Modeling Commodity Markets in the Global Economy: Familiar Findings and New Strategies

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MODELING COMMODITY MARKETS IN THE GLOBAL ECONOMY: FAMILIAR FINDINGS AND NEW CHALLENGES

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ABSTRACT

The paper revisits structural copper market modeling strategies, taking a fresh look at the implications that globalization of industrial activities has had in primary commodity markets, such as copper. Patterns of specialization in international trade are found to play a major role in explaining the evolution of long-used indicators such as Intensity of Use (Copper Consumption per unit of GDP).

A structural econometric model is estimated using annual data for the last 30 years and aggregate elasticities are computed through simulations. Aggregate elasticities are not so different from those found more than a decade ago in a similar study (Vial, 1988). The model is also used to estimate economic impacts of copper consumption promotion, and the simulation results show that promotion, when effective in raising copper use, have a significant impact in the market. However, shifting patterns in copper use in the World would require careful targeting of promotional activities.

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MODELING COMMODITY MARKETS IN THE GLOBAL ECONOMY: FAMILIAR FINDINGS AND NEW CHALLENGES

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Introduction

There has been plenty of excitement in commodity markets recently, with prices shooting up to unexpectedly high levels in a very short period of time. After many years of cheap and plentiful supplies of all kinds of natural resource-based products, we now find ourselves hearing and reading about resource scarcity, supply shortages, and even some whispers about the dangers of exhaustion of key non-renewables, like oil. One major source of speculation is the role that China and other developing countries are playing in the recent commodity price rally and, subsequently, the impact on the medium-term outlook if these countries remain on a high-growth path[3].

This is one very evident manifestation of the power of globalization at work, and, as we suggest in the paper, this is a new reality that we have not fully incorporated in our way of thinking about commodity markets and it has yet to be incorporated in the modeling of the structure of these markets. One major obstacle in this endeavor is the lack of adequate data. We already knew that commodity markets data were not up to the task of modeling these markets long time ago (Vial, 1992), and little progress has been made in the last decade. Unfortunately, the most recent developments make the old data classifications even less useful than before.

The paper is organized as follows: first we present a brief description of what I will call the traditional way of thinking about the structure of commodity markets, and introduce in that framework some of the changes that have taken place as a consequence of globalization, including some supporting evidence from aggregate data of the copper market. In the following section I describe a model built to analyze some structural characteristics of the copper market. The third section presents some properties of the model as well as key findings for the copper companies' strategy in terms of their (lack of) end-market orientation. The final section concludes.

Globalization and commodity markets: we are playing in a different field now

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[3] One interesting coincidence is that one of the natural resources rally with a shortage of shipping capacity.

In our traditional way of thinking about commodity markets we used an approach originally developed by Gere Adams and Jere Behrman back in the 70's (Adams, Behrman, 1976), that came to be known as the "standard commodity model"(SCM). In that model, commodities were treated as intermediate goods, so that their consumption was a derived demand from final production and ultimately driven by domestic income and prices (relative to other industrial inputs). Production was derived from the standard theory of the firm and supply functions were made a function of current and lagged prices of inputs relative to the price of the commodity. International trade played a limited role in the model, even though it was important: most of the production of the natural resources-based commodities took place in countries different from the Industrialized ones, were manufacturing production and consumption of final goods was located. So the demand side of the SCM was treated as a closed economy in which consumers of final manufactured goods were in the same country in which the manufacturing process took place. The distinctive feature of the SCM was its closure based on the equality between observed inventory changes and a demand function for inventories. The latter was usually normalized with the price of the commodity as the dependent variable.

The main features of the SCM still remain valid and useful for applied modeling. However, the specification of the demand side has to be revised in order to incorporate the effects of the deepening of the division of labor across countries in commodity markets. In the XXI century, trade in final manufactured goods has become routine and now raw materials are imported by the China, Korea, Taiwan and other industrial powerhouses in the Developing World to produce electric and electronic appliances as well as automobiles to be sold to the final consumers in the US and Europe. As these and other Developing countries reach higher levels of income, they develop their infrastructure and a rising number of citizens are able to purchase manufactured goods, becoming also significant players in the end-consumer markets for natural resource-intensive goods.

In the traditional view of natural resources markets, like the one for copper, for instance, the ratio of consumption of a commodity to GDP in a given country (Intensity of use, IU) was a useful tool of analysis and has been widely used by market observers. The common wisdom concerning the evolution of IU in a country was the following:

1. In early stages of development, IU was expected to rise as industrialization proceeds and the country catches up with consumption patterns in more advanced economies. In the case of copper, it was expected that progress in electrification, higher rates of consumption of durables, better access to telecoms as well as better housing, would rise with living standards, bringing up the rate of copper consumption per unit of GDP.
2. Once consumption patterns come closer to that of developed countries, IU should converge to a somewhat similar level, with discrepancies explained by differences in preferences in consumption of final goods, savings ratios and so on.
3. Technical progress could change IU in the most advanced countries, and the general prediction was that IU would tend to fall gradually as technical progress reduces the need for materials, changes the composition of output in favor of services, or simply

because some commodities like grains and basic staples are inferior goods (their income-elasticity is less than one).

The evolution of IU in the developed countries in the 70s and 80s generally agreed with this view (Chart 1 in Appendix I): IU in the industrial countries was falling at the time when major technological innovations were displacing some materials from traditional uses. In the case of copper, the introduction of fiber optics as well as the tendency to make transportation equipment more fuel efficient after the oil crisis in the 70s reduced copper consumption in those sectors, and IU for copper was falling fast. On the other hand, copper use in industrializing countries was on the rise, as well as in several countries in Asia, and the IU there was rising fast (Chart 2, Appendix I), making some of them noticeable at the aggregate consumption level.

The 90s brought some new developments that have gone beyond the predictions of the traditional view, even though, with the benefit of hindsight, they could not be considered unexpected or contradictory with the fundamentals of the SCM. Some stylized facts that we can mention are:

1. IU in developed countries stopped falling and it has actually risen somewhat in the 90s (Chart 1).
2. IU in some fast growing countries (Asian tigers, for instance) kept growing and in fact has largely surpassed IU in the most advanced industrial nations (Chart 2).

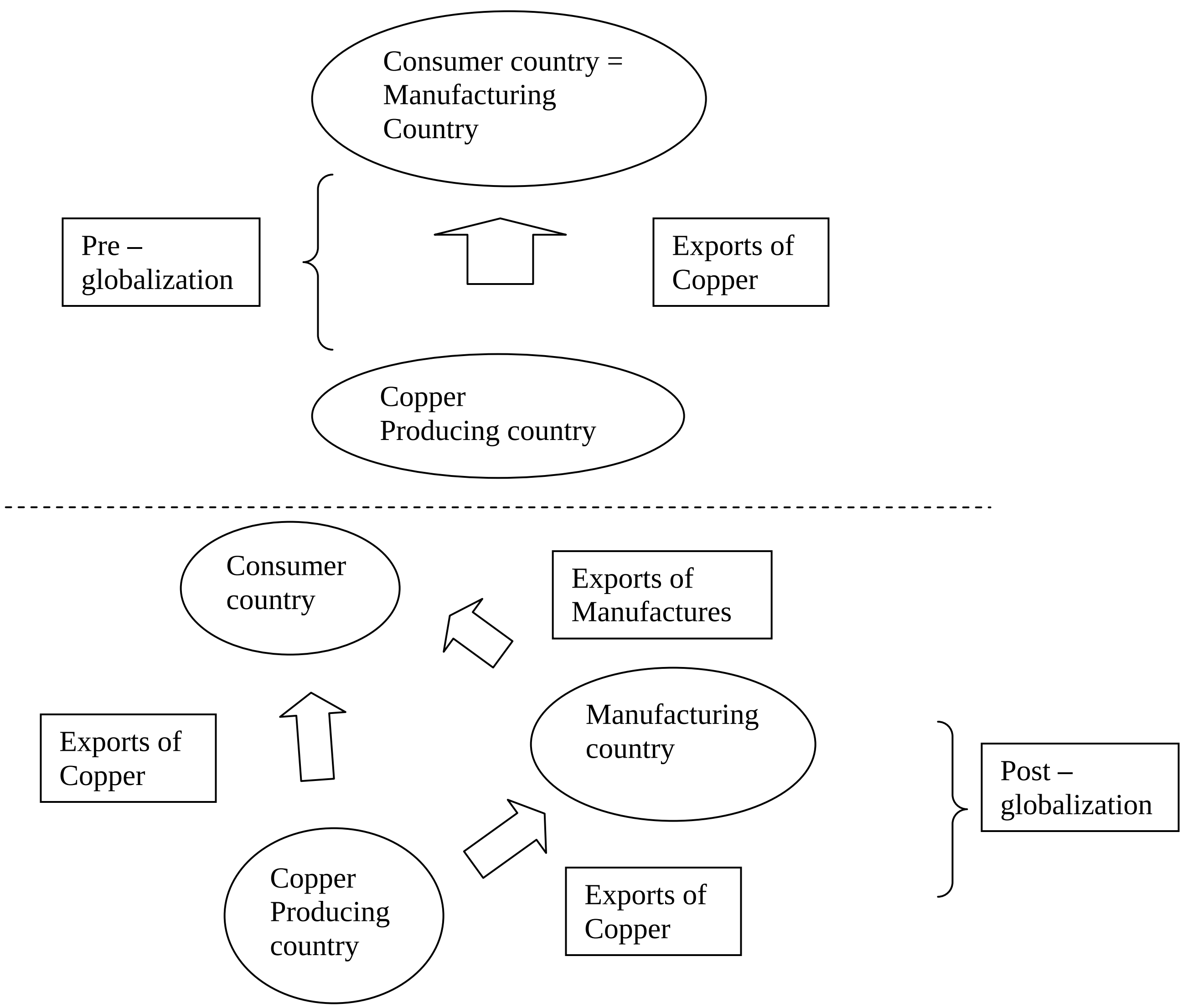
On the first fact, technology is probably the answer. In the case of copper, the IT revolution has meant that houses and offices had to be wired (at least for electric power). At the same time, cars and home appliances have far more electronic components than before and they rely a lot on electric power. The combination of these forces has meant higher ratios of copper use per GDP than before. Technology can work both ways, not just in the direction of materials savings.

The second fact requires the introduction of globalization into the picture: the lowering of trade barriers after the Uruguay Round and decisive action by some countries in order to promote their industrialization through exports of manufactured goods has caused greater specialization in the production of consumer goods. Starting with Japan in the 60s and the Asian Tigers in the 80s and 90s a handful of countries have rapidly become specialized in the manufacture of consumer durables (most of them electric appliances) and cars, concentrating most of the growth in World production of these goods and even displacing production from industrialized countries. More recently, the emergence of a powerful manufacturing power in China based on an overwhelming labor cost advantage has attracted massive flows of foreign capital, relocating manufacturing capacity from high cost producers in the Developed World to low cost plants in that country. This process has shifted copper consumption from Developed Countries to these fast growing emerging industrial powers. A simplified version of this process is shown in Diagram 1, which is self-explanatory: globalization brings a deeper division of labor, with new entrants in trade flows. Whenever these new entrants have comparative advantages to produce and export manufactured goods with a significant copper content to the rich countries (consumers of manufactured goods), there is diversion of exports of copper from consumer countries to the newly industrializing countries (NICs). As new income is generated in the NICs they will also become consumer of manufactures and – indirectly – of copper.

This process has two effects on copper consumption in the likes of China:

- Fast economic growth raises consumption of durables, use of electric power, telecommunications equipment and cars as well as the construction of more and better equipped houses, increasing the IU ratio in the "traditional" way.
- Relocation of industries in the global scale means that copper is also used to produce manufactures that will end up exported to Developed Countries.

Diagram 1. Copper trade and the effect of globalization



The first component is a net addition to copper consumption in the world. The second one is a mere geographical displacement of copper use, but the final factor inducing copper consumption remains in the Developed Countries: this part of copper demand in "China" is still driven by income and relative prices of industrial goods in those countries.

One interesting and quite unexpected outcome is that IU at the World level has remained more or less flat, after a moderate decline in the 70's, as shown in Chart 3 (Appendix I). In other words, the decline in IU in industrialized countries has been compensated by increases in the use of copper and other resources in NICs, and part of this process is due just to relocation of industrial capacity from advanced countries to the NICs.

This process means that modeling of copper use should take into account the pattern of international specialization that a given country has. Interpretation of market trends will be greatly affected by this change and we should be wary of specifications based on extrapolations of simple closed-economy demand models into the international copper market.

A model for the World Copper Market[4]

The findings mentioned above have been incorporated into the specification of an annual model for the global copper market. The general structure follows the SCM, but demand functions at country level have been modified in two ways:

- The introduction of time trends to capture the impact of copper-saving technological changes have been used in just some industrialized countries, and in all cases a non-linear specification including quadratic and cubic powers of the trend variable has been fitted instead of the more standard trend. This specification allows the data to "choose" the path of technical change (Ulloa, 2002).
- Measures of industrial exports over GDP or total exports have been used to bring international specialization patterns into the specification of copper demand.

The supply side of the model was disaggregated between primary and secondary production for the main producing countries. Primary production was made a function of long lags of copper prices relative to aluminum, energy and wages, to capture the slow response of capacity to these variables. Secondary production was made a function of the relative price of copper to wages and to energy prices, as well as of the stock of recoverable material (a weighted average of copper consumption in the previous ten years). The main econometric results for the estimation of these equations are presented in tables 1 and 2 at Appendix II.

The copper consumption equations by country were specified using the Intensity of Use of copper (with respect to GDP) as the left-hand side variable (in logs) and relative prices with

[4] A more detailed description and documentation of the model can be found in Joaquín Vial: "El mercado mundial del cobre: determinantes económicos de su estructura y evolución". Unpublished manuscript. This can be obtained directly from the author.

respect to aluminum and energy, as well as the level of GDP (to allow for non-unitary income elasticities) and the variables mentioned earlier. Econometric results for the consumption side of the model are presented in table 3 in Appendix II.

The model closes with the price-inventories equation and identity. A simple specification was applied for this variable, incorporating a scale variable (the ratio of inventories to consumption) and some financial variables to capture the opportunity costs of holding inventories (Ramey and West, 1997; Ramey, 1989). The estimation results for several alternative specifications of this equation appear in table 4 in Appendix II.

The estimated equations generally conform to the general outline of the specification described above and the main results do not depart much from previous work. The main characteristics of the model that emerge from the estimation results are the following:

- Supply and demand equations show significant price elasticities, albeit low in absolute terms. Long-term elasticities are higher (in absolute terms) than short-term elasticities.
- Income elasticity of consumption equations tend to be 1 or close to 1 for most countries.
- In the long run there is significant (negative) effect of energy prices on the supply of copper.
- Prices are responsive to the main variables in the specification, with the exception of financial variables (exchange rates, equity prices, etc.). Perhaps the interaction with these markets is still too young, so we do not have enough annual observations to capture the effect of these variables.

When comparing the results for elasticities obtained through the analysis of shocks to different parts of the model we obtained short-term results that closely resemble those in Vial (1988)[5], notwithstanding the differences in specification and sample period, as can be seen in Table 1. However, the long-term (10 years) price-elasticities are higher for consumption in the new model, and about one half of what they were for production.

Table 1. Price Elasticities of Present and Previous Models
(obtained through simulations of shocks to a baseline simulation)

Comparison of Price-elasticities in two studies of the World Copper Market

	Consumption		Total Production		Primary Prod.		Secondary Prod.	
	Vial (1988)	Current	Vial (1988)	Current	Vial (1988)	Current	Vial (1988)	Current
Short term	-0,03	-0,03	0,11	0,05	0,05	0,02	0,33	0,20
Long run	-0,10	-0,20	0,22	0,13	0,26	0,13	0,26	0,11

Model properties were evaluated through ex-post simulations within and outside the sample period and they showed significant non-linearities in the responses as well as long

[5] The actual paths of the elasticities over time are shown in Appendix III.

lags. Even though the long delays have been documented in previous models, impulse functions tended to be smoother than the ones presented here. Just as an illustration of these properties, we show here the dynamic responses of aggregate consumption and production to two permanent shocks carried outside the sample period: a 1% increase in World GDP and a 1 percent increase in LIBOR. Both shocks are independent and the shocked variables remain 1% above the baseline solution after the initial shock. Prices react in each case in tune with the deviation of inventories from the baseline solution. Results are shown in parts 3 and 4 of Appendix III. One important feature of these results is the high sensitivity of copper prices to permanent displacements of the consumption paths.

One traditional topic of discussion among copper market experts is the lack of attention that copper producing companies devote to the development of the end uses of copper and the very limited extent of promotion activities. In copper as well as other minerals producing companies, there is a very long tradition of competing through development of new deposits, introduction of cost-cutting technologies and new mining procedures. All the competition is focused on the supply side and very little or no attention is given to the development of the end market.

The results from this model show that there is a lot of potential in investing money in the development of the end market for copper products: as the advantages of copper over other materials are developed and shown to end-users, copper consumption per unit of GDP can rise and that would result in major gains for copper producers.

As a way to illustrate this, I show here the results of a simulation of the impact on copper prices and the value of World Copper sales of an exogenous increase in consumption of just 50 thousand tons over the course of 7 years.

Table 2. Impact in World Copper Market of a 50 thousand ton increase in consumption

	Absolute Differences			Changes in values *
	Consumption	Prices		
		Cts/pound	$/ton	
2003	-	-	-	-
2004	49,7	0,0	1,1	17,5
2005	45,3	0,6	14,0	227,5
2006	36,3	1,0	21,8	359,8
2007	25,3	1,2	26,0	442,0
2008	14,7	1,1	24,7	436,2
2009	6,7	1,0	21,3	393,7
2010	-1,8	1,1	23,7	461,9
Average	25,2	0,9	18,9	334,1

* Million dollars

These results show the extraordinary value of investments in the development of the copper market. This can be achieved both through direct promotion with end users, as well as contributing to applied research in the development of new materials that could enhance the use of copper. In order for this to happen, though, copper mining companies will have to change the way they see themselves: cease being just copper miners, and become copper suppliers, with an increasing focus on consumers and end markets.

Conclusions

The elimination of trade barriers and the accession of China, Taiwan and other developing countries to the WTO has been changing trade flows dramatically in the last decades, and manufacturing capacities are being relocated throughout the world. Natural resource markets are beginning to feel the impact of these changes, as direct copper use is shifting from developed countries to these newly industrializing countries. In our view, these changes have not permeated quickly enough to affect the way in which we analyze the evolution of these markets.

The first challenge we face now is the development of better statistics showing the copper content of international trade flows, to identify who and where are the final users of copper. Modeling demand for copper is becoming increasingly difficult, especially when we try to do it with some disaggregation.

A second lesson we draw from the application of a simple econometric model to the study of copper market reactions, is the very high economic impact of the development of copper consumption, either through promotion or research into new uses of copper. This is especially important at a juncture where potential mega-markets for copper are showing signs of vitality in China and India. Copper promotion in fast developing markets could very well be the critical factor influencing the evolution of the copper market in the next 20 to 30 years. If inadequate attention is given to these markets, they could very well end up being major sources of frustration.

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APPENDIX I. INTENSITY OF USE OF COPPER

CHART 1. COPPER IU IN DEVELOPED COUNTRIES

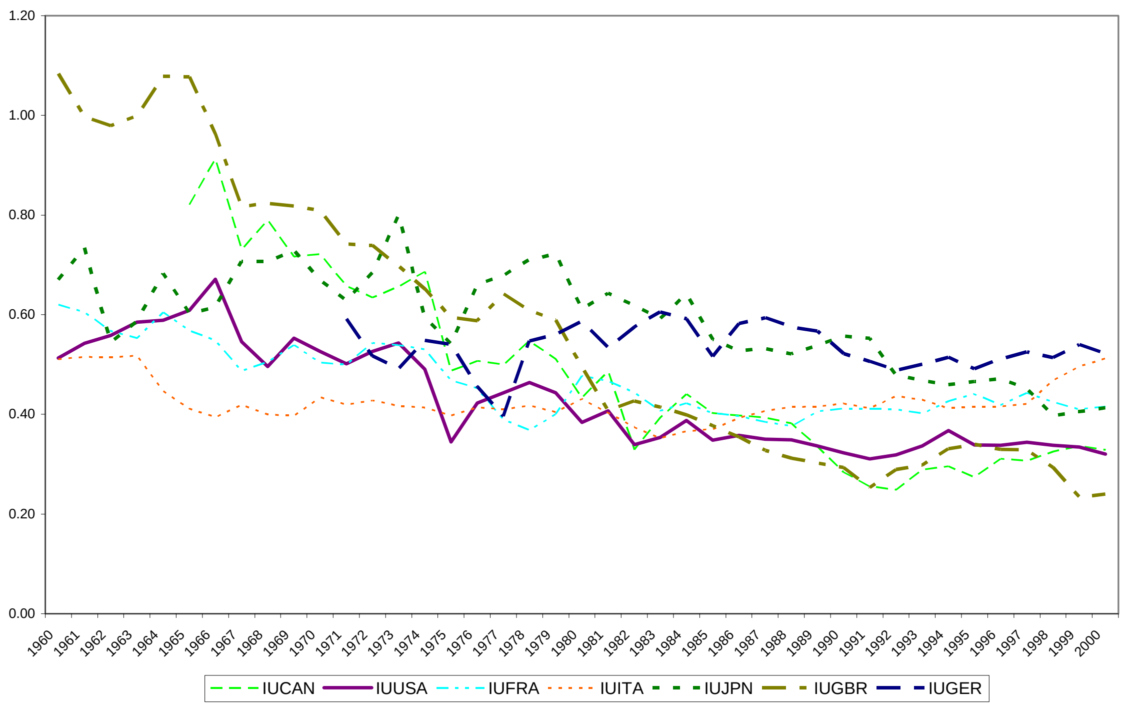


CHART 2. COPPER IU IN SELECTED DEVELOPING COUNTRIES

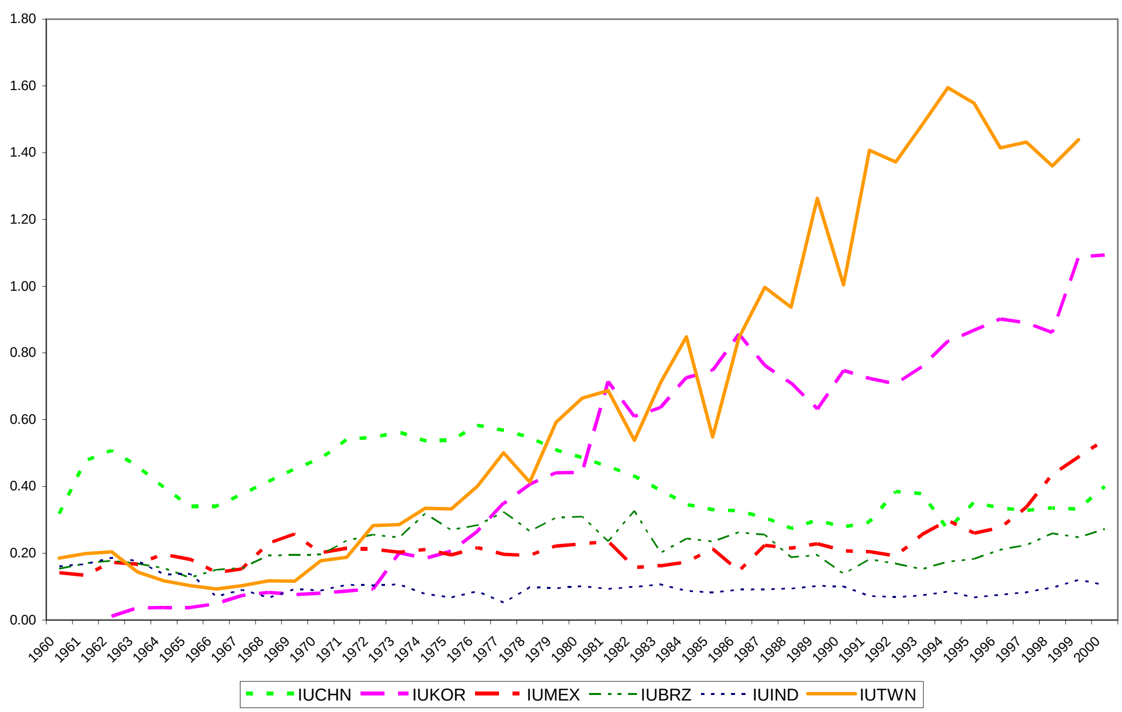
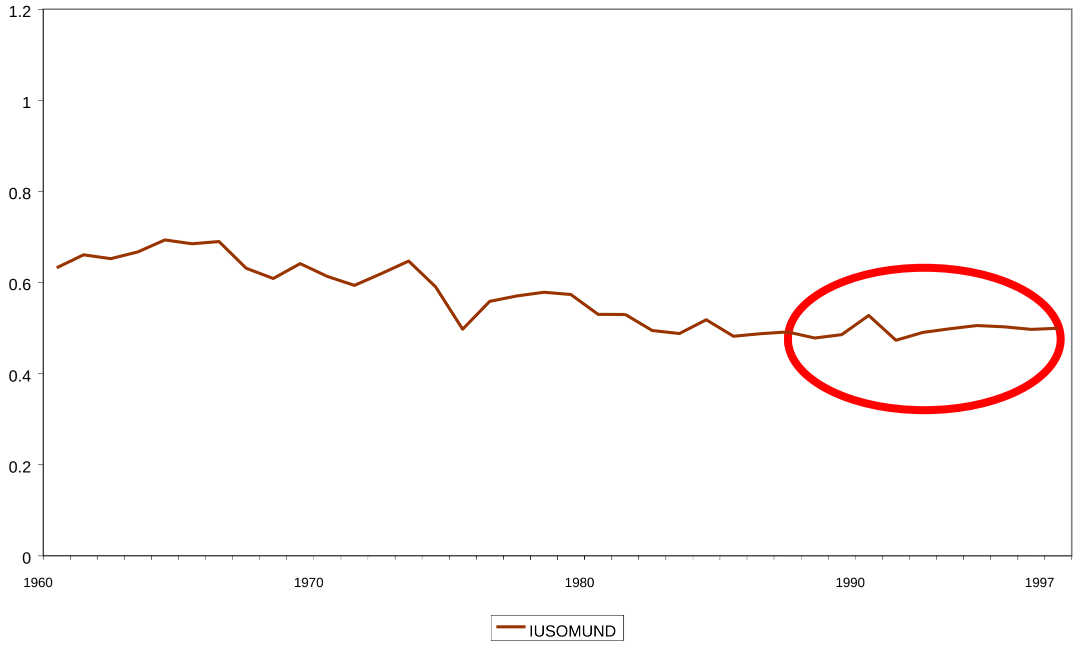


CHART 3 COPPER IU AT THE WORLD LEVEL



APPENDIX II. ECONOMETRIC RESULTS FOR THE MAIN EQUATIONS OF THE MODEL

Table 1 PRIMARY PRODUCTION OF COPPER

Countries	Long- run elasticities			Short – term elasticities			Adj. R^2	D-W	sample	Primary prod.
	Copper	Energy	Labor	Copper	Energy	Labor				2001
										(Th Metric tones).
Australia	0,115	-0,115		0,065	-0,065		0,969	2,07	62-02	873
Canada	0,189	-0,103	-0,086	0,022	-0,012	-0,010	0,815	2,32	61-02	633
Chile	0,227	-0,227		-0,058	0,058		0,991	2,65	63-02	4738
Unites States	-0,362	0,132	0,231	0,190	-0,069	-0,121	0,872	2,03	61-02	1337
Indonesia	3,210	-3,210		0,125	-0,125		0,988	2,51	74-02	1047
Mexico							0,981	2,00	61-02	367
Papua N. Guinea	0,149	-0,149		0,092	-0,092		0,657	1,77	73-02	208
Peru	-0,182	0,182		-0,082	0,082		0,929	2,40	63-02	722
Portugal	-1,331	1,331		0,329	-0,329		0,961	1,57	61-02	82
Southfrica	0,355	-0,355		0,031	-0,031		0,980	1,85	61-01	142
Swede	-4,489	0,474	3,472	0,169	0,031	-0,200	0,959	2,15	63-02	74
Zambia	0,860	-0,860		0,023	-0,023		0,942	2,33	63-02	311
Countries Total										10534
World Total										13598

Table 2 SECONDARY PRODUCTION OF COPPER

Countries	Long – run elasticities			Short–term elasticities			Adj. R^2	D-W	Sample	Sec.Prod.	Estimation
	Prices			Scale	Copper	Other				2001	Technique
	Coppe	energy	salares		Price					(Th.M.T.)	AR(1)
United States	1,15	0,39	-1,54	0,93	0,51		0,63	1,70	63-99	161	0,577
Germany	0,04	-0,04		0,33	0,06	-0,06	0,90	1,97	62-99	372	-0,562
Japan	0,59		-0,59	0,79	0,32	-0,32	0,71	2,11	61-99	135	0,449
Belgium	0,58		-0,58	0,86	0,13	-0,13	0,74	2,46	65-99	220	0,779
World Total										1838	

Table 3 CONSUMPTION OF COPPER

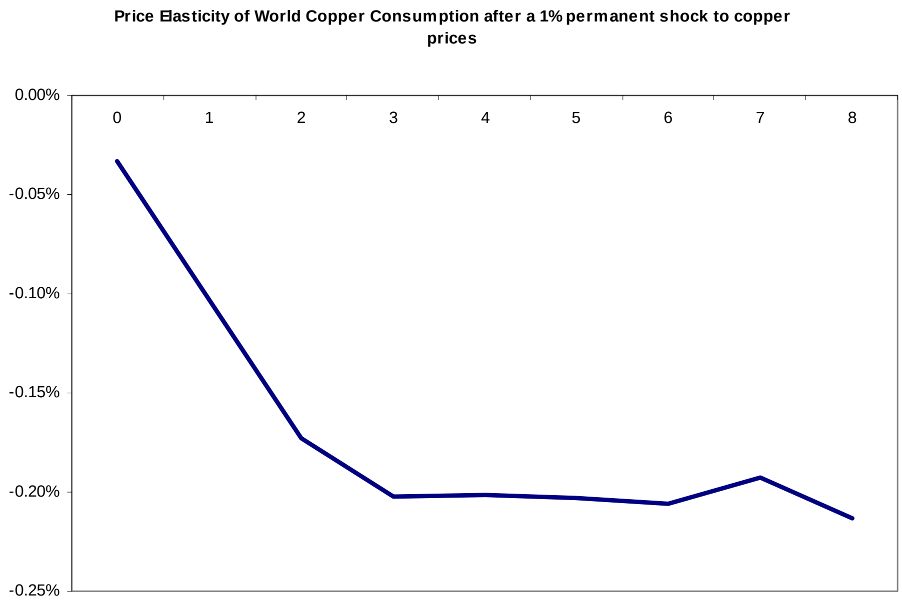
Country	Time Trend			Price - elasticities				Other		Comments	Adj. R^2	D-W	Sample
				Copper		Alum.	Energy	GDP	Industr. Exports				
	Time	Time^2	Tiime^3	ST	LT	LT	LT						
Germany					-0,144	0,111		0,681	0,022		0,805	2,50	1982 - 01
Australia	-0,019	-1,6E-04	-2,82E-07	-0,008	-0,118			1,000	0,115		0,859	1,40	1970 - 01
Belgium				0,068	-0,740			1,000		AR(1)=0.811	0,760	1,88	1964 - 02
Brasil				-0,177	-0,689			1,000	0,692	AR(1)=-0.641	0,625	2,54	1962-89/91-01
Canada	0,008	-2,5E-03	2,92E-05	-0,118	-0,229			1,000	0,038		0,956	2,12	1970 - 01
China								1,102	0,016		0,364	1,95	1987 - 01
Soth Korea				-0,537	-1,479	0,292		1,000			0,953	2,10	1975 - 02
Spain				-0,183	-0,241			1,000	1,213	AR(1)=0.615	0,720	1,94	1975 - 00
United States	-0,047	1,0E-02	-8,62E-05	-0,061	-0,274			2,366	0,398	VI	0,928	1,61	1970 - 00
Finland	0,228	-4,2E-03	2,30E-05	-0,011	-0,011			1,000	0,008		0,887	2,09	1975 - 01
France				0,027	-0,050		-0,101	0,688			0,839	1,44	1963 - 01
United Kingdom	-0,562	1,3E-02	-1,10E-04	-0,098	-0,638			1,000	0,077	AR(1)=0.453	0,967	1,95	1971 - 01
Greece					-8,157			1,000		AR(1)=0.973	0,959	2,26	1964 - 02
India				-0,101	-0,606	0,464		0,795			0,455	0,88	1962 - 01
Italy				-0,030	-0,100	0,089	-0,076	1,000			0,782	1,73	1965 - 02
Japan	-0,189	1,3E-03		-0,091	-0,091			2,890	0,221		0,938	2,20	1977 - 01
Mexico				-0,403	-1,058	1,112		1,000		AR(1)=0.619	0,821	1,93	1976 - 01
Suecia				-0,083	-0,375		-0,266	1,000		AR(1)=-0.778	0,825	2,16	1964 - 02
Taiwan				0,039	-0,300			1,540		AR(1)=0.471	0,871	2,32	1975 - 02
Turkey								2,317		AR(1)=0.569	0,950	1,84	1969 - 01

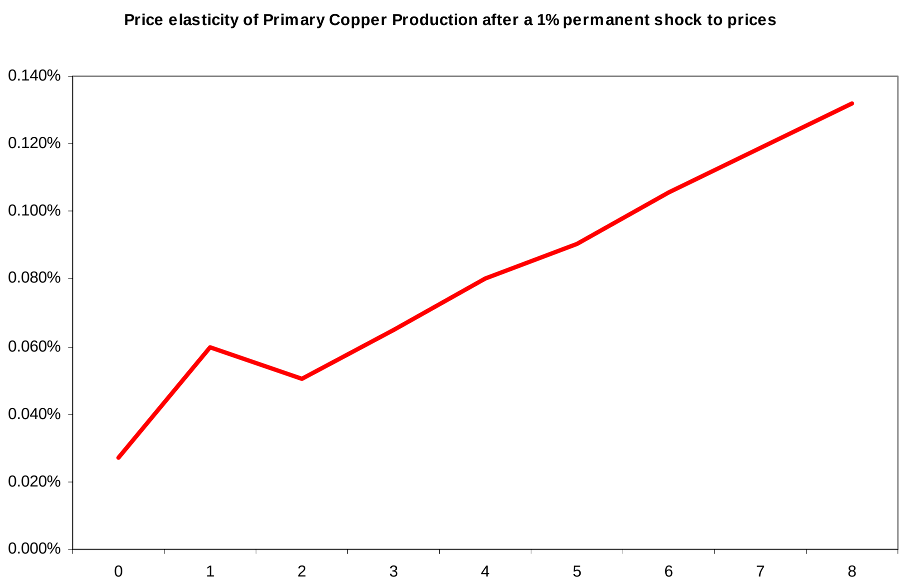
Table 4 PRICE-INVENTORIES EQUATION

Equation	Explanatory Variables											Statistics			
	Constant	LRI	LPCL(+1)	LPIB2	LPIBRS	D80	DDJAND	trend	$trend^2$	$trend^3$	AR(1)	R^2 c	DW	F	n
Eq. 1	0.337	-0.244		0.226	-0.658		-0.184				0.373	0.922	1.95	77.9	36
	(.32)	(-3.84)		(2.23)	(-5.1)		(-1.16)				(2.58)				
Eq. 2	-0.962	-0.2	0.153	0.325	-0.726		-0.052				0.359	0.907	1.81	62.3	36
	(-.51)	(-1.83)	(.39)	(3.3)	(-5.1)		(-.24)				(2.4)				
Eq. 3	0.097	-0.222		0.265	-0.716	-0.257	-0.145				0.398	0.931	2.05	76.9	36
	(.1)	(-3.53)		(2.97)	(-6.27)	(-2.28)	(-1.01)				(2.99)				
Eq. 4	0.695	-0.271	-0.325	0.317	-0.93	-0.414	-0.176				0.387	0.886	2.39	43.7	36
	(.43)	(-2.72)	(-1.02)	(3.04)	(-5.35)	(-2.36)	(-.88)				(2.74)				
Eq. 5	0.311	-0.223		0.248	-0.703						0.371	0.917	1.85	88.2	36
	(.28)	(-3.69)		(2.53)	(-6.05)						(2.64)				
Eq. 6	-1.4	-0.177	0.252	0.342	-0.707						0.354	0.905	1.76	73.1	36
	(-.83)	(-2.01)	(.72)	(4.00)	(-4.39)						(2.32)				
Eq. 7	0.214	-0.205		0.269	-0.734	-0.266					0.405	0.931	1.91	86.2	36
	(.21)	(-3.45)		(2.93)	(-6.66)	(-2.37)					(3.11)				
Eq. 8	0.341	-0.232	-0.253	0.352	-0.959	-0.419					0.4	0.893	2.22	53.9	36
	(.18)	(-2.34)	(-.60)	(3.75)	(-4.49)	(-2.07)					(2.91)				
Eq. 9	5.889	-0.3919		-0.344	-0.556	-0.199		0.3249	-0.0085	7.73E-05	-0.0587	0.949	2.1	77.45	36
	(0.576)	(-9.16)		(-0.52)	(-7.94)	(-2.04)		(2.22)	(-2.81)	(2.7)	(-0.38)				
Eq. 10	0.562	-0.3913			-0.54	-0.2036		0.2518	-0.0071	6.44E-05	-0.05165	0.95	2.05	90.23	36
	(.83)	(-9.18)			(-8.77)	(-2.12)		(6.11)	(-5.19)	(4.59)					

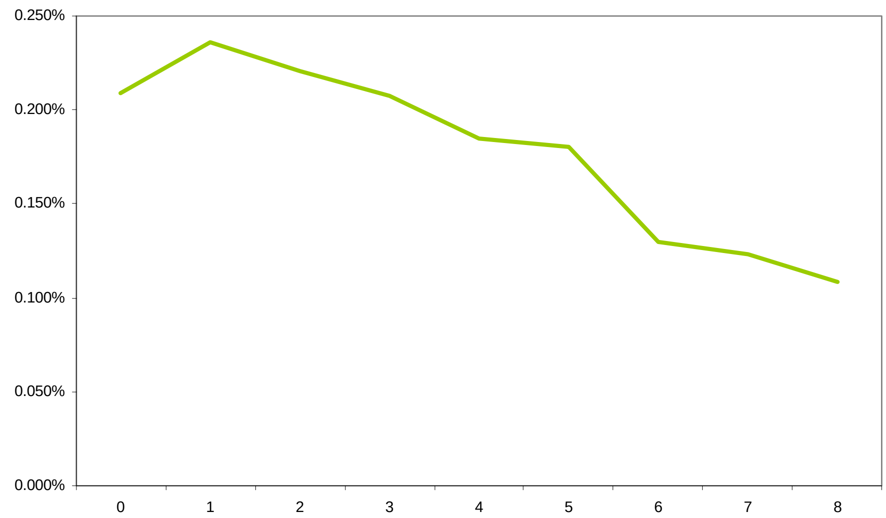
APPENDIX III. PROPERTIES OF THE MODEL

1. Price elasticities of supply and demand (estimated through simulations, setting copper prices and inventories as exogenous variables)

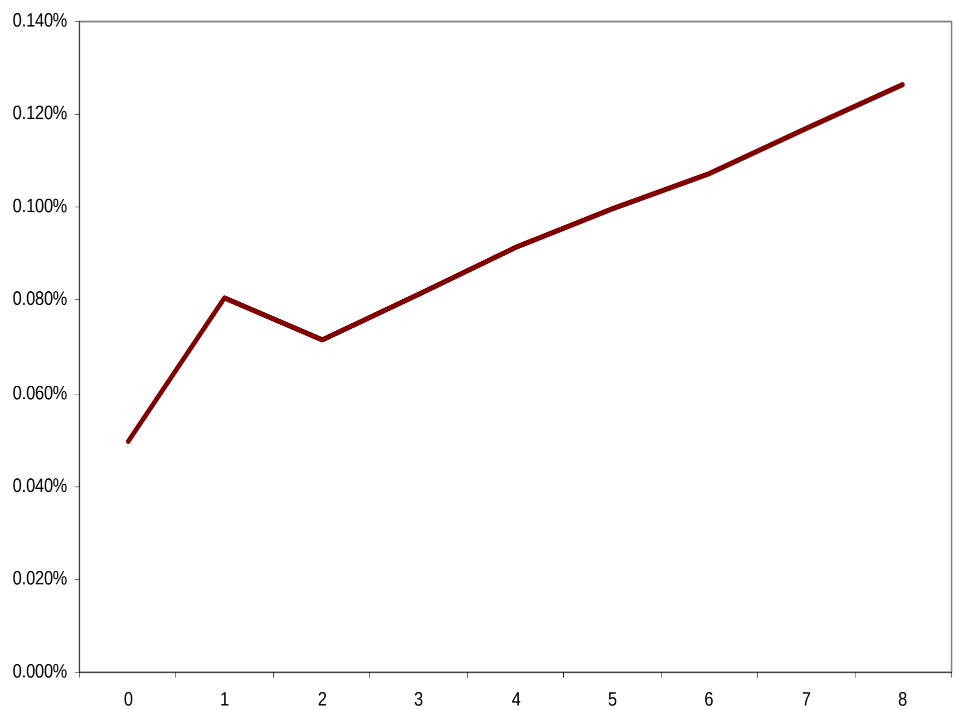




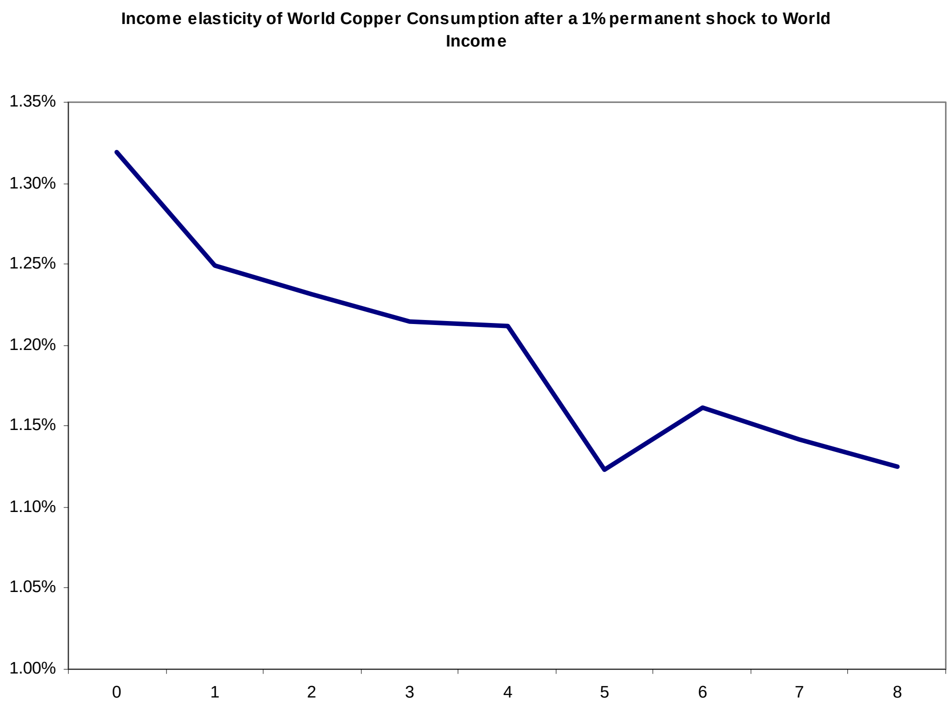
Price elasticity of Secondary Copper Production after a 1% permanent shock in copper prices



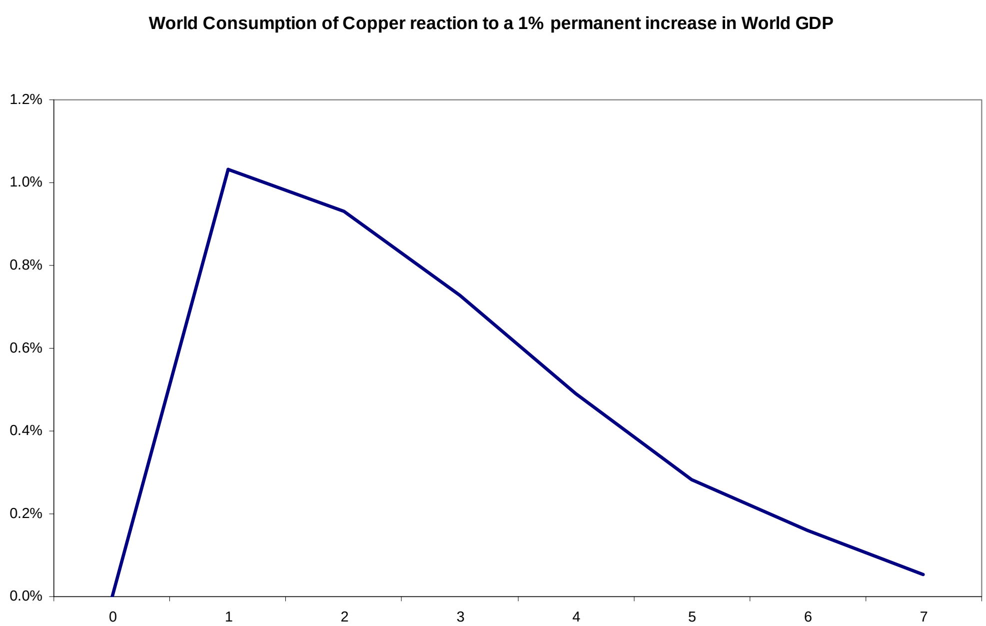
Price Elasticity of Total Copper Production after a 1% permanent shock in copper prices



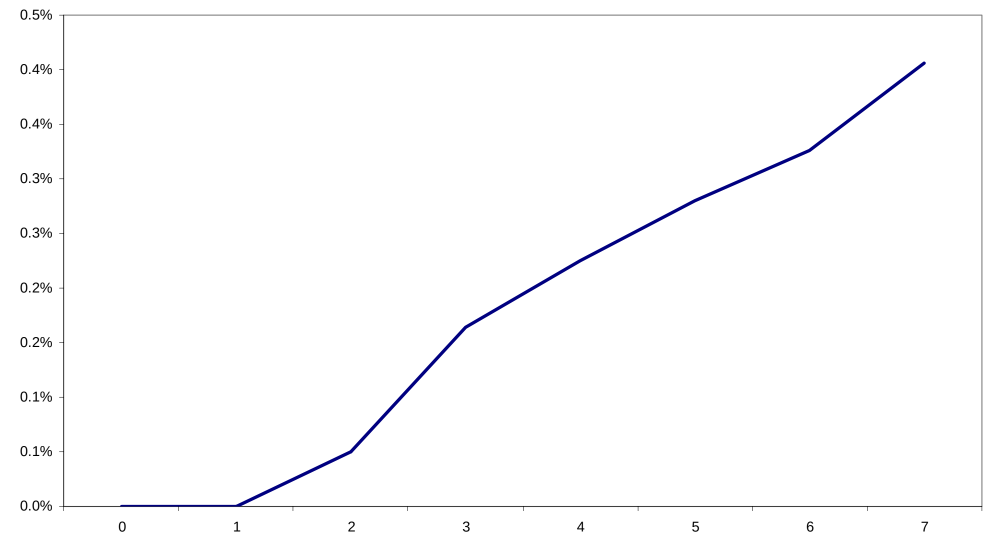
2. Income elasticity of Copper Consumption



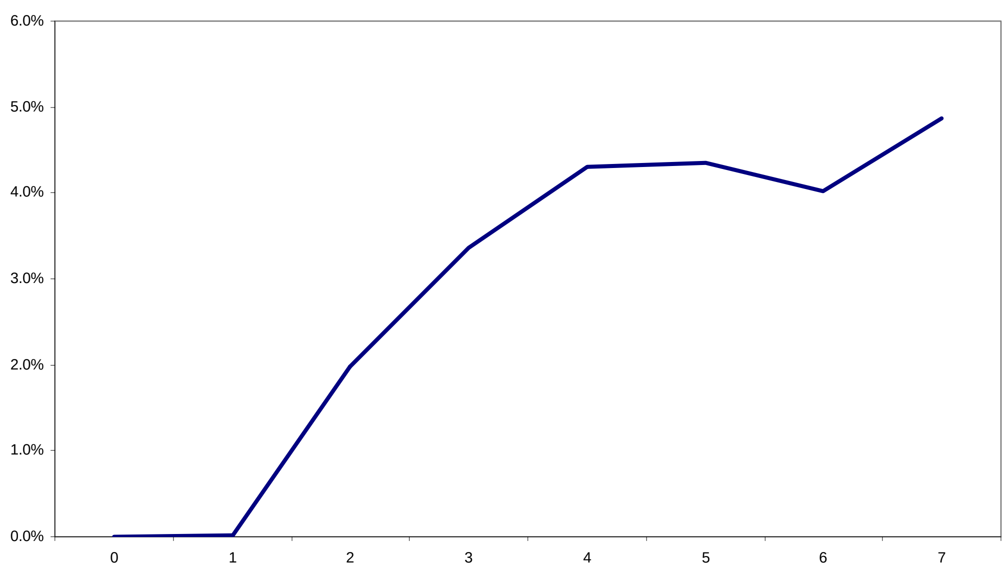
3. Reactions to a 1% permanent shock to World GDP



World Copper Production reaction to a 1% permanent increase in World GDP

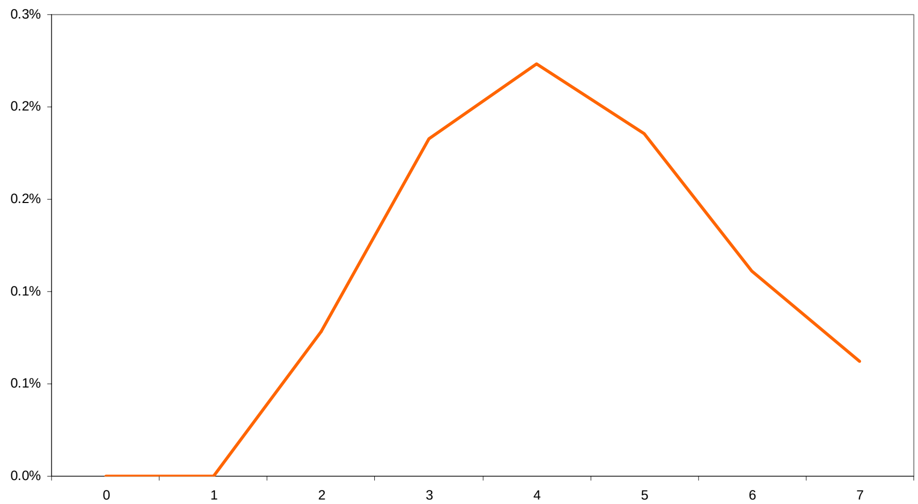


Copper price reaction to a 1% permanent increase in World GDP

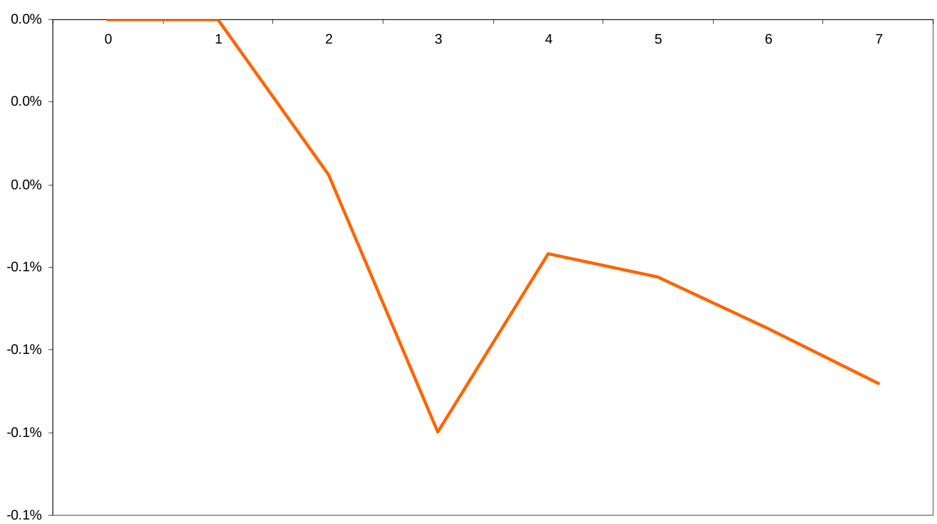


4. Reactions to a 1% increase in International Interest Rates

World Copper Consumption reaction to a 1% permanent increase in LIBOR



World Copper Production reaction to a 1% permanent increase in LIBOR




Copper price reactions to a 1% permanent increase in LIBOR
0.0%
-0.2%
-0.4%
-0.6%
-0.8%
-1.0%
-1.2%
-1.4%
-1.6%
-1.8%
-2.0%
0
1
2
3
4
5
6
7