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Base metal pricing variation: a contribution to a conceptual model for nickel

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Abstract: This paper contributes to the discussion of Base Metal Pricing Variation by analysing Nickel data for the year 2007. 2007 was the culmination of a period of unprecedented Nickel price turbulence and the purpose of the analysis was to identify the most important factors which could have resulted in such significant variation. Based on this analysis a conceptual model was developed of Nickel pricing dynamics. This model is presented in the paper as it may prove useful in further research on price variation or for other mineral resource commodities.

Keywords: base metals, mineral resource commodity prices, available inventory, warehouse stock, price variation model, supply and demand
JEL: D400

1. Introduction

The global metals mining and extraction sector as well as the production, trade and distribution of metals (among them Nickel) has been the subject of significant research at the AGH University of Science and Technology, Cracow, Poland at the Faculty of Management. This research has covered:

- Sustained and sustainable development of the metals industrial sector in a national, regional and global context (Preisner, Pindór 2014).
- Geological and environmental aspects (and limitations) of metals production.
- Factors affecting metals supply and demand.
- National and international metals trading, volume, turnover and structure.

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- Procedural and institutional aspects of metals trading markets and exchanges (especially with regard to product specifications and contract requirements).
- Analysis of centralised metals trading markets.
- Metals pricing and price types.
- Managing risk in exchange transactions and risk mitigation strategies.
- Metals import / export volumes and importer / exporter rankings (Pindór 2014b).
- Logistics and transportation of metals and metals ores.
- National and regional supply security of metals.
- Financial aspects of metals sector development and restructuring (Pindór 2008, Preisner, Pindór 2013).

Significant research in these areas has been carried out at the Department of Economics, Finance, and Environmental Management of the AGH Faculty of Management (Pindór 2014b, Preisner, 2008).

Research in the above areas as well as in mineral resource commodity price variation is, for many companies (not just those in the mining, mineral extraction or refining sectors), a critical business issue. For these companies, the above areas plus price and price variation have a key impact on their operational and business strategies and on their overall performance. Therefore, as well as the above areas, it is critical for them to understand mineral commodity pricing dynamics. In this context, based on an analysis of London Metal Exchange (LME) Nickel Price Variation in 2007, this paper attempts to provide some indications on possible factors affecting these prices and to develop a conceptual model of the interplay of these factors.

LME prices were selected because, according to the International Nickel Study Group (INSG), the LME: "acts as a barometer of Nickel Supply/Demand world-wide" (INSG 2015: 3) therefore: "LME official Nickel prices are used as bench mark prices by the international trade" (INSG 2015: 3-4). Thus, LME Nickel Prices (plus accompanying data) should provide the most comprehensively used base information for analysing Nickel Price Variation.

For the analysis, 2007 data was selected based on work on real (i.e. inflation and exchange rate adjusted) Nickel Prices from 1900 to 2010 (Deverell, Yu 2011: 4). This work showed that over the entire 1900 - 2010 period, 2007 was a year of historically unprecedented Nickel Price Variation with LME Nickel Prices reaching an "all-time" peak of USD 54.200,= / ton (May 2007) (around 7 times higher than the average prices in the previous decade -

Westmetall 2015). What was also significant about the 2007 pricing peak was that it was followed by a steep decline which lasted until October 2008 (Westmetall 2015). The third significant aspect about 2007 was that the peak occurred in a year when total Nickel Supply exceeded total demand by 11% (INSG 2012). In effect therefore, Nickel Prices reached their highest recorded level in a year in which there was a significant excess supply (thus, a phenomenon running counter to Supply / Demand models of pricing variation (Smith 1776). For these reasons, although taking data for just one year limited the scope of the analysis, it was felt that this focus could help in developing a conceptual framework which, in attempting to encompass the unprecedented turbulence in this one year, could be modified or extended as necessary to similar models for other periods or (potentially) for other commodities.

Nickel Pricing is the dependent variable analysed in this paper, However, two other variables were analysed in relation to price in an attempt to identify the relationships between them. These two variables were:

- Trading Volumes.
- Warehouse Stock.

Trading Volumes were analysed as a proxy for Supply / demand to try to identify whether there was a relationship between Price Variation and Purchase Volumes. This was based on the concept, in-line with Supply / Demand Theory (Smith 1776), that demand should decrease as Price increased resulting in a reduction of Trading Volumes. Warehouse Stock was analysed based on an anticipated relationship, identified by a number of authors (Working 1933, Currie, et al., 2010, Roache, Erbil 2010, Geman, Smith 2013), between Inventory and Commodity Price Volatility.

To present the above, this paper is divided into seven sections. Section 1 is this Introduction. Section 2 is a literature review discussing the work of various authors on the Supply / Demand relationship and on the Pricing impact of Inventory. Section 3 describes the Global Nickel Market. Section 4 starts is a presentation of Nickel Supply / Demand and Available Inventory data for 2007 and, to place the 2007 data in context, starts with a graph of Nickel price variation over the last 10 years. Section 5 is a presentation of the Nickel Price Variation Conceptual Model which is further discussed in Section 6 in a comparison between anticipated results from applying the Conceptual Model and the analysis of 2007 data described in Section 4.

The Conclusions, in Section 7, present a discussion of "industry relevance" and some "next steps".

2. Literature review

This section of the paper discusses literature relating to Commodity Pricing and Supply / Demand and the impact of Inventory or Speculation on Commodity Prices or Volatility. A discussion, from an economics perspective, about parameters affecting price really begins with the Supply / Demand Model presented by Adam Smith (1776). In Chapter 7 of "the Wealth of Nations" entitled: "Of the Natural and Market Price of Commodities" Smith sees the impact on Price of a Demand surplus as follows (Smith 1776:52): " When the quantity of any commodity which is brought to market falls short of the effectual demand, […]. A competition will immediately begin among them, and the market price will rise more or less above the natural price, according as either the greatness of the deficiency, or the wealth and wanton luxury of the competitors, happen to animate more or less the eagerness of the competition. Among competitors of equal wealth and luxury, the same deficiency will generally occasion a more or less eager competition, according as the acquisition of the commodity happens to be of more or less importance to them. Hence the exorbitant price of the necessaries of life during the blockade of a town, or in a famine."

In the sane chapter he goes on to describe the Pricing impact of a Supply surplus as: "When the quantity brought to market exceeds the effectual demand, […]. Some part must be sold to those who are willing to pay less, and the low price which they give for it must reduce the price of the whole. The market price will sink […] according as the greatness of the excess increases more or less the competition of the sellers, or according as it happens to be more or less important to them to get immediately rid of the commodity (Smith 1776: 52)".

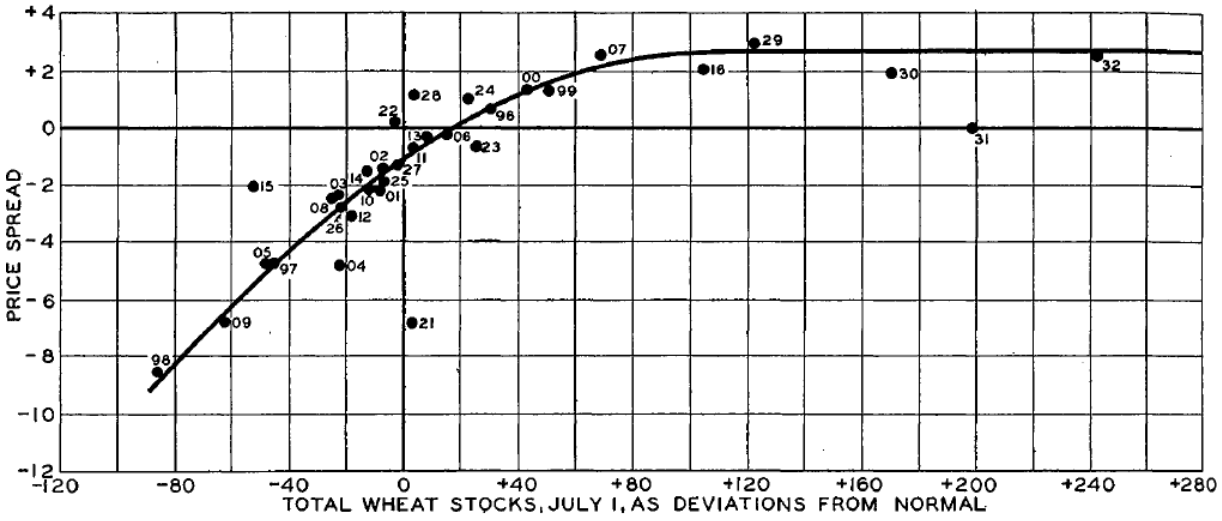
Smith continues by describing the impact of balanced Supply / Demand: "When the quantity brought to market is just sufficient to supply the effectual demand, and no more, the market price naturally comes to be either exactly, or as nearly as can be judged of, the same with the natural price. The whole quantity upon hand can be disposed of for this price, and cannot be disposed of for more. The competition of the different dealers obliges them all to accept of this

price, but does not oblige them to accept of less (Smith 1776: 53)." What Smith is describing is how Supply and Demand affect Price so that a Price equilibrium is reached depending on the level of Demand and the Level of Supply. In effect therefore, Smith is describing a market driven Price Discovery Process where Supply and Demand are the primary factors affecting Price.

Further in chapter 7, in describing Supply surplus Smith (1776: 52) hints at another factor he sees as influencing not only Price but also the velocity of Price Variation: "The same excess in the importation of a perishable, will occasion a much greater competition than in that of durable commodities; in the importation of oranges, for example, than in that of old iron." Using the phrase "much greater competition" Smith presents an "excess in the importation of a perishable" as resulting in "much greater competition" among the sellers because, being perishable, the commodity has to be disposed of fast by the supply side (hence the competitively induced price reduction). Thus, what Smith is describing is (effectively) the Velocity of Price Variation where the impact of Inventory is as a moderating variable on Price.

In an early paper on the subject of Supply / Demand and the effect of Inventory on Commodity Pricing, Holbrook Working (1933) presented a careful and very thorough analysis of Wheat Trading in Chicago based on price and volume data recorded in the Chicago Daily Trade Bulletin between the years 1885 and 1932. Discussing Supply, he makes a comment which reiterates Smith's view of the relationship between the Supply / Demand Balance and Price. "If supplies of wheat are short, prices of cash wheat tend to be higher […] than they are expected to be after the new crop is harvested (Working 1933: 204)."

However, a main focus of Woking's paper was on the relationship between wheat stocks and price spreads. He presented a graph (Figure 1) showing Price Spread (¢ / bushel) against 1'st. July Carry-over Stock (Mln. bushels) for each year he analysed (shown by last 2 digits of the year). Zero on the Price Spread axis = zero spread, 0 on the Stock axis = a normal U.S. Stock of 120 Mln. bushels (Woking 1933:228).



Source: Woking (1933:206)

Fig. 1. Relationship between Chicago July-September Spread in June and United States Wheat Stocks on July 1

Fig. 1 shows that in situations of significant shortage, low 1'st July Stock results in a larger Price Spread. Moreover, as the Stock increases, the spread tapers off to around US$ 0.02 / bushel (this ¢ 2, Woking described as resulting from Grain Elevator Operator costs (Woking 1933: 204)).

What is interesting about Fig. 1 from an Inventory Impact perspective is three points:

- Firstly - Low Inventory Years result in negative Spread on Future Prices where the lower the Inventory the larger the negative Spread (i.e. Backwardisation with prices of Longer Futures below Short Future or Spot Prices).
- Second - Low Inventory Years result in higher Price Volatility compared to High Inventory Years (as evidenced in the size of the spread).
- Third - With High Inventory Levels, a point is reached where the Inventory Level no longer has much impact on the Price (the Spread tapers to a steady level).

The first two points above form the basic tenets of the Theory of Storage which Woking described more fully in a later (and more frequently quoted) paper (Woking 1949). The third point may be significant from a modelling perspective as it may indicate that, as Inventory increases, a saturation point is reached beyond which additional Inventory no longer has significant impact on Price.

There is a significant volume of academic work on the impact of Inventory on Commodity pricing and related subjects (including Mineral Commodities). Much of it confirms

Woking's work. An example of this is a Research paper prepared by Goldman Sachs Global Economics, Commodities and Strategy Research (Currie et al., 2010) which, among other subjects, discusses specifically the impact of Inventory on Commodity Price Volatility. This paper presents an analysis of the impact of Inventory and Storage Capacity on Price Volatility over a one year period across a range of Commodities and demonstrates that Prices for Commodities where there are difficulties in maintaining Inventory (for instance: because of volume or storage capacity constraints) are significantly more volatile than for Commodities which do not have these constraints.

Another paper which is relevant in this context, especially as it relates specifically to Base Metals prices on the LME is a study by Geman and Smith (2013) entitled "Theory of storage, inventory and volatility in the LME base metals." This paper starts with a discussion based on Woking's (1949) Theory of Storage and its relevance to the LME Price Discovery for Base Metals. The authors find "strong validation for the theory. Moreover, […] we find that including Chinese inventories strengthens the relationship further (German, Smith 2013:18)."

A subject that is often raised with regard to Commodities is the influence of Speculation on Price. Discussing the subject in relation to Base Metal pricing it is worth looking again at Fig. 1 (Woking 1933:228) (Woking's graph of the relationship between Price Spread and Inventory Level) in the context of Geman and Smith's (2013: 18) comment about finding "strong validation for the theory" in LME Base Metal Pricing Development. The importance of German and Smith's comment is that they see as a strong correlation in Base Metal Pricing between results calculated by applying Woking's (Woking 1949) Theory of Storage and their own results (in fact they also present a graph identical to Fig. 1 in their paper (Geman, Smith 2013:24)). In this context, discussing the possibility of sustained Speculative Investment in Base Metal Commodities two items are apparent from Fig. 1.

- Firstly - When Inventory is low - Backwardisation is to be expected (i.e. Future Price below Spot Price).
- Second - When Inventory is high - Futures Prices tend downwards towards a level which is fairly stable and which, from Woking's analysis, covers Elevator Operator Costs (Woking 1933: 204).

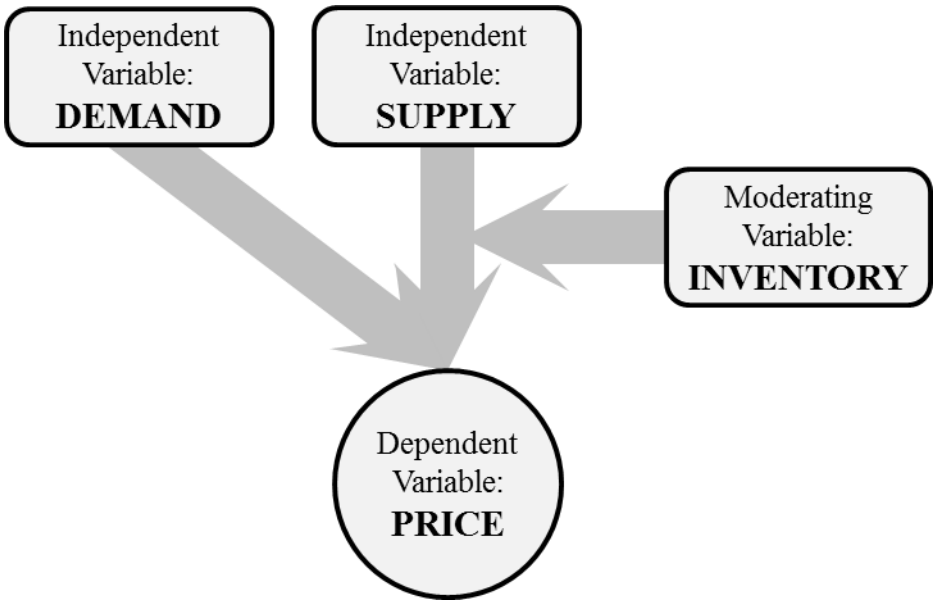
The conclusion from the first point above is that speculative investment only realistically makes sense if Inventory is high. The conclusion from the second point is that even if Inventory is high

then, in a competitive market, there is a cap on the spread where the level of the cap will depend on the degree of competition in that specific market. Therefore, as the funding needed for Speculative Investment in Base Metals is significant (and realistically only available to skilled and knowledgeable investors), it would be difficult to imagine skilled and knowledgeable investors not being aware of these conclusions.

The (apparent) absence of Speculative Investment in Base Metals is confirmed in a paper by Dwyer et al. (2011) published by the Federal Reserve Bank of Australia which concluded that "There is a lack of convincing evidence (at least to date) that financial markets have had a materially adverse effect on commodity markets over time periods of relevance to the economy. It is possible that speculators have had some effect on commodity price volatility, but their contribution would appear to be relatively small - particularly when compared with the contribution from fundamental factors - and short term in nature (Dwyer et al. 2011: 57)."

In the absence of significant Speculative Pressure on Base Metal Commodity Prices two conclusions can be drawn from the above review. The first conclusion is the possible existence of an open research area with regard to Base Metal Price Discovery. This open area may exist between the work done on Supply / Demand Impact and the work done on Inventory Impact. Both Supply / Demand Impact and the Inventory Impact are well researched areas. However, there is an area where Inventory Impact probably becomes less significant (e.g. because of a large Inventory Surplus - for instance the area on Fig. 1 where Inventory Surplus is greater than 90 Mln. bushels) but there could still be high variability in Price. This open research area may therefore exist in attempting to identify the factors causing Price Variability in situations when Inventory no longer has an impact.

The second conclusion from the Literature is that, per the papers presented in the Review (and also from the first conclusion regarding the possibility of an open research area when Inventory has less impact but Base Metal Prices still show variance), The Base Metal Price Discovery Process can be seen as one where Price is a Dependent Variable of the Independent Variables Demand and Supply and Inventory acts as a Moderating Variable on Supply. This Model is shown in Figure 2 and presents the Variable Relationships for the conceptual model which will be discussed further in this paper.



Source: Stepan (2012)

Fig. 2. Base Metal Price Discovery Variable Relationships

3. The global nickel market

The main use of Nickel is as an alloy component for applications which have a requirement for lightness, strength, ductility, corrosion resistance and aspect. Stainless Steel is the major market (66%) where Nickel content can be up to 25% in specific Steel Grades. The second major application area is non-ferrous alloys (24%) where Nickel, because of its primary characteristics plus its magnetic conductivity, is alloyed with Copper or other metals. The third major market area is Electrolytic Coating (7%) where Nickel is used to enhance aspect and provide corrosion resistance. Other uses of Nickel (or Nickel Derivatives) are as catalysts or reaction initiators in Chemical processes (Liu 2012).

In terms of the Demand for Nickel, China is by far the largest consumer with 38% of Global Consumption (mainly used in in Stainless Steel). The EU is second with 22%, followed by Japan (11%), USA (8%) and South Korea (7%) (Liu 2012). Global Demand for Nickel is around 2M tons with a year on year growth around 3 - 5% (INSG 2014).

Total Supply of Refined Nickel equivalent (defined as either Refined Nickel or as Concentrate suitable for downstream use) is aligned with Demand also at around 2M tons. Supply growth (whilst less linear) is in-line with consumption also at around 3 - 5% (INSG 2015). In

terms of Supply, Russia is currently the largest Producer Country with 15%, followed by Indonesia and the Philippines (both 13%) and Canada (11%) (Liu 2012).

Current Nickel Reserves (Potential Supply) are around 81M tons with Australia having by far the largest deposits (30%), followed by New Caledonia (15%) and Brazil (11%) (Liu 2012). What is interesting in this context is that some of the newly exploited fields have been known for a long time but are lower grade ores where production is now feasible because of increases in the overall price level. Table 1 shows the Nickel Supply / Demand Balance over the last 10 years.

Table 1

Nickel Supply / Demand Balance - 2005 to 2014

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Supply (k.t.)	1 290,0	1 390,0	1 440,0	1 406,0	1 316,4	1 441,8	1 601,8	1 759,7	1 963,1	1 993,6
Demand (k.t.)	1 240,0	1 360,0	1 300,0	1 277,0	1 234,3	1 465,2	1 606,7	1 667,7	1 784,9	1 868,5
Balance (k.t.)	50,0	30,0	140,0	129,0	82,1	- 23,4	- 4,9	92,0	178,2	125,2

Source: Based on - INSG: http://www.insg.org/stats.aspx (03.11.2015, 09:54) / INSG newsletters

Analysing Table 1 Supply / Demand data one can see that, whilst there can be years in which Supply is Short (e.g. 2010 - 2011), the situation is generally Balanced to Surplus with a tendency for volumes to increase and Supply short-falls to be compensated by surpluses from previous years (INSG 2015). There was however an exception to this trend in the 2007 - 2009 period when, due to the Global Recession, Demand declined significantly. The start of this decline in 2007 resulted in a Nickel Supply "peak" of 11% caused by a production increase compared to the previous year occurring at the same time as a Demand decrease. Even though Nickel Producers significantly cut back their production over this period, the Surplus continued for the next two years before Demand improved significantly in 2010 to absorb the excess production of previous years (INSG 2012).

Prices for Nickel (Settlement Prices) are established on a daily basis in the second of two trading sessions at the LME. The Settlement Price is normally the price of the last "cash" offer of the trading session ("cash" in LME parlance is effectively a "spot" price). This Price is used as the global reference for physical contracts and, being the LME Official Settlement Price, it is the price at which LME futures are settled. Effectively therefore, the LME Settlement Price is the standard price for global prices and as such is used as the pricing standard for Over-the-Counter (OTC) contracts even when these contracts are outside the LME framework. For this reason, it is

also the International reporting price for Nickel with, for example, bodies such as the World Bank using LME Nickel prices and stock levels in their Commodity Reporting (World Bank 2015). One of the main reasons for the general usage of LME pricing is that these prices are seen as transparent being arrived at ("discovered" in LME parlance) in an Open Out-Cry bidding system. Prices are for standard technical and delivery specifications (LME 2015) with standardised delivery terms (CIF LME Warehouse) and based on standard buy / sell contracts under English Law (LME 2015). Thus, the LME has a structure which enables the "price discovery process" to focus on price as the sole remaining open variable.

Regarding possibilities for Nickel Substitution. Per the British Geological Survey Nickel Commodity Review, there are limited possibilities for Substitution in end-products. This is due "to the unique properties of Nickel, especially in alloying" which provide "very limited options for substitution." However, some Substitution has taken place on the raw material side where (depending on the Nickel Price), for certain Stainless Steel grades refined Nickel is replaced with Nickel Pig iron (NPI) which is "a low grade alternative to Nickel Metal". However, use of NPI has side-effects. "Unfortunately, this has a higher environmental impact than the production of refined Nickel (Bide et al. 2008: 19)." This last point (environmental impact) is the reason why NPI is mainly used in countries where this higher environmental impact is permitted. However even so, use is significant as can be seen from the volumes and percentages in Table 2 showing the development of NPI usage over the last 10 years in equivalent tons of refined Nickel:

Table 2 NPI Usage and as a percentage of Supply - 2005 to 2014

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total Demand (k.t.)	1 240,0	1 360,0	1 300,0	1 277,0	1 234,3	1 465,2	1 606,7	1 667,7	1 784,9	1 868,5
NPI use (k.t.)	-	29,0	96,0	85,0	112,0	208,0	289,0	370,0	510,0	485,0
NPI use as % of Demand	0,0%	2,1%	7,4%	6,7%	9,1%	14,2%	18,0%	22,2%	28,6%	26,0%

Source: data from - Glencore (2013) / Rockstone Research (2015)

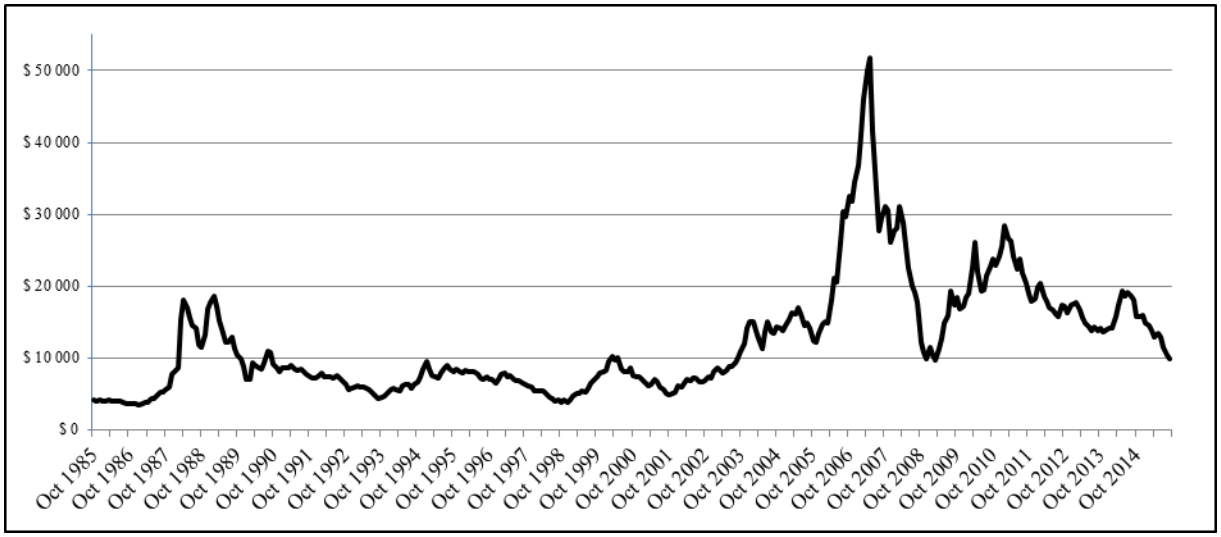
Table 2 shows significant NPI volume increases which stem mainly from its application in China consuming (as written earlier) 38% of the world's Nickel (Liu 2012). However, use of NPI in other parts of the World is limited because of the environmental issues described above. Likewise, the possibilities of substituting Nickel by other products are, according to Bide et al. (2008:19), also limited. One can thus conclude that Nickel Demand is relatively Inelastic because of this difficulty of substitution.

Summing-up, Nickel is a large and growing Global Market, with Supply relatively "in-step" with Demand and with relatively stable Supply / Demand growth patterns. However, Demand for Nickel is inelastic with the accompanying Price consequences if there are real or perceived shortages of the metal.

Another conclusion from the above overview is that, analysing this Market should provide a good basis for developing a Conceptual Price Variation Model which, once it is verified and reaches a more refined state, could then be extrapolated to mineral resource commodities with more multi-faceted Price Discovery Processes, more complex Pricing Structures, or much higher Volumes.

4. Nickel pricing, supply / demand and inventory - analysis of 2007 data

Section 3 above, presented a relatively stable scenario. In practice however, as can be seen in Figure 3, perhaps as a result of the Demand Inelasticity described earlier, Nickel Prices has little of the stability one would expect of a commodity with stable Supply / Demand, no major imbalances and a fairly even growth trajectory.



Source: http://www.indexmundi.com/commodities/?commodity=nickel&months=360 (17.10.2015 11:30)

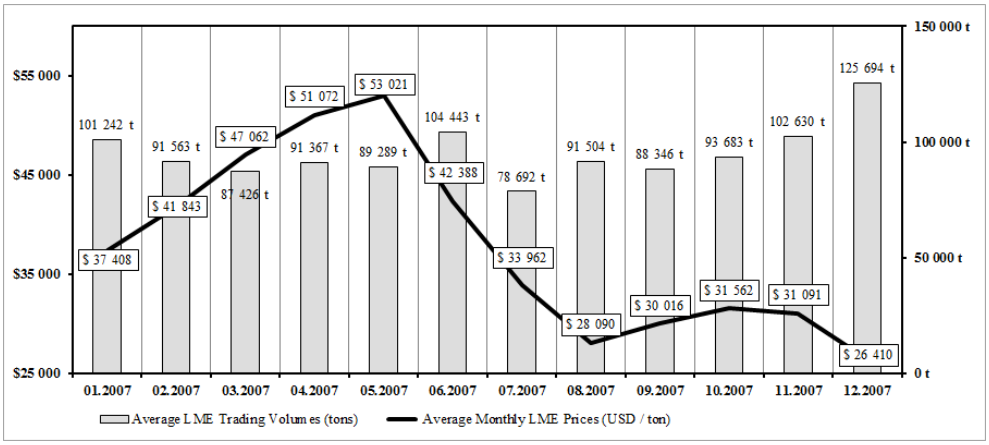
Fig.3. LME Nickel Prices - 1985 to 2015

Reviewing Fig. 3 above, one can see that in the period of highest price variation, (Oct. 2005 to Oct. 2008), Nickel prices first rose by over 400% reaching a peak of USD 54.200,= in May 2007, then per data recoded in (Westmetall 2015), fell by 89% within two years to a low of USD 8.810,= (on 24'th Oct 2008). The question that arises is, in a situation of the "seeming stability" presented in Section 2 above, what factors could have caused such a high variation.

To analyse these factors, LME Historical Data for Price, Volume and Warehouse Stock was taken for the year 2007 (LME 2015). 2007 was selected for several reasons. Firstly, because, as shown on fig. 3, in May 2007 after an extremely steep rise, Nickel Prices reached "an all-time high (Kuck 2015)." Second, the very steep growth before the 2007 peak was not something that happened over a short time but was preceded by strong, sustained upward pricing movement across the two previous years. Third, after the May 2007 price peak prices went into a steep (and dramatic) decline. Forth, because these changes occurred in years where there were Production Surpluses with a large Surplus (11%) occurring precisely in the year in which Nickel prices were at their highest level ever.

Initial analysis of the 2007 data was on LME Trading Volumes. This was to try to understand the relationship between Supply / Demand and Price. Trading Volumes were taken as a "reflection" of Supply / Demand as they are the actual volumes being traded for the "Settlement Price" of the Trade (this also includes the price of Futures Contracts which is tied in to the Settlement Price). Thus, Trading Volumes can be used to reflect Supply / Demand at the specific point in time at which the pricing relationship is established.

The reason for the analysis was that, according to Smith (1776: 56), as Prices increase Demand should decrease. Therefore, the analysis was to attempt to ascertain if "in reality" there was a relationship of this nature between the two variables. This Price / Volume data is presented in Figure 4 showing 2007 LME Nickel Prices (black line graph / left axis) against 2007 LME Trading Volumes (grey bar graph / right axis).



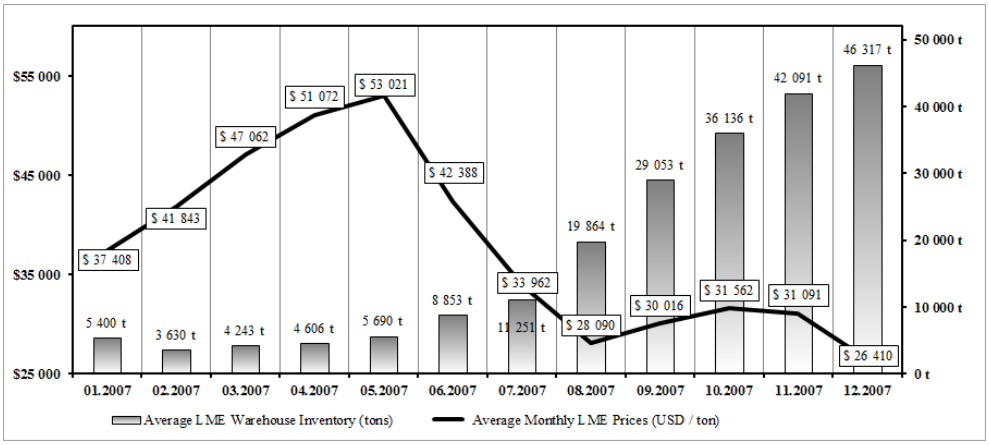
Source: Based on LME Historical Data (2007)

Fig. 4. LME Nickel Prices and Trading Volumes - Jan. to Dec. 2007

Reviewing Fig. 4, there seems little (if any) relationship between the two variables. Prices increase with no visible drop in Trading Volumes. Prices decrease but Trading Volumes seem broadly comparable with the levels when Prices were increasing. This seems to confirm the relative inelasticity of Nickel Demand in 2007. This was then verified by a Pearson Correlation Analysis of the two variables which gave a result of: **-0,35** (i.e. below the correlation threshold of +/- 0,5).

The second stage of the 2007 data analysis was to assess if there was a relationship between Prices and Available Inventory. This assessment was performed comparing LME Price Data for 2007 against the equivalent LME Warehouse Stock Data. Warehouse Stock Data was taken as proxy data for Available Inventory Level as Available Inventory figures are exceptionally difficult to identify within the current LME data structures. Thus Warehouse Stock was taken as best available substitute data.

The two variables (Price / Warehouse Stock) are presented in Figure 5 which shows 2007 LME Nickel Prices (black line graph / left axis) plotted against 2007 LME Warehouse Inventory (shaded bar graph / right axis).



Source: Based on LME Historical Data (2007)

Fig. 5. LME Nickel Prices and Warehouse Stock (Available Inventory proxy) - Jan. to Dec. 2007

The two variables (LME Prices LME Warehouse Inventory) seem in fairly close negative correlation. This was verified by a Pearson Correlation Analysis of the two variables which gave a result of: **-0,78** (i.e. significantly above a correlation threshold of +/- 0,5) indicating a close negative correlation between the two datasets.

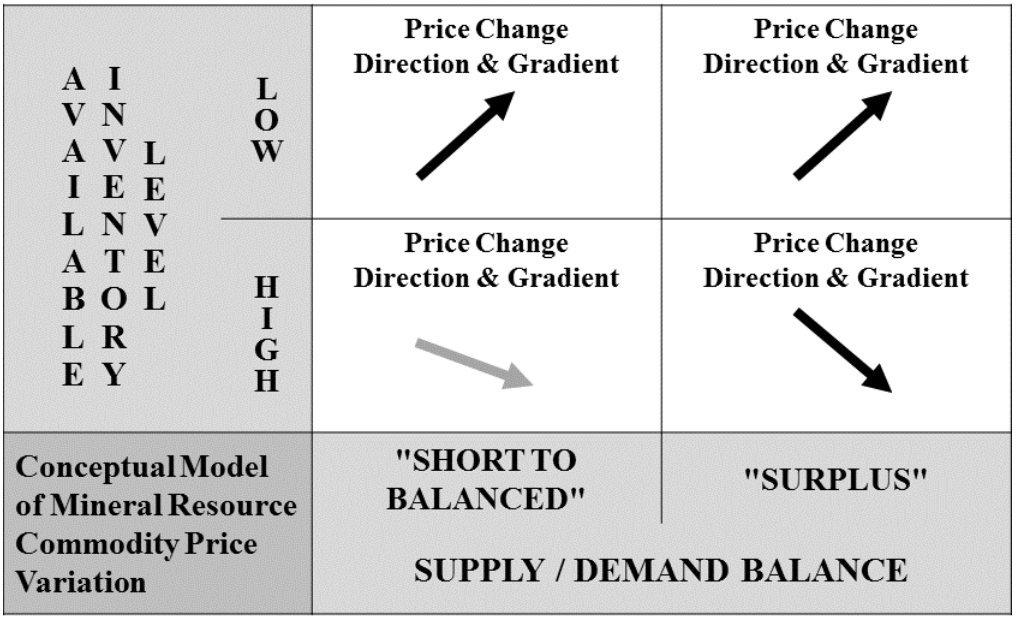
Reviewing the above, one can say in conclusion that, using LME Warehouse Inventory as a proxy for Available Inventory Level, the analysis presented above indicates a relationship between Available Inventory and Nickel Price Determination. Whether this relationship is causative or coincidental or whether Available Inventory Variation results in Price Variation, or the impact is vice-versa, are subjects for further analysis.

Further analysis may also be needed to isolate "pure" Available Inventory figures from the LME Warehouse Stock Data. This would enable an unequivocal statement to be made whether there is a relationship (or not) between Available Inventory and Price and, if there is a relationship, what are its salient features.

5. Proposed conceptual model of base metal price variation

The Mineral Commodity Price Variation Model proposed in this paper consists of a "two by two" matrix with the left axis showing "Available Inventory Level" and the bottom axis showing "Supply / Demand Balance". The inclusion of "Supply / Demand Balance" is despite the lack of relationship identified in the 2007 data (presumably resulting from inelasticity of 2007

Demand) and is because it is impossible to exclude Supply / Demand from Price Discovery Processes. For this reason Supply / Demand is included in this version of the model to enable the inclusion of Price Discovery Processes when, in line with the discussion in Section 2 Available Inventory Level has less impact. This model is presented in Figure 6 and is followed by a description of its elements.



Source: Author's own research and concept

Fig. 6. Mineral Resource Commodity Price Variation Conceptual Model

The model presented in Fig. 6 shows a concept proposal of Mineral Resource Commodity price variation direction and gradient by presenting the impact on price of four distinct scenarios. However, before going into the details of each scenario it may be worth discussing the model framework. The left axis (Available Inventory Level), is divided into two categories being: "High" and "Low" (clearly, for practical use a standard should be applied to prevent arbitrary definitions of the two categories). The bottom axis (Supply / Demand Balance) reflects the Global Balance for a particular Mineral Commodity over a particular period of time The reasons for including this axis, despite the 2007 analysis results, have already been described earlier in this Section. This axis, is divided in two categories being: "Short to Balanced" and "Surplus" (here also a standard should be applied to reduce arbitrariness which resulting in a reduction of the usefulness of the model for comparative analysis).

The reason for just two categories (and not for instance a separate one for Balanced) is based on the authors own commodity purchasing experience. Purchasers react to Short and Balanced availabilities in fairly similar ways and, from a Purchaser's point of view, both scenarios have significant levels of risk. In fact, one can argue that the risk in a Balanced situation is unquantified thus is often larger than in a Short situation because in a Balanced situation, the Purchaser never knows when the overall situation will result in Shorting. On the other hand, the risk in "Short" situations whilst high is clearly defined. Purchasers in a Short situation know they must have effective plans in place to mitigate the impact of the shortage.

Having discussed the model framework, it is now appropriate to discuss the four model segments. These can be described as follows:

1. Low Available Inventory Level & Short to Balanced Supply / Demand Balance - In this scenario the model proposes prices will increase rapidly and with high velocity (i.e. a scenario in accordance with Smith (1776)).
2. Low Available Inventory Level & Surplus Supply / Demand Balance - This scenario also proposes that prices will increase rapidly and with high velocity. The logic behind this is that what most probably governs price movement on a day-to-day level is not the overall Supply Balance but something more fundamental. It is the need to discover the specific price which Purchasers are willing to pay for the actually available inventory to enable them to cover their own very short term (and often critical) requirements. Thus, what is important in this context is not the overall Supply / Demand Balance but the actual Physical Quantity Available today by the Purchasers who have a critical need to purchase today. In this situation, as the need is critical, Purchasers will buy for (almost) any price and price will be less of a barrier.

3. High Available Inventory Level & Short to Balanced Supply / Demand Balance - Here, the model presents that Prices will decrease but gradually. The thinking behind this is that as what determines daily prices is today's Available Inventory, prices will have a downward tendency when Available Inventory is High. On the other hand, it is very clear that, as Available Inventory slack gets used up, prices will probably move to the segment described under (1) above - Low Available Inventory Level & Short to Balanced Supply / Demand Balance.

4. High Available Inventory Level & Surplus Supply / Demand Balance - This is the only scenario in which the model proposes prices will actually reduce significantly. This significant decline will probably be until Available Inventory starts getting used up. At this point, either the scenarios described in the other segments start coming into play or the Available Inventory reduction results in a slower price reduction velocity. On the other hand, if there is no use-up of Available Inventory, prices will probably continue their decline until the point is reached where the "use-up" starts to take effect.

Concluding this description of the theoretical model, one can reiterate the emphasis placed not just on the role of the Supply / Demand Balance in establishing Price but, even more so, the role of Available Inventory.

As presented in the Literature Review, Supply / Demand is an area well researched in Economics as also increasingly in the context of Commodity Pricing, is Available Inventory. This significance of Available Inventory in discussing Commodity Pricing is probably for two reasons:- partially because of the relationships between Supply / Demand, Available Inventory and Price presented in Fig. 2 where Price is a Dependent Variable of Supply / Demand and Inventory is a Modifying Variable on Supply but also because of behavioural aspects in Commodity trading.

Looking at Price as a Dependent Variable of Supply / Demand, and Available Inventory as the Modifying Variable, if Demand is higher than Available Inventory, Price will peak at a level which will ensure Available Inventory is consumed. If there is no Demand on a particular day then the actual volume of Available Inventory is irrelevant. It can be very high or very low but the price impact will be the same. This means that in this dependency on Supply / Demand, Price can be seen as a proxy of Demand moving upwards or downwards as Demand changes with Available Inventory as the supply component.

Looking at the behavioural aspects of the model, the main trigger of Demand is need (obviously) but with Commodity Purchasing, it is also (as in many different types of Purchasing) the perceived risk of this need not being met.

It is this sense of risk (in the author's opinion and experience) that is the trigger causing Price Level Independence in decision taking whenever there is a shortage or (very often) even just a risk of shortage. In this situation concepts such as: value for money purchasing, cost plus analyses or price benchmarking which are basic Purchasing Concepts forming part of most

Purchasing Manager's basic portfolio become irrelevant. What matters is (purely and simply) Available Inventory and the Price a given Purchaser is prepared to pay for that part of Available Inventory their company needs to mitigate the risk of a (real or perceived) threat of product non-availability and its negative impact.

6. Comparison of 2007 nickel price variation against base metal conceptual pricing variation model

In this context, whilst this can only be a tentative conclusion pending further research, the analysis of Nickel Prices presented in Section 3 could be seen to initially confirm three out of four of the scenarios of the model presented in Section 4:

1. Low Available Inventory Level & Short to Balanced Supply / Demand Balance - In this scenario, a rapid price increase is expected. This was probably the scenario at the start of 2007 before the global recession started having a major impact. In this situation the model proposes rapid price increases. These took place in the first few months of 2007 (at an even faster velocity than the price rises of the previous two years).

2. Low Available Inventory Level & Surplus Supply / Demand Balance - Because of the low level of Available Inventory, Prices are also expected to increase rapidly in this scenario. This situation probably became apparent later in the first part of 2007 (but will need more detailed research to verify) when Prices were still increasing sharply but the Global Recession was starting to have an impact on the Supply / Demand Balance. From the data it is clear there was a Supply Surplus in 2007 and so one can imagine a situation in which Available Inventories were still insufficient to cover even a decreased daily demand.

3. High Available Inventory Level & Surplus Supply / Demand Balance - Prices are expected to decline in this scenario. The data shows that prices started to decline in May 2007 in the same month that Available Inventory Levels started to increase. One can therefore envisage a scenario in which Available Inventory started to increase as a result of Nickel demand becoming increasingly weak due to the Global Recession. This weakness could also generate lower levels of critical daily Demand at the same time that

Available Inventory started to increase (maybe because in the face of a critical Demand drop attempts to restrict Available Inventory became untenable) thus Prices went into a steep decline. This scenario seems plausible but it needs verification.

The scenario not analysed in the 2007 Nickel Data is the one described as: - High Available Inventory Level & Short to Balanced Supply / Demand Balance - which, according to the model, should result in a "mild" price decrease tendency. This is because the situation described in the segment probably did not occur in 2007. Therefore, another year should be analysed (e.g. 2011) to see if the price movement proposed by the model is confirmed (or not) by data on Available Inventory.

Another aspect that could lead one to give credence to the pricing movements in the model is the high negative Pearson Correlation between Available Inventory Level and Price Level. A correlation of -0,78 is significantly above the 0,5 threshold indicating if a correlation exists between two variables.

To verify this high Pearson Correlation, a second analysis was carried out on the Price Level / Available Inventory Level for each day in the period between May and July 2007. This period was chosen because it included the moment at which the increases "peaked" and pricing entered into a steep decline. Pearson Correlation Analysis of this daily data also showed a negative correlation between the two variables. This came out to: **-0,88** being an even higher negative correlation than the one for the monthly data.

Concluding this section, whilst clearly more research is needed to verify the pricing dynamics presented in the model, one could perhaps make a tentative comment that, based on the analysis results, for three of the four scenarios presented, the pricing dynamics are not implausible. The forth scenario (High Available Inventory Level & Short to Balanced Supply / Demand Balance) could not be verified because in 2007 there was no period which could have reflected this situation. What lends additional credence to this conclusion is the even higher correlation of the Daily Price Level / Available Inventory Level. Albeit the daily results were analysed for just a three month period but this period was the "cusp" of the 2007 Price graph and the result may indicate that data which reflects higher volatility and higher sensitivity (because it is not "smoothed out" in monthly weighted averages) shows a higher correlation between Price Level / Available Inventory Level.

7. Concluding remarks

This paper presents a Conceptual Model of Nickel Price Variation together with some base empirical data to initially verify the model's applicability. Whether the model can be used for further analysis is an open question at this stage pending further research and validation. What however, is probably less equivocal is the role of Available Inventory in setting daily prices. Longer term Pricing Trends are usually an extrapolation of Daily Price Trends. Therefore, understanding why a specific mineral resource commodity's daily price "is on the level it is" should certainly help with understanding how to build predictive elements into commodity pricing models.

Whilst Available Inventory plus Demand can be the key determinants of daily pricing, they are probably not the sole determinant of Pricing Trends. The Supply / Demand Balance defines Volume and, if there is a Surplus, one can expect situations to arise where the (sheer) Volume of potentially available product makes it impossible to maintain restrictions on Available Inventory. This Volume Surplus can be physical (in the sense of high stocks at Producer Plants or high restricted stock in LME Warehouses) but it can also be reflected in high throughput of Available Inventory. Thus, if Producers are obliged for business reasons to sell product fast (even if prices are declining), this can automatically lead to an increase in Available Inventory which in-turn would lead to a decrease in Price.

As often written above, the model presented in this paper is conceptual and requires further validation and research. However, even with this type of model one of the first questions raised in discussion is its relevance outside the academic community. These questions look for answers regarding who (or what institutions or companies) would be interested in using a model of this nature or in applying the results. In this context, if the model presented in this paper is successfully verified, it may provide a mechanism for a better understanding of mineral resource commodity price discovery processes by applying just three variables. In addition, it may also provide a structure not just for understanding the processes but also for quantifying the results.

This quantifying function could prove very useful for the many production companies for whom mineral commodity prices are a critical or very important subject. These are many more companies then "just" the businesses involved in the mining, mineral extraction or refining sectors (although these sectors on their own, are very large indeed).

Regarding next steps, the first step should be to identify and attempt to isolate LME Available Inventory data. LME Warehouse Stock can provide a proxy but this proxy may not withstand the more robust data analysis needed to fully verify the model. Once this Available Inventory data is generated, the second step would be to combine it with Price data and verify the correlation between the two sets of data across a significantly longer period. Should this Price / Available Inventory Level correlation prove significant, the third step would be to verify Price Dynamics in the four scenarios presented by the model adjusting the model as necessary to ensure the best possible replication of empirical results. If this verification process is successful it should result in a conceptual model robust and comprehensive enough to model Nickel price variation. The next step would be to verify the model on a limited range of mineral resource commodities and adjust it as appropriate. It is possible, that a (realistic) conclusion from this step results in the definition of different models for different mineral resource commodities. At this stage, after successful completion of all four steps, the model should be suitable for further use.

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Zmiany cen metali nieszlachetnych: przyczynek do budowy modelu koncepcyjnego cen niklu

Streszczenie

Na podstawie analizy danych niklu z roku 2007 artykuł stanowi przyczynek do dyskusji o czynnikach powodujących zmiany cen metali nieszlachetnych. Rok 2007 został wzięty pod uwagę ponieważ stanowił kulminację kilkuletniego okresu zawirowań cenowych na rynku niklu. Celem analizy było określenie czynników, które spowodowały te zawirowania. Na podstawie tejże analizy został stworzony model koncepcyjny zmian cenowych niklu. Model przedstawiony jest w artykule i może ukazać się pożyteczny w dalszych badaniach nad zmianami cen również przy innych metalach nieszlachetnych.

Kluczowe słowa: metale nieszlachetne, ceny surowców, dostępny zapas, zapas magazynowy, zmiany cenowe, popyt i podaż
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