THE RELATIONSHIP BETWEEN SCARCITY OF NATURAL RESOURCES AND THEIR REAL PRICES

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Abstract

There has been a long running concern about resource depletion. Some argue this concern is misplaced, while others consider it to be an urgent problem requiring immediate action. Economists suggest that long term prices, adjusted for inflation (real prices), provide a useful and effective indicator of resource scarcity. This study tests this hypothesis in consideration of the accepted theory that traditional price deflators, such as the US consumer price index, overestimate inflation-, and accordingly-, are likely to underestimate long term commodity prices.

To investigate the usefulness of real prices as an indicator of scarcity, a case study of two metals considered to be expensive (platinum and rhodium) and two considered to be relatively inexpensive (copper and lead) was used. Real long term price indices were constructed and econometric analysis used to determine the direction and significance of long-term price trends and whether real prices were correlated with other scarcity indicators such as the Reserves-to-production ratio.

The results show, when an appropriate adjustment is made to the deflator, long-run trends in real metal prices are all upward, and there is a significant relationship between the real prices and scarcity indicators, such as the reserves-to-production ratios, for platinum and rhodium, but not for copper and lead. These findings suggest that real prices of platinum and rhodium are more affected by their scarcity, while copper and lead prices are likely to be more dependent on other factors such as high substitutability with other virgin and recycled materials.

Key words: non-renewable resources; depletion; real price; inflation bias
JEL classification: Q50

1. INTRODUCTION

There has been long running concern about resource depletion. Some argue this concern is misplaced, while others consider it to be an urgent problem requiring immediate action. For many, the oil crisis in 1973 was the event that drew people's attention to the seriousness of resource scarcity. Actually, we have always been worried about resource security. The famous best-seller Limits to Growth (Meadows et al., 1972) also placed substantial emphasis on this issue, claiming that gold reserves would be exhausted by 1981, silver and mercury by 1985 and zinc by 1990. These predictions proved inaccurate.

Economists, suggest that long term prices, adjusted for inflation (real prices), provide an effective and useful indicator of resource scarcity, pointed out that these fears were erroneous, as long term real prices had been falling. In 1980 Julian Simon struck a wager that the real price of any given material chosen by his challenger would have fallen at least one year later (Lomborg, 2001). The bet was finally determined ten years later in 1990. Simon won the wager, as the price of total basket of minerals and also each individual mineral had decreased. The weight of evidence supports a trend of falling long run mineral commodity prices (Krautkraemer, 1998). It is generally accepted that this trend is driven by factors that increase supply relative to demand, such as discovery of new deposits, new technologies allowing more efficient use of the minerals and increasing availability of recycled materials.

However, it has been shown that the hypothesis that real long term commodity prices are falling is dependent on the choice of deflator used (Svedberg and Tilton, 2006). In earlier work on commodity prices, nominal prices denominated in US dollar are converted to real prices using the US producer price index and other standard deflators, but the choice is rarely examined in detail. However, deflators frequently overstate inflation and understate the change in long run commodity prices. For example, Svedberg and Tilton (2006) examined the real long run price of copper and found that when no adjustment was made to the deflator (in this case, the Consumer Price Index (CPI)) a downward trend was quite apparent, but a reversal in trend occurred when a CPI that was adjusted by subtracting 1% point every year from the annual rise in the CPI was applied. This has important implications, as not properly adjusted deflators can misinform resource policy about the real level of scarcity, provided that real prices are reliable indicators of scarcity in fact.

The aim of this paper is to investigate the usefulness of real prices as an indicator of scarcity in consideration of the accepted upward bias inherent in the CPI, using a case study of two metals considered to be expensive (platinum and rhodium) and two considered to be relatively inexpensive (copper and lead).

The paper is structured as follows: Section 2 elaborates on the methodology that was followed to produce this paper. Section 3 provides a short review of the real market price as a scarcity indicator. Section 4 summarizes the reason why the CPI overestimates inflation. Section 5 presents the importance of the metals selected for this study briefly. Section 6 gauges the long term trends in the real prices of the chosen commodities and provides a discussion of the results. Section 7 concludes the main findings and makes suggestions for further research.

2. METHODOLOGY

The method for this study is divided into two different parts. Stage 1 is research, while Stage 2 is modelling.

In the field of resource scarcity and inflation bias there are great many articles published, and these provided insights with regard to scoping this study and gaining a better understanding of the issues mentioned above. They also played a crucial role in helping to find the tools to approach the method as well as were useful and reliable to extract data for this study. Data related to demand

and supply, metal prices, reserves and the price deflator stem, among other, from the USGS, the US Bureau of Labor Statistics (BLS) and Platinum Today, the world's leading authority on platinum group metals, and cover the period 1913-2009.

First, nominal prices were converted to real prices (adjusted for inflation) using the US CPI. The reason for selecting CPI instead of the more commonly used Producer Price Index (PPI) is that Svedberg and Tilton (2006) argue that the CPI reflects the real price of metals studied in reference to a representative basket of consumer goods and services. Accordingly, the effect of commodity price trends on the welfare of the society is displayed more accurately. To correct for the upward bias in the CPI the equation calculated by Cuddington (2009) was used. It is the following:

$P_t=CPI_t*e^{-gt}$

where P_t is the corrected deflator, g is the correction factor (coefficients that adjust prices to account for inflation bias) and t is the time trend that takes the value of 1 in the first year and increases by 1 for each succeeding year. Three bias correction factors were considered (g= 0.005, 0.01, 0.015).

Once the different real prices had been calculated, long term price trends were determined by an autoregression model (only the trends were used). It was assumed that the long-run trends in real prices were linear. The equation estimated is the following:

$P_t=\beta_0+\beta_1 t_1+\varepsilon_t$

where P_t is the average US producer price of the selected metal for year t, deflated by the CPI adjusted by subtracting 0.5% or 1% or 1.5% points (depends on the correction factor chosen) from the CPI each year. Variable t is the time trend taking the value of 1 and increasing by 1 each year. The β's are the parameters to be estimated and ε_t is the error term.

The final step involved econometric modelling to determine the existence or otherwise of correlations between real prices of the selected metals and other recognised indicators of scarcity. This involved the implementation of linear regression in STATISTICA® to identify the relationship between the independent variable (in this case, the reserves-to-production ratio) and the dependent variable (in the case, the real prices of the metals examined).

3. REAL MARKET PRICE AS A SCARCITY INDICATOR

Although there are other scarcity indicators, such as physical indicators, the real marginal extraction cost and the marginal exploration and discovery cost, real (inflation-adjusted) market price is the most commonly used. Time-series data on market prices are widely available, relatively easy to use and are forward-looking (to some extent) unlike real marginal resource extraction costs. However, price data are an imperfect indicator too. For example, taxes, subsidies, exchange rate controls and other governmental interventions will distort prices, obscuring market signals. Real price indices are also sensitive to the choice of deflator used. There is disagreement regarding what index deflator should be used to deflate nominal prices. Despite these limitations of real prices, Perman (2003) concludes that market price data are broadly the most appropriate existing measure of resource scarcity.

4. INFLATION BIAS INHERENT IN THE CPI

Assertions that consumer price indices and similar price series in the United States and elsewhere overstate inflation arose 50 years ago (Svedberg and Tilton, 2006). Inflation measured incorrectly will over, or understate aggregate economic growth and productivity, budget deficits, government spending programs, industry prices and productivity, real financial returns, real median incomes and real wages and the competitive performance of economies (Gordon, 1990). The Boskin Commission was appointed by the United States Senate in 1995 to measure inflation bias and devise subsequent improvements to the CPI. They found that the CPI overestimated inflation by around 1.1% per year (Boskin et al., 1996). Several economists have tested the robustness of the findings of the Boskin Commission. For instance, Costa (2001) analysed the CPI between 1888-1994 and found different biases for different subperiods ranging from -0.1% to 2.7% points a year, Stewart and Reed (1999) examined the CPI in the period of 1978-98 and found that the CPI bias was 0.45%.

Inflation measured incorrectly also has an impact on long-run real price trends of mineral commodities, which is the focus of this paper.

The Boskin Commission paid particular attention to three important problems concerning the calculation of consumer price indices: substitution bias, new goods, and quality change.

Substitution bias arises when consumers change their behaviour in response to price changes. In creating the consumer price index the Bureau of Labor Statistics in the US used a Laspeyres index or „Lowe" formula. This formula presumes zero substitution, as initial quantities used in the formula are assumed to stay fixed until the next expenditure weight is updated (in the Laspeyres index the weights of the different items are derived from consumption expenditure survey). However, buyers tend to shift toward goods with lower price more frequently than the weights are updated. Accordingly, the Laspeyres formula will result in an upward bias in the index. The Boskin Commission (Boskin et al.1998) conclude that the use of such a formula is „extreme, unrealistic and unnecessary" and estimates bias attributable to substitution effect to be 0.4% point per annum in the 1974-95 period.

The most fundamental problem in constructing price indices is that the market basket constantly changes and price indices have to adjust to these changes (Johnson et al., 2006). New goods can enter the CPI basket of goods during repricing, through sample rotation and during a revision of the item structure (Johnson et al., 2006). When handling new products on the market at least three biases can arise. First, new products are included in the indices years after they emerged on the market. Gordon & Griliches (1997) find that both air conditioners and personal computers were all introduced in the index years after they had been first appeared in the market place (Boskin et al., 1997). This means that the accumulated price fall for these products during the years they were on the market were not captured in the price indices. Second, many products that were improved in quality were included as completely new goods ignoring the quality improvements they reflect. Third, new products are introduced in the indices without allowing for consumers surplus they generate. Boskin et al. (1997) estimates that the new goods bias has caused the CPI to overstate inflation by 0.3-0.4% per year.

Over time the quality of goods and services in the market basket changes. Because of such changes, consumers receive more for the price paid (Johnson et al., 2006). This quality change is highly visible if we take the example of computers and related electronic products. According to several estimates made by Jorgenson and Stiroh (2000) quality improvements have outstripped prices increases by some 15-30%. Although it is inevitable that CPI should make some quantitative estimate of such changes, it has been a source of disagreement, as consumers' preferences are different, accordingly, their valuation of changes in quality vary. Changes in quality that are unrecorded cause an upward bias in the CPI. The size of quality change bias was estimated to be 0.3-0.4% points (Boskin et al., 1998).

5. OVERVIEW OF THE EXAMINED MATERIALS

Several sources indicate that platinum and rhodium are the two most expensive metals in the world with their prices moving around $1,500 and $2,000 per troy ounce respectively, while the same quantity of copper and lead cost approximately 10,000 times less (Platinum Today, 2010; US Geological Survey, 2010). The demand for platinum and rhodium is projected to increase as they are an important factor of production in the automotive, jewellery and hi-tech industries which are set to expand in the coming decades, consequently prices are expected to rise further (Johnson Matthey, 2010). Both copper and lead are important industrial metals too (copper's principal uses involve construction, electrical and communication infrastructure, domestic and industrial equipment and transport; 75% of the world's lead is used in batteries); in 2008 the global annual production is approximately 15 and 4 million tonnes respectively (USGS, 2010). Moreover, there are reliable and consistent data on these minerals stretching back to the early 1900s.

6. RESULTS AND DISCUSSION

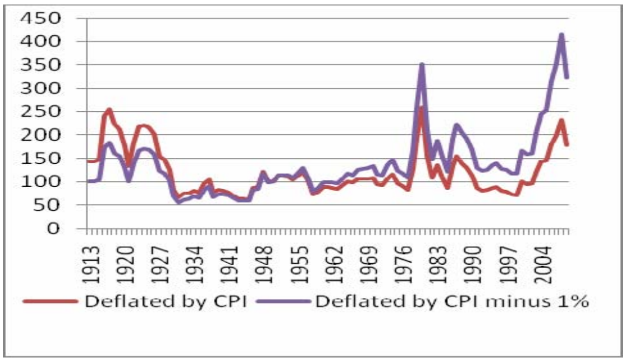
6.1 Price trends

For each metal studied, there is a base case, where the inflation bias is taken to be 1.0% point a year throughout the period that varies depending on the data available, but roughly covers the whole 20th century till present. The inflation bias of 1.0% was chosen to be the benchmark case as it is close to the estimates reported by Boskin et al. (1996), Lebow and Rudd (2003) and Nordhaus's (1997) „thought-experiment" estimation. Beside the base case alternative estimates are provided taking a bias of 0.5% (low) and 1.5% (high) points per year, and the case when the CPI was left unchanged (conventional) is also examined. The objective, similarly to Svedberg and Tilton (2006), is to demonstrate how the long-run trends in the real prices change when different adjustments are employed.

6.1.1 Platinum

Figure 1 illustrates the average annual US producer price for platinum for the years of 1913-2009 deflated by the CPI and the CPI minus 1.0% points a year. The difference between the two cases is quite apparent. When no adjustment is made to the CPI then there is a moderate downward trend, but when there is a correction for the bias the trend reverses, showing an upward trend in the price index.

Figure 1. Index of the US producer price of platinum from 1913-2009 with 1950=100. Platinum price deflated by the CPI and the CPI minus 1.0%.



Source: Own creation based on Platinum Today and USGS statistics.

Table 1. Results for the US producer price of platinum deflated by CPI and adjusted CPI

	Conventional (0.0%)	Low (0.5%)	Base case (1.0%)	High (1.5%)
Constant				
Coefficient	133.79	104.83	74.63	41.76
t-Statistic	13.72	10.20	6.38	2.93
Probability	0.00	0.00	0.00	0.00
Time				
Coefficient	-0.29	0.45	1.28	2.25
t-Statistic	-1.67	2.45	6.16	8.92
Probability	0.10	0.02	0.00	0.00

Equations are estimated using both linear regression and autoregression (only the trends are used) models.

Table 1 contains the results related to the statistical significance of the trends in Figure 1, it also shows two other alternative cases (bias correction of 0.5% points and 1.5% points per year). The long-run trend in real platinum price calculated with the unadjusted deflator is downward, though significant only at the 10% level. In contrast, the results for the other three cases (0.5%, 1% and 1.5%), when adjustments were applied, suggest that the real price of platinum has trended upward over the period studied, and the three trends were significant.

6.1.2 Rhodium

Even when the inflation bias is not taken into account the trend already seems to be upward rather than downward, but when inflation bias is considered the upward trend is more obvious.

Indicators of long-run trends in real rhodium prices suggest that independent of the deflator used, real prices of rhodium have been upward over the past 80 years. Results for each case proved significant at the 1% level.

6.1.3 Copper

In case of no adjustment to the CPI a downward trend is conspicuous, but the index for the base case (adjustment by 1.0% point) exhibits a reversal in the trend.

The long-run trend in real copper prices when unadjusted by a deflator is downward and the coefficient on the trend variable is significant at the 7% level. When the CPI is reduced by 1% point a year, the trend is upward and statistically significant at the 1% level. The first alternative bias factor, a correction of 0.5% points per year, suggests a more moderate upward trend, though significant only at the 7% level. The last case, when an adjustment of 1.5% is employed, indicates that real price of copper has trended upward over the last 95 years and is significant at the 1% level.

6.1.4 Lead

The results for the long-term trends in real lead prices show when no adjustment is made to the CPI the long-run trend in the real US producer price of lead is downward and significant at the 1% level. When the CPI is reduced either by 0.5% or 1% or 1.5% points a year, the trends are all upward, however, the coefficient on the trend variable for the low case is significant only at the 30% level.

There is much to suggest that inflation bias does exist. Numerous studies (Johnson et al. (2005)) and the fact that the US Bureau of Labor Statistics made important changes to improve the CPI all underpin this statement. However, it is hard to ascertain the exact value of the inflation bias but it is likely to fall between 1.0% and 2.0% points a year, varying year on year.

For all the selected metals, adjusting the deflator value changed the long term trend in real prices from downward to upward sloping. Therefore, the choice of deflator used to judge long term trends is crucial. Given the assumption that the point estimate of the bias range from 1.0% to over 2.0% points per year, it seems that long-run price trends have trended upward over the period studied and are statistically significant if either an adjustment of 1.0% or 1.5% is applied. When the unadjusted CPI and the one that is adjusted by 0.5% points a year are used to calculate the trends, the findings are different. With the exception of rhodium the use of the unadjusted CPI results in a downward trend, though is significant only for lead. When the CPI reduced by 0.5% point a year results already indicate upward trends that are significant only for platinum. For rhodium both the conventional and the low case lead to upward trends that are both significant.

Upward trends in the long term real prices of the metals examined show the issue of resource depletion is more pressing than previously thought. Higher real prices are thought to indicate that resources are becoming less available and this contradicts the dozens of empirical investigations that have failed to detect statistically significant upward trends in the long-run real price of mineral commodities that Krautkraemer (1998) and Brown (2000) noted.

With rising mineral commodity prices indicated by the base case it is worth examining how the growth of mine production and of real prices (adjusted by 1% per year) relate to each other. Results that are shown in Appendix E vary. In the case of platinum and rhodium, the real price growth exceeded mine production growth over the period studied. While their supply increased 2.35 and 3.09 fold respectively, real prices increased more than three and four times each. In contrast, for copper increase in real prices had been significantly smaller than the increase in mine production. For lead, the growth rate of the examined factors increased proportionately.

It is important to note that a more exhaustive research could have been undertaken, but limited time and data prevented this. A lack of data and time hindered more robustness tests such as the construction of price trends using London Metal Exchange (LME) prices or the US producer price index (PPI) as a deflator instead of the CPI. Moreover, it would have been worthwhile to see how long-run price trends would have changed if they had not been linear, but, for instance, inverse or quadratic, or if non-competitive market periods, when interventions and collusive actions distorted the market had been excluded.

6.2 Material scarcity

This section gives an estimation of the current, 2009, reserves-to-production ratios (R/Ps), a frequently used indicator that gauges the number of years that a particular mineral will still be present, of the materials studied. Table 2 shows that lead is the most scarce metal from the list with a little more than 20 years of availability if the production is presumed to continue at the current rate. Lead is followed by copper with almost 35 years of availability. According to the calculations, the world is not likely to run out of platinum and rhodium in the foreseeable future. However, considering the results for the trends in the reserves-to-production ratios of the examined materials, it seems that platinum and rhodium (especially rhodium, its time coefficient equals to -9.19) should be paid greater attention, as their R/Ps are falling at a significantly faster rate than those of copper and lead (in fact, R/Ps for copper show an increase in trend with time coefficient of 0.49, while lead's time coefficient is -0.23). Results for all metals are significant.

These numbers have been found to approximately match the outcomes of other studies undertaken in this area. For instance, according to Wouters and Bol (2009), Diederen found that copper reserves would last for 25 years, lead for 19 and platinum group metals (PGMs), that include the relevant platinum and rhodium besides others, for more than 70 years. Frondel et al. (Wouters and Bol, 2009) concluded that copper was likely to be available for 32 years, lead was for 21 and PGMs for another 177 years.

It is crucial to note that new discoveries increasing the amount of available reserves might occur and technological progress also can relax resource constraint by boosting productivity and turning resources that can not be economically extracted or produced at present into economically available.

In order to answer the question of „Are mineral prices a reliable signal of resource scarcity?" linear regression was carried out. Reserves-to-production ratios were taken as independent variables, while real prices constructed by using both the unadjusted and the adjusted deflator were selected to be the dependent variables. Results of the regression are shown in Table 3.

Table 2. Estimates of current (2009) availability of metals

	Pt (t)	Rh (t)	Cu (million t)	Pb (million t)
Mine production	178	24	15.8	3.9
Reserves[a]	33725	7100	540	79
R/Ps	189.47	295.83	34.18	20.26

[a]Reserves: that part of the reserve base which could be economically extracted or produced at the time of determination. Reserves include only recoverable materials. Platinum and rhodium reserves are based on Patricia J. Loferski's (Ph.D. Platinum-Group Metals Commodity Specialist, National Minerals Information Center, U.S. Geological Survey) estimation that platinum accounts for 47.5% of Platinum Group Metals reserves, while rhodium accounts for 10% of it.

Table 3. Results for correlations between R/Ps and real prices of selected metals

	Copper		Lead		Platinum		Rhodium	
	Con. (0.0 %)	Base case (1.0 %)	Con. (0.0 %)	Base case (1.0 %)	Con. (0.0 %)	Base case (1.0 %)	Con. (0.0 %)	Base case (1.0 %)
Var. (R/P)								
Beta	0.45	0.47	-0.18	-0.22	-0.61	-0.60	-0.54	-0.54
Coef.	7.80	9.67	-1.58	-2.44	-5.48	-6.67	-13.11	-15.49
t-Stat.	1.74	1.82	-0.62	-0.78	-2.80	-2.72	-2.30	-2.32
p-level	0.11	0.09	0.55	0.45	0.02	0.02	0.04	0.04
R	0.45	0.47	0.18	0.22	0.61	0.60	0.54	0.54
R^2	0.20	0.22	0.03	0.05	0.38	0.36	0.29	0.29
Adj.R^2	0.14	0.15	-0.05	-0.03	0.33	0.31	0.23	0.24
f-Stat.	3.03	3.33	0.38	0.60	7.83	7.43	5.30	5.38

Equations are estimated using linear regression.

Independent of the deflator used, in the case of copper and lead, results were found to be statistically insignificant. This means that there is no linear relation between the real prices and the reserves-to-production ratios. In contrast, the numbers for platinum and rhodium indicate a linear relation between the observed variables. For platinum, the Pearson's r coefficient shows a strong negative correlation of 0.61 that is significant at the 2% level. For rhodium, the multiple R indicates a slightly weaker negative relation of 0.54 which is significant at the 4% level.

An other linear regression was also carried out to test for the hypothesis that long term commodity prices provide a useful and effective indicator of resource scarcity. The annual percentage changes in the R/Ps (independent variable) of the metals were regressed against the annual percentage changes in their real prices (dependent variable).

Independent of the deflator used, all results were found to be insignificant, indicating that there were no correlations between the examined variables.

It is important to stress that resource scarcity is not the only factor that can have an impact on commodity prices. Morley and Eatherley (2008) claimed that resource scarcity by itself is insufficient to map material security. They set out numerous factors that might influence material prices. These are the following: global consumption levels, lack of substitutability, global warming potential, total material requirement, scarcity, monopoly supply, political instability in the key supplying regions and vulnerability to the effects of climate change in the key supplying regions.

Hall and Hall (1984) also note, that although scarcity is reflected in real prices, this does not mean that physical scarcity is the only factor that influences price, consequently, real prices may not fully reflect scarcity. They also suggest that changing relative prices are just a possible consequence of resource scarcity, but not identical to that. They suggest that activities of foreign and domestic governments distorting prices, market failures and recycling that plays an ill-defined role in total supply all hamper the relationship between real prices and resource scarcity.

When searching for the possible underlying reason why there is no relationship between real prices and the reserves-to-production ratios for copper and lead the following have been found: compared with other metals, lead enjoys an extremely high recycling rate. According to the International Lead Association (ILA, 2010), more than half of the lead produced and used each year across the world is recycled and furthermore, its quality is identical to that of primary metal. Copper has relatively high substitutability, its substitution with iron in mass applications such as structural purposes, with aluminium in car radiators and electrical applications, with plastic in piping and with optic fibres for message transmissions in telecommunication are all feasible with no loss to functionality (Radetzki, 2009).

In the light of the reserves-to-production ratios the fact that the price of platinum and rhodium is approximately 10,000 times more than copper and lead might seem surprising. However, there are some reasonable factors that are likely to account for this huge price difference. Platinum and rhodium belong to the group of precious metals that comprises rare metals with high economic value. It can be argued that their demand is driven by their practical use, but also by their role as investments and a store of value. Hi-tech industry use, growing demand in the jewellery sector and physical investments and the fact that they have become a symbol of wealth in recent years all contribute to high prices. Moreover, their substitution is limited only to other platinum group metals that are also precious. Although accurate data were not found on extraction costs, but Morley and Eatherley (2008) suggests that the total material requirement, which expresses the weight of rocks and other substrate that need to be moved in order to obtain a given weight of metal, of platinum and rhodium is about 10,000 times more than that of copper and lead. A higher total material requirement is assumed to result in higher extraction costs as well. Finally, while platinum and rhodium supply are highly dependent on the production of one country, namely South Africa (77% of world's platinum supply and 87% of the world's rhodium supply in 2009), copper and lead has a dispersed supply (Platinum Today, 2010; USGS, 2010).

7. CONCLUSION

The results of the price trends show that when the nominal prices of the metals examined are converted to real prices using the unadjusted US CPI, which does not correct for the overestimation of inflation, the linear trends over the period studied, with the exception of rhodium, are all downward, though only significant for lead. When the adjusted CPIs are employed to correct for the upward bias inherent in the CPI, the findings are different. With the two higher adjustments, a reduction of 1.0% and 1.5% point a year, the estimated trends are all upward and significant at the 1% level. The CPI reduced by 0.5% point per year, results in upward trends that are significant only for platinum and rhodium.

As for the issue whether real prices are a reliable signal of resource scarcity, the findings of this paper can also be called into question. Results for copper and lead show a statistically insignificant relationship between the real prices and the chosen scarcity indicators, the reserves-to-production ratios. In the case of platinum, a relatively strong, statistically significant negative correlation is found between the variables, while results for rhodium show a slightly moderate negative correlation that is significant too. However, results for correlations between annual percentage changes in R/Ps and in real prices of the selected metals were all insignificant, indicating no correlation between the variables.

Four main themes for further research are recommended by this paper. The first is to examine to what extent findings for price trends can be generalized to other mineral commodities. Second, further investigation is required to find out which other mineral commodities have experienced rising long-run price trends (Svedberg and Tilton, 2006). Third, it is clearly needed to investigate further how and to what extent high substitutability of copper and high recycling rate of lead affected their real prices. Finally, it is also suggested that other scarcity indicators are examined whether they are a more effective signals of resource scarcity or not.

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