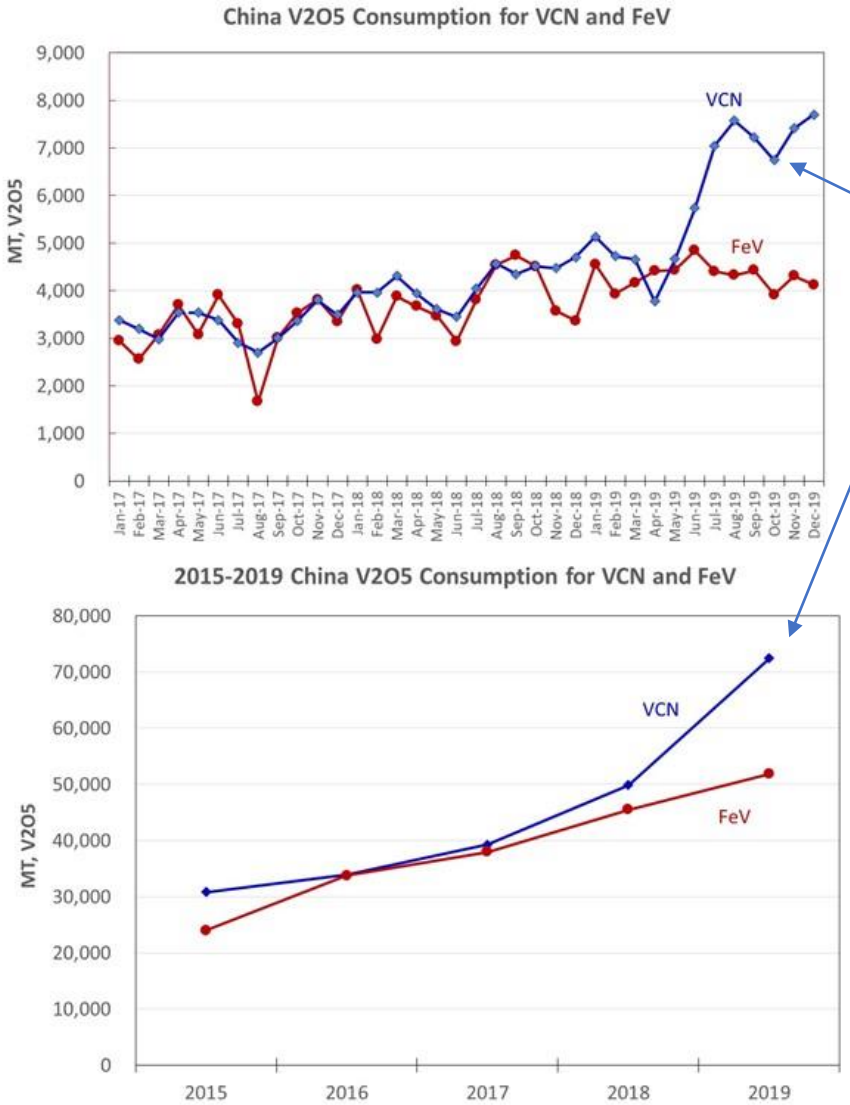


Source: Traxys, TTP Squared, Inc.

China New Rebar Standard

- **Results of National Inspection on Rebar Quality in 2019**
  - **State Administration of Market Supervision: about 180 rebar producers**
  - **6 organizations to be confirmed by bidding**
  - **Time Schedule: during Aug.-Oct., 2019**
  - **Result: ~10% rebar producers not meet the requirement of the new standard （Official report hasn't published.）**
- **New Standard GB/T 1499.2－2018 took effect since Nov.1, 2018. The most rebar producers follow up the new standard for their production, and it promoted significantly V applications in rebars.**

Source: China Iron & Steel Research Institute



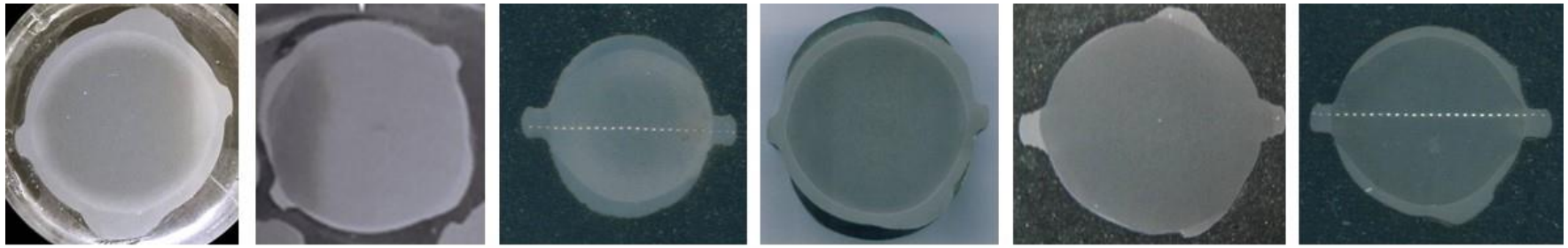
VCN is used primarily in rebar applications

CISRI's Survey on Quality of China Rebar

Source: China Iron & Steel Research Institute

- **51 rebar producers from 23 provinces in China**
  - **Substandard mills (8 producers, 15.7%): Xianfu, Qujing-stee, Shui-steel, Longxin-steel, San-steel, Tonghua-steel, Guihang-steel, Xinda-steel**
- **Process instead of V/V-N**
  - **Nb Microalloying**
  - **TMCP**
  - **Low V+QT**

Steel	Size	C	Si	Mn	V	Nb	N
Xianfu-steel	Φ22	0.24	0.39	1.49	0.008	<0.005	0.0036
Qujing-steel	Φ16	0.24	0.36	1.43	0.015	0.010	0.0077
Shuigang-steel	Φ20	0.24	0.56	1.40	0.005	<0.005	0.0028
Longxin-steel	Φ25	0.23	0.38	1.52	0.011	<0.005	0.0056
San-steel	Φ20	0.23	0.65	1.43	0.016	<0.005	0.0067
Tonghua-steel	Φ32	0.22	0.44	1.51	0.026	<0.005	0.0110
Guihang-steel	Φ32	0.23	0.54	1.46	0.018	<0.005	0.0062
Xinda-steel	Φ25	0.22	0.39	1.38	0.013	<0.005	0.0059

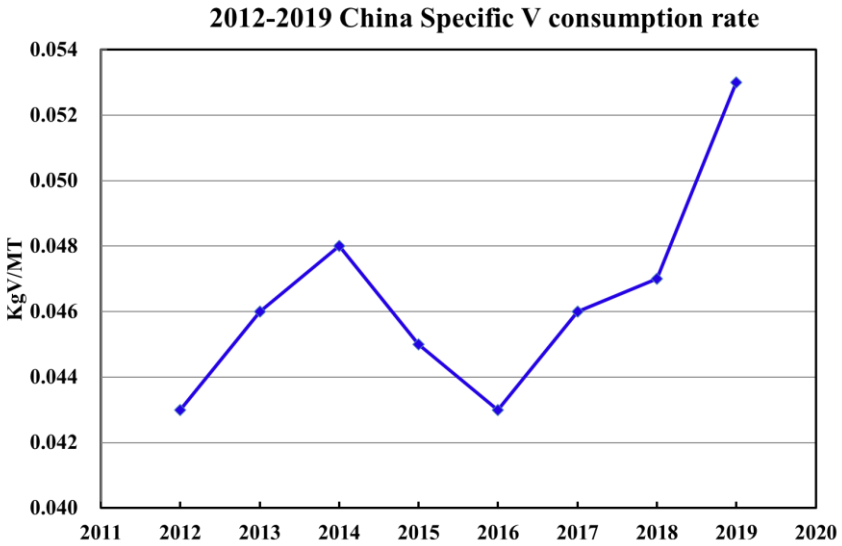


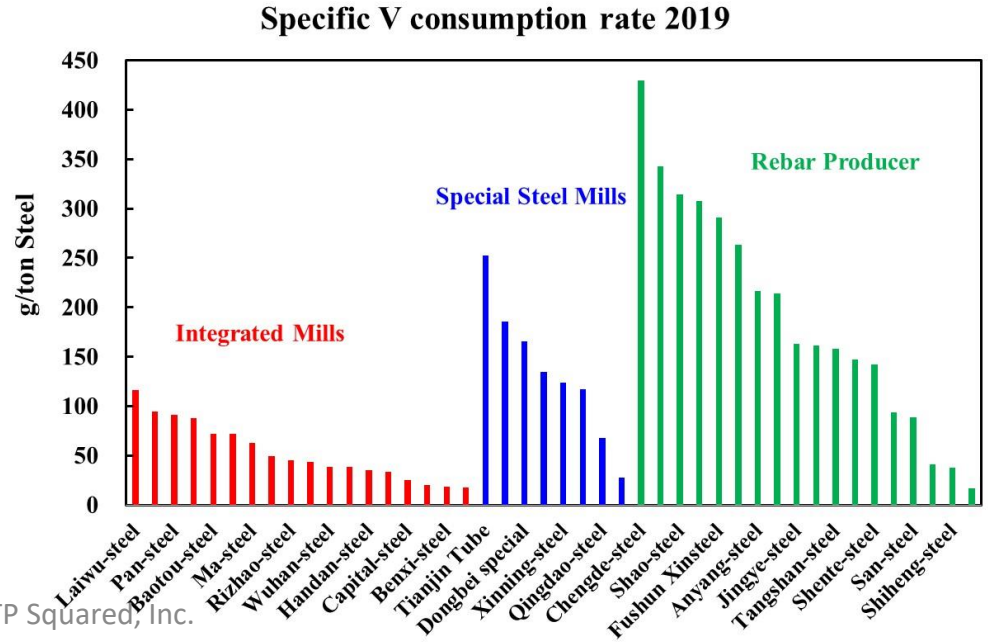
Xianfu Qujing-steel Shuigang Longxin Sangang Tonghua

Specific V Consumption Rate

Source: China Iron & Steel Research Institute

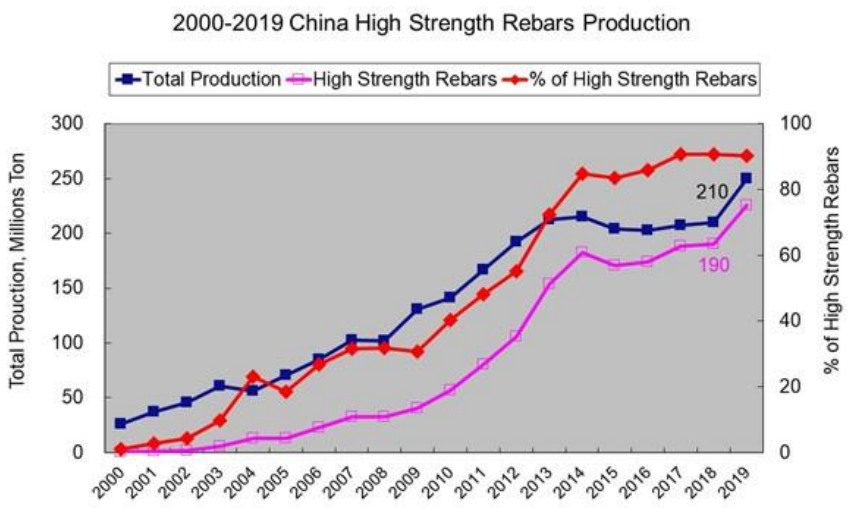
No	Company	Crude steel (million tons)	V Consumption	
		2019	2019	2018
1	Capital-steel	29.34	730.90	554.26
2	Anshan-steel	27.23	1190.70	1097.73
3	Xiangtan-steel	24.31	940.35	376.89
4	Ma-steel	19.84	1244.70	1100.43
5	Shan-steel	18.65	1634.00	1412.94
6	Bao-steel	16.19	803.00	1046.07
7	Benxi-steel	16.17	292.20	214.81
8	Baotou-steel	15.46	1116.98	1305.15
9	Laiwu-steel	15.00	1737.40	1645.29
10	Liuzhou-steel	14.40	256.40	247.60
11	Rizhao-steel	14.20	640.50	535.06
12	Taiyuan-steel	10.86	360.00	335.00
13	Pan-steel	10.38	943.13	1399.34
14	Nanjing-steel	10.97	1037.12	868.52
15	Handan-steel	9.68	342.79	392.34
16	Xinyu-steel	9.47	192.00	166.05
17	Bayi-steel	5.80	418.90	536.93
18	Wuhan-steel	4.90	190.00	335.44
19	Xingcheng-steel	6.71	904.00	819.53
20	Fangda-steel	3.67	100.00	117.50
21	Xinyegang	3.65	678.00	574.00
22	Qingdao-steel	3.19	215.00	220.00
23	Dongbei special-steel	2.23	370.00	787.50
24	Shijiazhuang-steel	1.93	225.50	131.42
25	Xinning-steel	1.79	221.60	155.00
26	Tianjin Tube	1.47	370.00	329.00
27	Jingye-steel	7.01	1145.00	966.30
28	San-steel	6.53	581.35	196.34
29	Kun-steel	5.44	512.05	338.06
30	Zhongtian-steel	5.30	1136.40	759.68
31	Sha-steel	5.29	778.00	937.00
32	Yongzhou-steel	4.69	1234.00	1029.85
33	Shao-steel	3.81	1197.70	424.38
34	Xuanhua-steel	3.80	1301.00	709.52
35	Wuyang-steel	3.09	126.18	201.34
36	Anyang-steel	3.01	651.75	474.58
37	Fushun Xinsteel	2.91	847.00	509.73
38	Chengde-steel	2.73	1175.00	1019.67
39	Shiheng-steel	2.68	100.00	60.00
40	Tangshan-steel	2.66	420.48	267.73
41	Jiuquan-steel	2.61	802.05	313.65
42	Lianyuan-steel	2.51	404.55	157.06
43	Lianxin-steel	2.47	42.00	32.00
44	Shente-steel	1.84	261.80	308.00

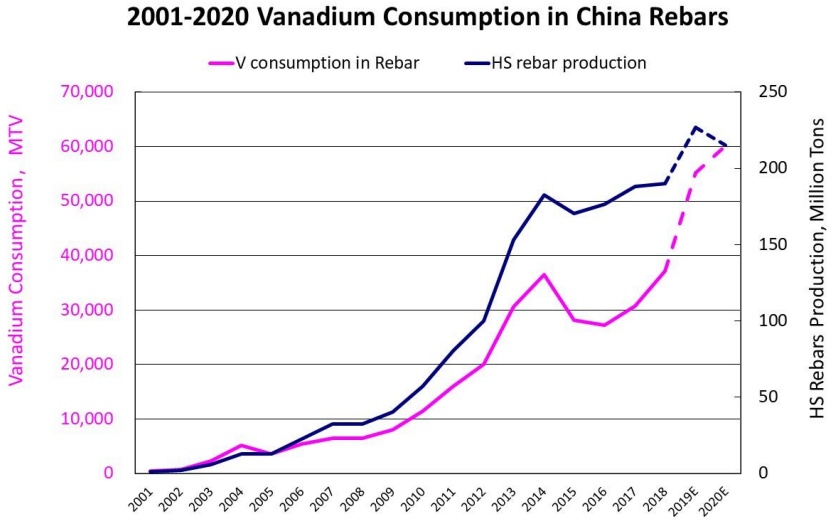


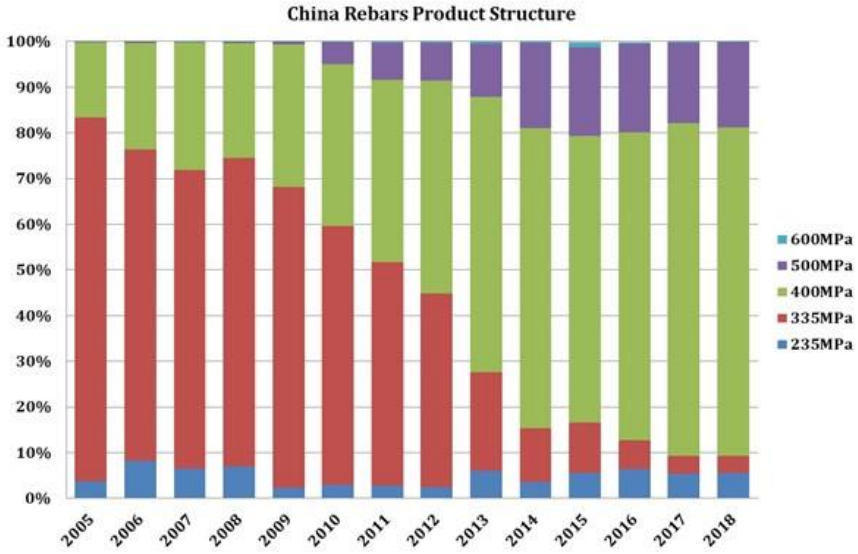


V Consumption in China Rebar

Source: China Iron & Steel Research Institute





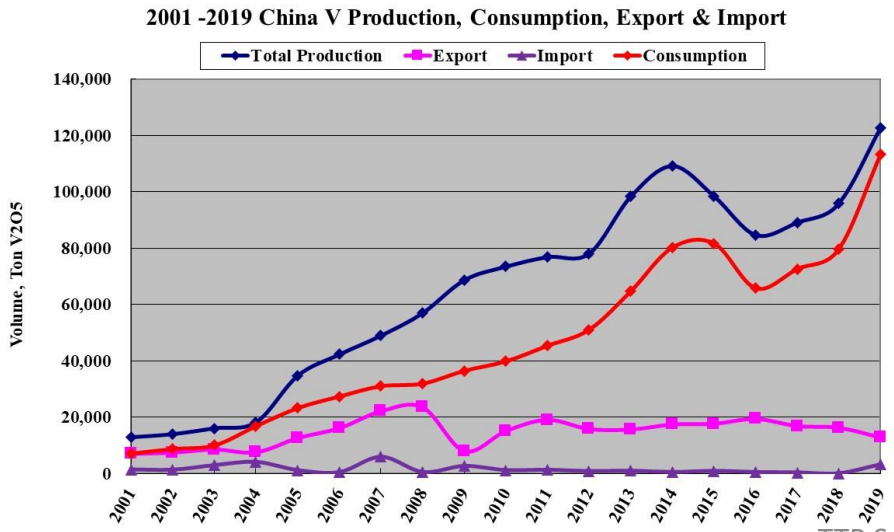


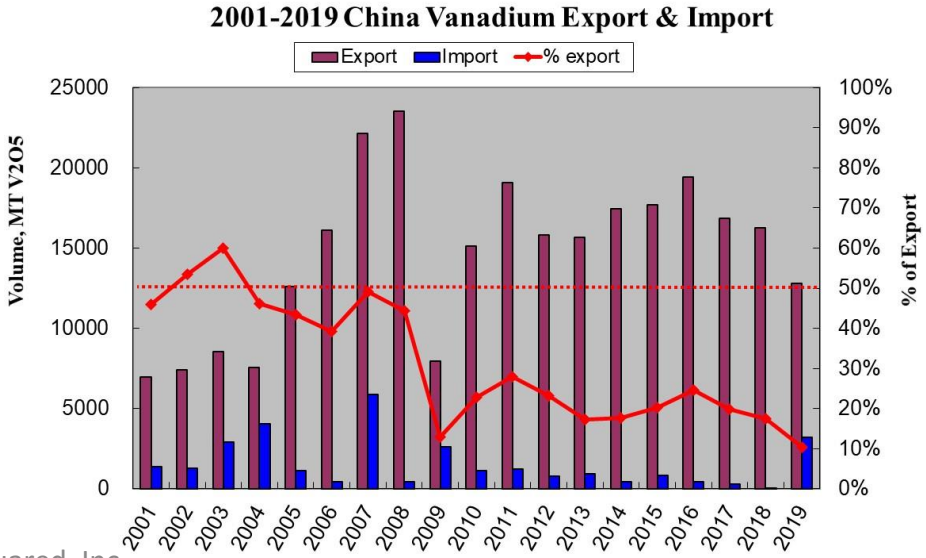
2019	Grade 3	Grade 4	Grade 5	Total
Rebar Production	179,776,100	46,424,904	495,973	226,696,976
% of V Rebar	60%	80%	100%	64%
% of Nb Rebar	15%	10%	0%	14%
V Rebar	107,865,660	37,139,923	495,973	145,501,556
Nb Rebar	26,966,415	4,642,490	-	31,608,905
others	44,944,025	4,642,490	-	49,586,515
V Consumption	32,359.7	22,284.0	496.0	55,140
Nb Consumption	5,393.3	1,160.6	-	6,554

Source: China Iron & Steel Research Institute

China V industry Investigation

2019	Production	Export	Import	Consumption
Q1 2019	16,688	2,360	22	14,350
Q2 2019	16,875	1,713	39	15,201
Q3 2019	17,159	1,588	271	15,842
Q4 2019	16,640	1,358	1273	16,555
Total	67,362	7,019	1,605	61,948





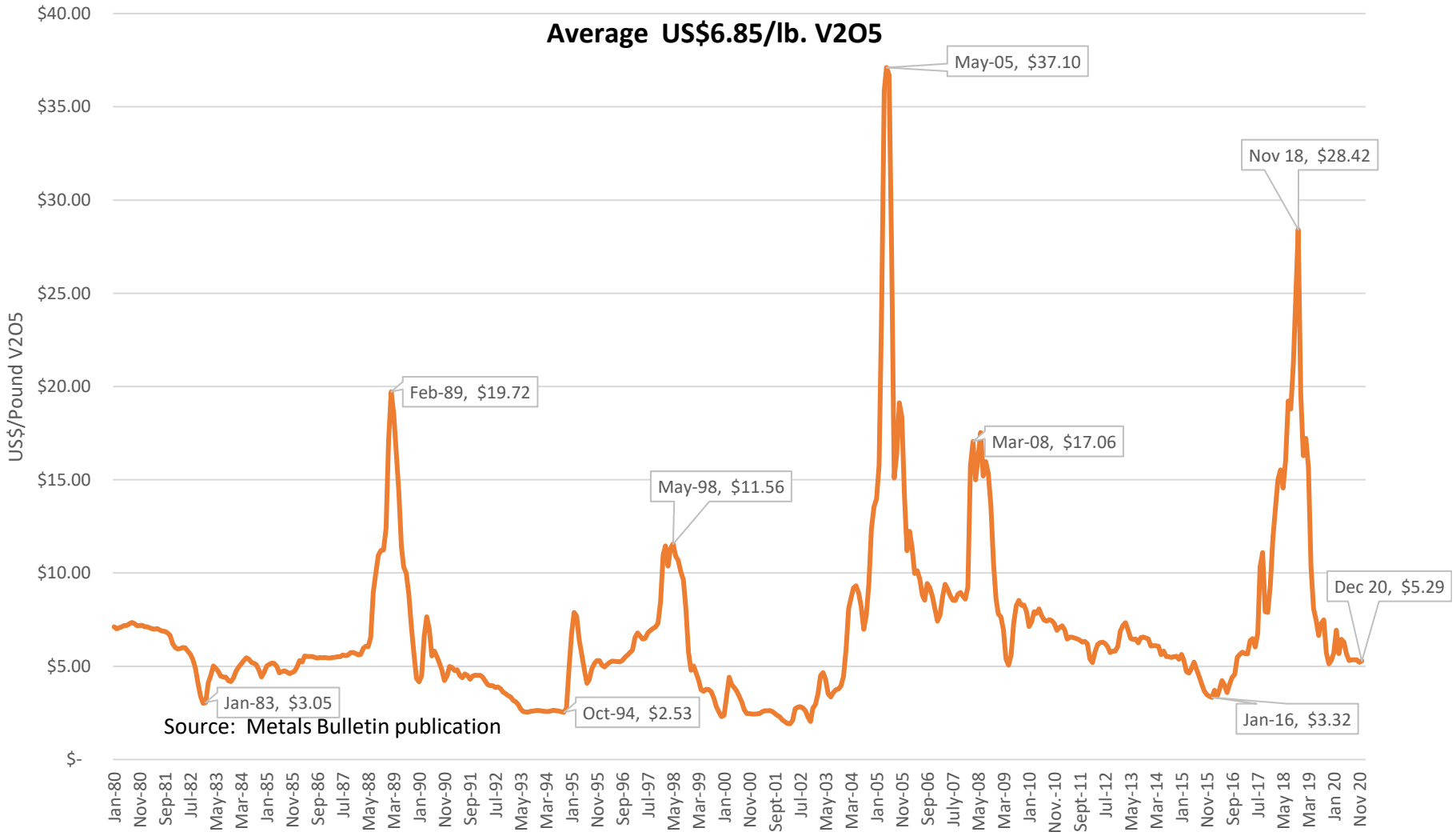
China Rebar Market

- Production of steel reinforcing bars used in concrete construction in China surged to 241 million MT in 2019 as compared to 211 million MT in 2018.
- As we exited the Chinese New Year we saw the traditional patterns of production, consumption and inventories being disrupted by the virus.
- As a result of the COVID-19 virus rebar inventory reached a high level and production reached a low level in January and February.
- Production and consumption of rebar in China are now at levels seen in 2019 before COVID-19.

Source: TTP Squared, Inc.

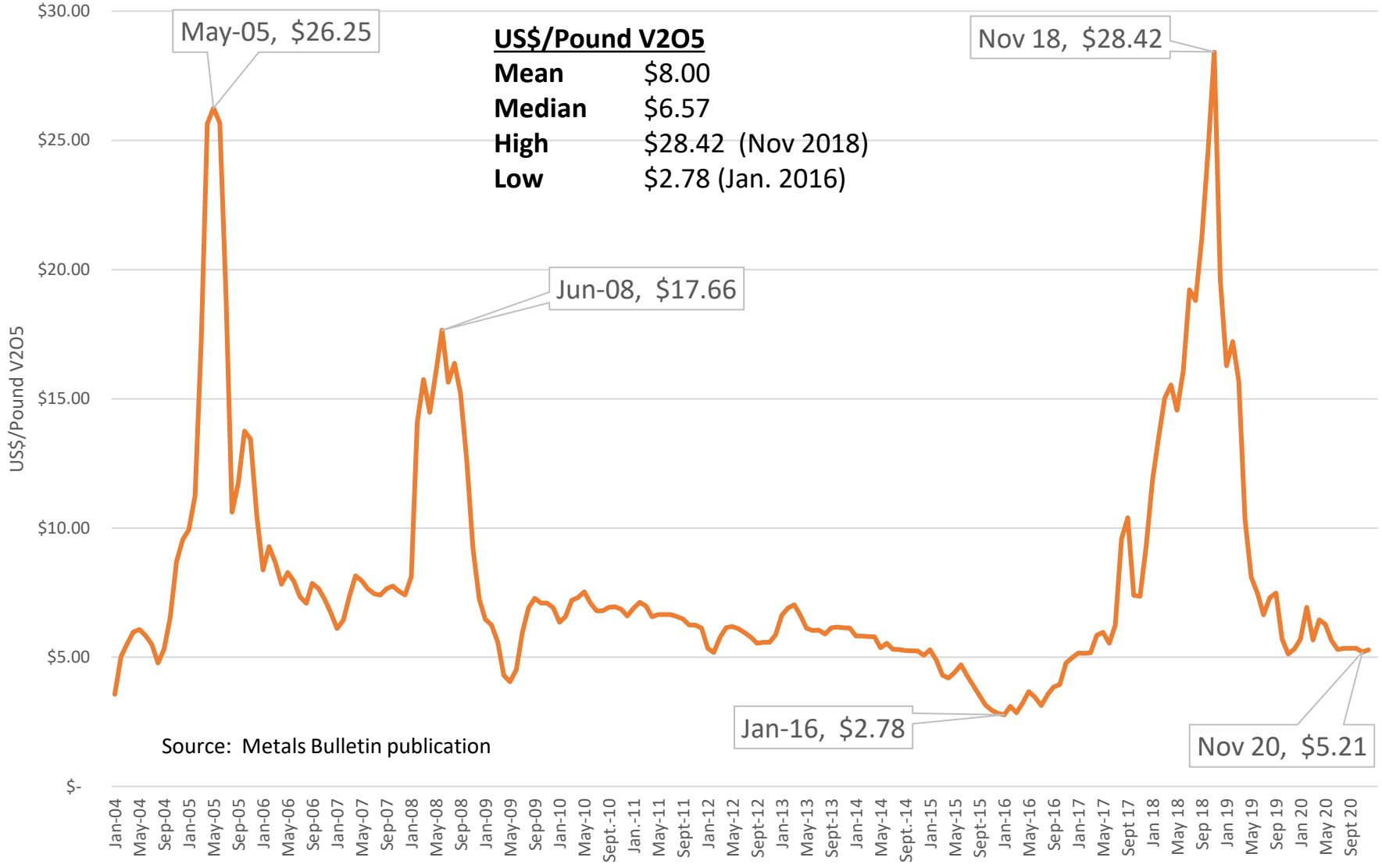
Historical Price Data

Metal Bulletin V2O5 Monthly Midpoint Average Real Price
Jan. 1980 - Dec. 2020
Inflated to Nov. 2020 US$



Source: Metals Bulletin publication

Metal Bulletin V2O5 Monthly Midpoint Average Nominal Price
Jan. 2004 - Dec. 2020

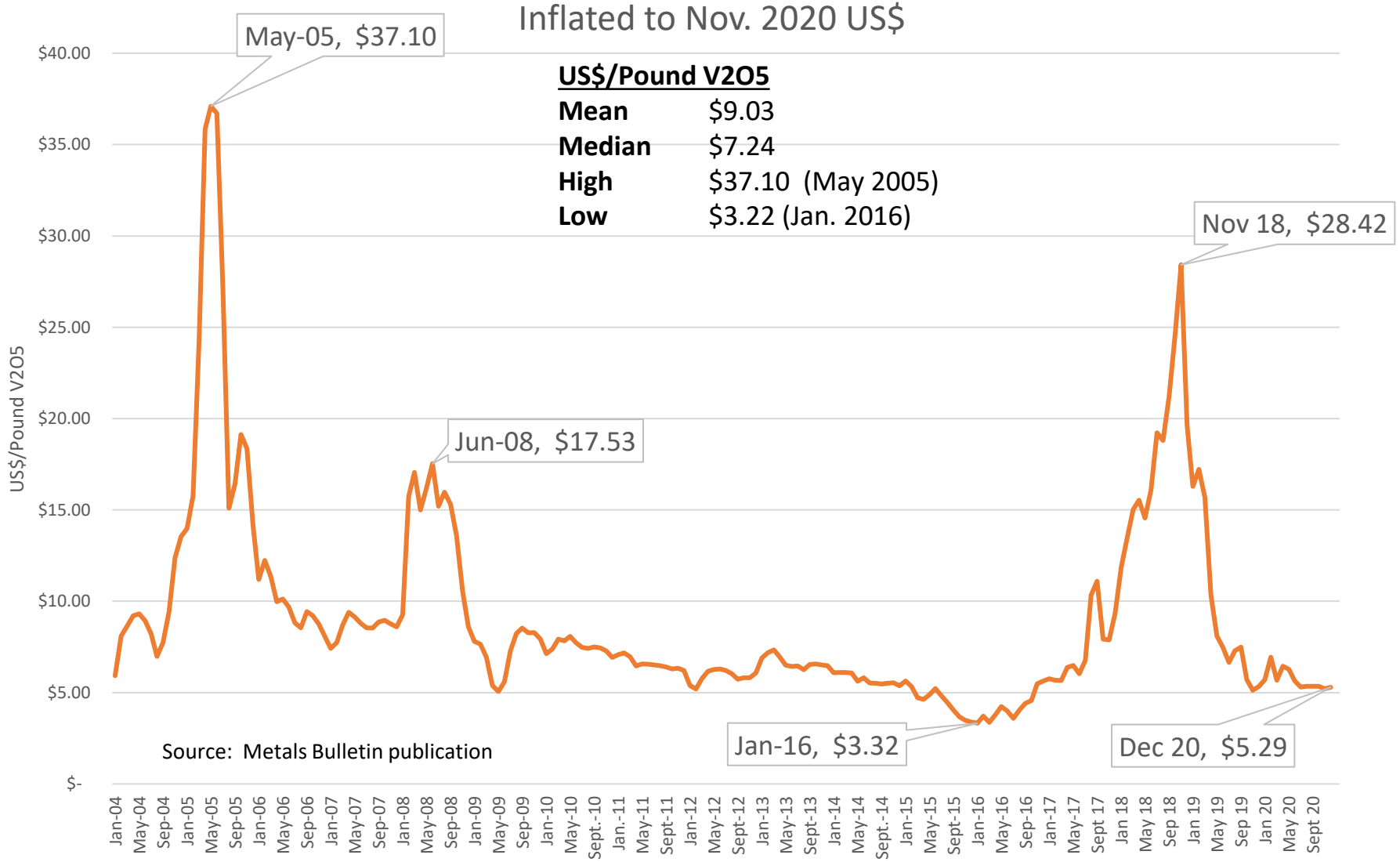


US$/Pound V2O5

Mean	$8.00
Median	$6.57
High	$28.42 (Nov 2018)
Low	$2.78 (Jan. 2016)

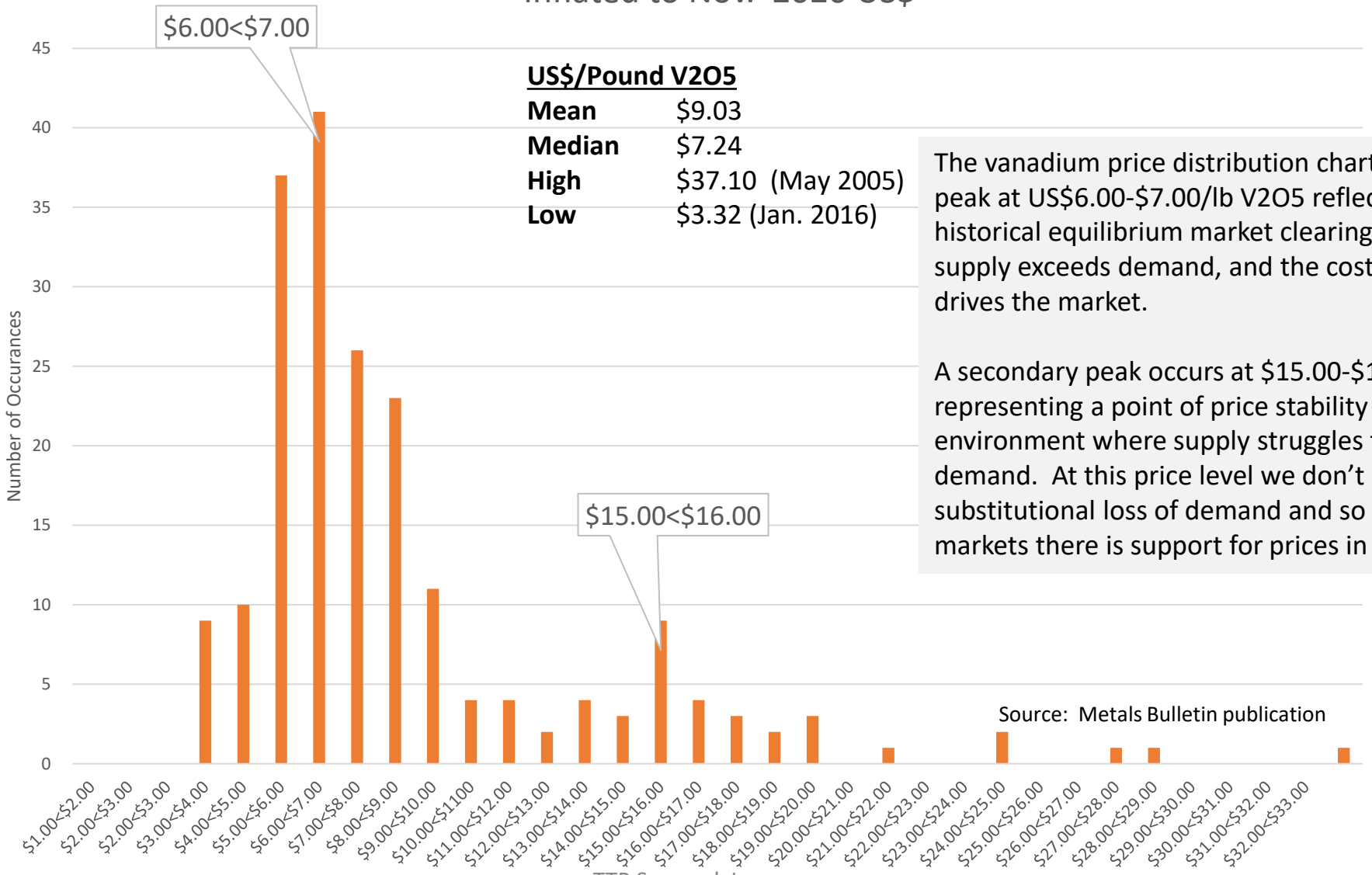
Source: Metals Bulletin publication

Metal Bulletin V2O5 Monthly Midpoint Average Real Price
Jan. 2004 - Dec. 2020
Inflated to Nov. 2020 US$



Source: Metals Bulletin publication

V2O5 Real Price Distribution Chart
Jan. 2004 - Nov. 2020
Inflated to Nov. 2020 US$



US$/Pound V2O5

Mean	$9.03
Median	$7.24
High	$37.10 (May 2005)
Low	$3.32 (Jan. 2016)

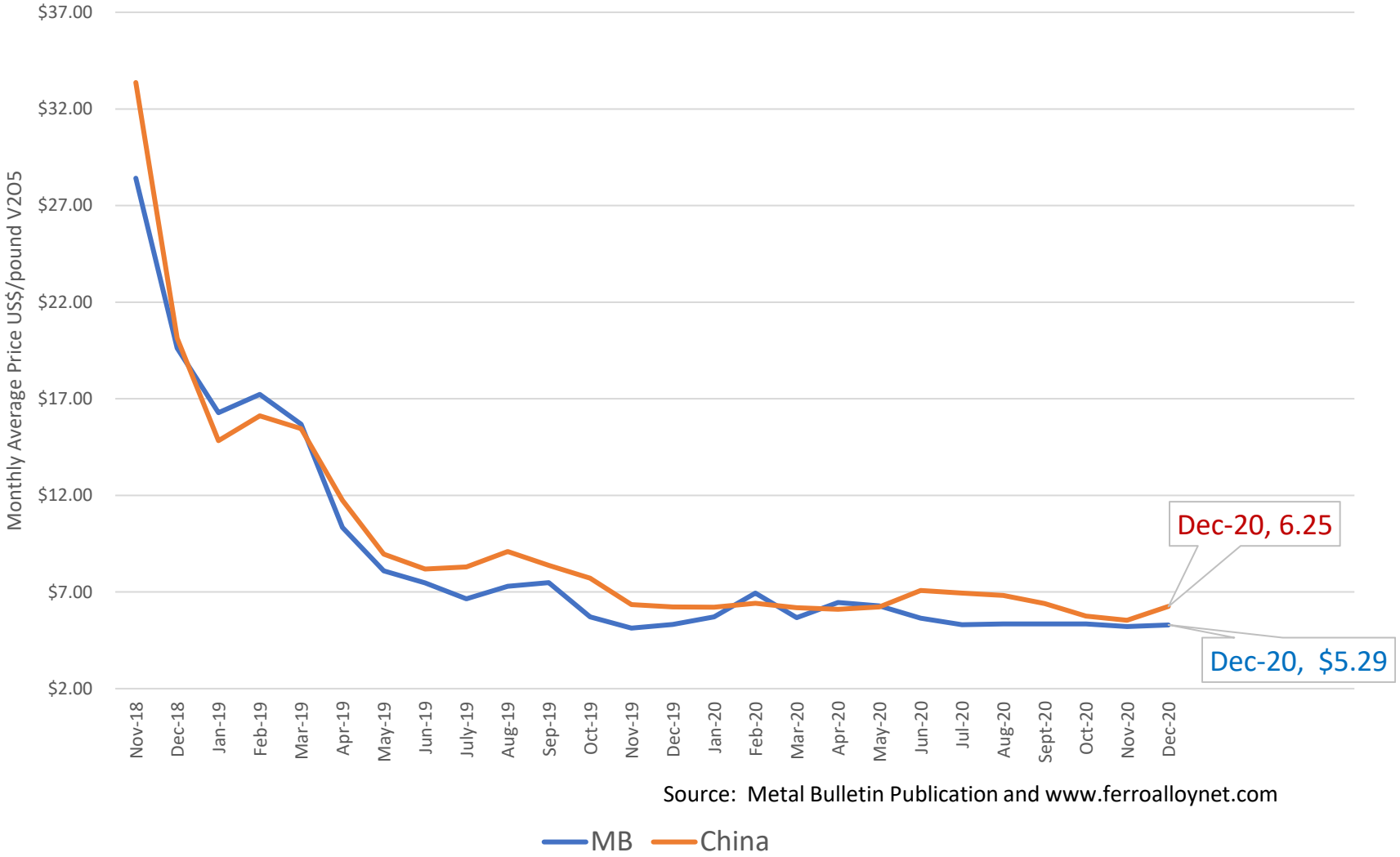
The vanadium price distribution chart shows a clear peak at US$6.00-$7.00/lb V2O5 reflecting the historical equilibrium market clearing price when supply exceeds demand, and the cost of production drives the market.

A secondary peak occurs at $15.00-$16.00/lb V2O5 representing a point of price stability in an environment where supply struggles to meet demand. At this price level we don't see very much substitutional loss of demand and so in tight markets there is support for prices in this range.

Source: Metal Bulletin, TTP Squared, Inc.

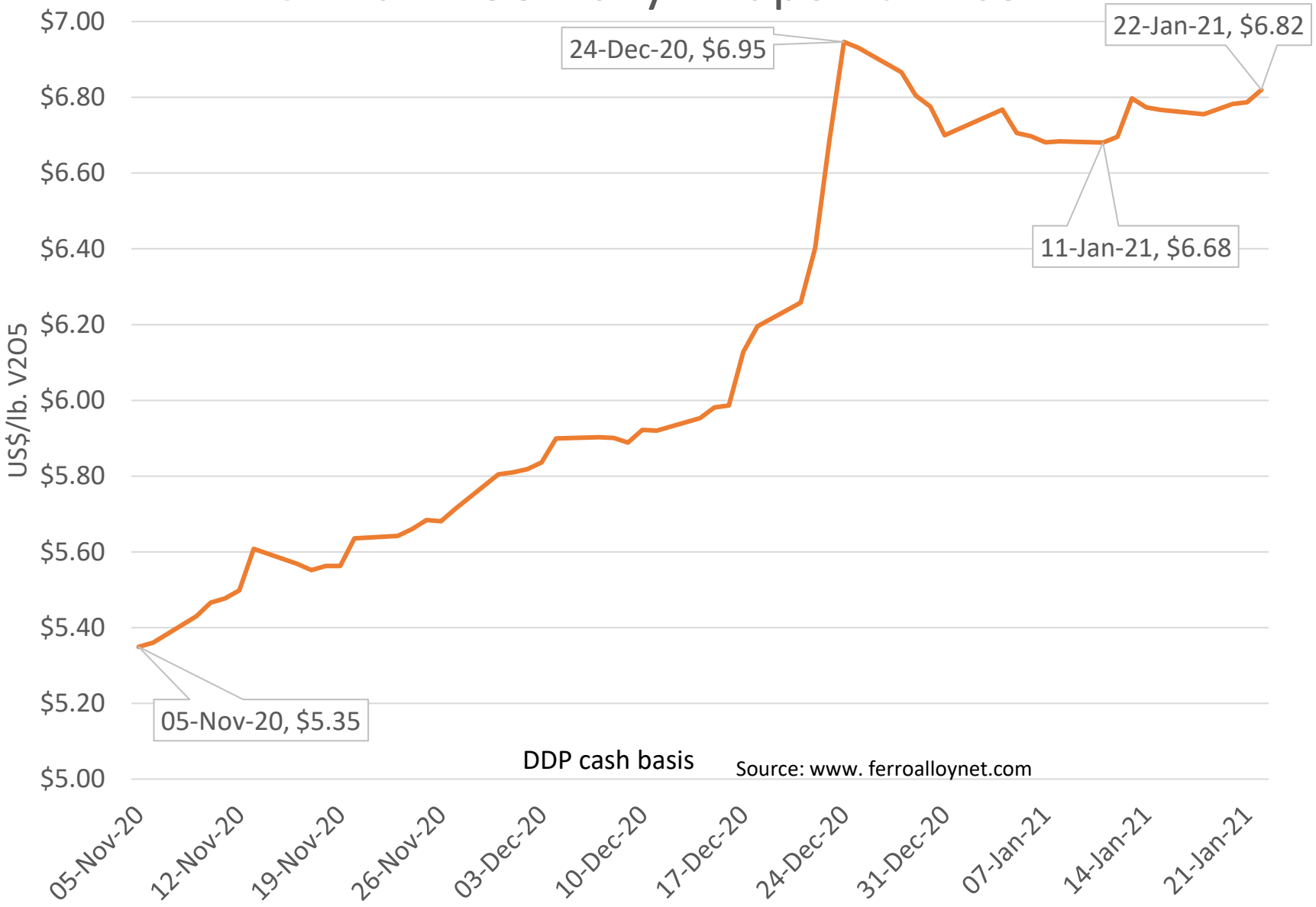
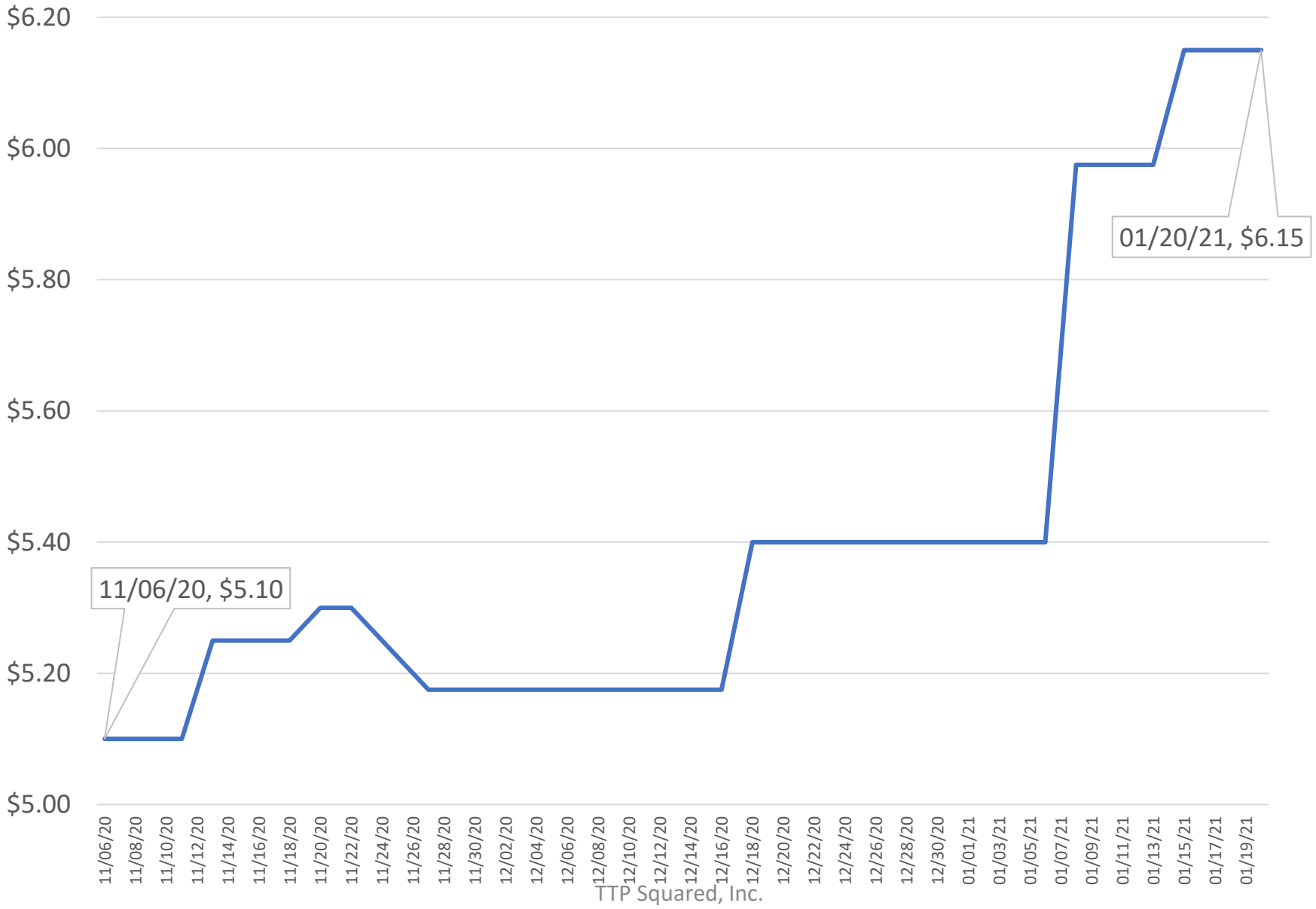
V2O5 Published Prices
Metal Bulletin Vs China

Monthly average published prices for commodity grade fused flake V2O5



Source: Metal Bulletin Publication and www.ferroalloynet.com

China V2O5 Daily Midpoint Price



Metal Bulletin V2O5 Midpoint Daily Price