



## Trade, Transportation, and the Chinese Finger Trap

Posted by [Nate Hagens](#) on December 29, 2009 - 8:14am

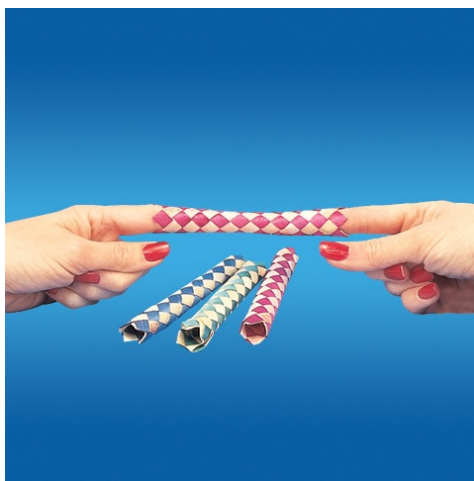
Topic: [Demand/Consumption](#)

*(This essay originally ran [three years ago](#) but the concepts and implications remain relevant today.)*

One of the central underpinnings of neo-classical economics is trade. And one of the central tenets of trade is the Ricardian theory of comparative advantage. Trade (in theory) benefits both parties because both are better off after the exchange. But our international trade system has, by baby steps, become completely dependent on twin enablers: crude oil and credit. By air, water, land or rail, petroleum accounts for 95% of all transportation energy. As we move up the complexity chain in the products that make up our daily lives, are we moving further into a Chinese finger trap where there is no backing out?

This post will examine the theory of international trade and the hierarchy of goods transport, production and consumption. It is quite possible that in the next decade, the increase in price (or the decreasing availability) of oil and financing, will offset the benefits of many types of trade.

The pursuit of economic efficiency, through increasingly diverse and extensive global trade has glossed over two important facts which this post will examine: 1) higher oil prices in long distance transport must at some point exceed (economically or otherwise) the benefits achieved from some trade and 2) a complex global trade system is gradually but pervasively decreasing the ability for localities, regions and nations to be self sufficient – so many of our supply chain inputs are imported that continued increase in oil price/affordability will resurrect import substitution policies, not only for less developed countries, but for the US and rich nations as well.



*International Trade - A Chinese Finger Trap?*

## INTRODUCTION

The idea for this post originated on a recent errand to Fleet Farm to buy a replacement spark plug for my dad's chain saw. I discovered there are not one or two kinds of spark plugs but hundreds, depending on the type of machine they go into. The plugs were made by a variety of companies, some domestic, some foreign but none from my state (currently Wisconsin). As I noticed this, I looked around the dozens of aisles and hundreds of shelves at the thousands of products and 'saw' for the first time how complex our import/export system has become. And the fact that my dad couldn't cut our firewood without that certain sparkplug reminded me of [Liebig's law of the minimum](#), or in the vernacular - something is only as good as its weakest link. I couldn't help wondering how much oil was embodied in those spark plugs: their parts, their manufacturing, their delivery to central Wisconsin, etc. While my research didn't discover this answer, it did result in my viewing trade, transportation, and our society's consumption habits in a different light.

Much has been written on this site and elsewhere on the exact date or time range when we begin the second half of the age of oil. I will not address timing in this post other than to point out that the later it is, the more can be done to address the systemic risks suggested below. The human pendulum of complacency and panic is in full effect as oil breached \$50 on the downside today. Those who read this piece and connect the dots should recognize that \$50 oil is not a reflection of its abundance or scarcity but is rather an opportunity to effect change (because change is cheaper). There are after all, about [30 billion barrels](#) less oil left than there were a year ago.

Finally, though the following analysis may suggest otherwise, I am not against free trade. I think trading is fundamentally human and improves people's lives. The theory of comparative advantage was one of the coolest principles I learned in graduate school. But the giant extended tentacles of free trade are one of many premises that were initiated on an empty planet that may require contraction/adjustment on a full one.

## TRADE

[Trade](#) has been around almost as long as humankind. Historically trade was largely a barter system, before currency was adopted as a medium of exchange. Modern [international trade](#) is based largely on Ricardian model of comparative advantage, one of the most eloquent but non-intuitive concepts in economics. Indeed, a story told amongst economists is that when an economics skeptic asked Paul Samuelson (a Nobel laureate in economics) to provide a single, meaningful and non-trivial result from the economics discipline, Samuelson quickly responded with "comparative advantage."

## ABSOLUTE AND COMPARATIVE ADVANTAGE

The early logic that free trade could be advantageous for countries was based on the concept of absolute advantages in production. Adam Smith wrote in *The Wealth of Nations*:

*"If a foreign country can supply us with a commodity cheaper than we ourselves can make it, better buy it of them with some part of the produce of our own industry, employed in a way in which we have some advantage." (Book IV, Section ii, 12)*

The idea here is simple and intuitive. If one country can produce some set of goods at lower cost than a foreign country, and if the foreign country can produce some other set of goods at a lower cost than can be done locally, then clearly it would be best to trade for the *relatively* cheaper

goods of both countries (or regions). In this way both parties gain from trade.

If a person/region/country can make a product cheaper or more efficiently than someone else, they have an [absolute advantage](#) in this product. However, a country that can produce two things (or everything) better than another country can still benefit from trade. This is due to the brilliant (on an empty planet) theory of [comparative advantage](#) first articulated by [David Ricardo](#). Here is an example:

### The Magic of Comparative Advantage – A Hypothetical Example

Both Wisconsin and North Carolina have lots of trees, productive farmland, access to labor, and cows. (assume for this example their labor force and populations are equal) Both produce cheese and furniture. But Wisconsin (for various reasons) has an absolute advantage in the ability to produce both cheese and furniture. If they were to devote all their resources each laborer could produce 12 units of cheese or 4 units of furniture. In North Carolina, each unit of labor can produce 6 units of cheese or 3 units of furniture.

Wisconsin is 'better' at making both products, but applying the theory of comparative advantage, North Carolina is 'less worse' at producing furniture. This can be seen via the concept of opportunity cost. For every unit of furniture production, NC is giving up 2 units of cheese production (6/3). For every unit of furniture production in Wisconsin, they are giving up 3 units of cheese production (12/4). Therefore it is 'more costly' in terms of opportunity lost for Wisconsin to produce furniture than it is for North Carolina, in a world of frictionless trade.

Specifically, in a position of [autarky](#) (or closed economy), each state will devote half its resources to each production pursuit – Wisconsin will produce 6 units of cheese and 2 units of furniture. North Carolina will produce 3 units of cheese and 1.5 units of furniture. In our hypothetical *world without trade then, a total of 9 units of cheese and 3.5 units of furniture are produced.*

But then a trade agreement is signed. Because they have a comparative advantage in furniture, North Carolina devotes 100% of their resources towards producing 3 units of furniture. (and no cheese). Wisconsin produces 12 units of cheese (and no furniture). Now the 'world' has 12 units of cheese and 3 units of furniture. However, Wisconsin can easily shift 3 units of its cheese production to create one unit of furniture. *The world now has 9 units of cheese and 4.5 units of furniture with no extra resources or labor.*

Trade, via specialization, has magically created an extra piece of furniture, with still the same amount of cheese!

WHAT PRICE CHEESE?

**A key question in this post: what happens when the cost of transportation of cheese and furniture between North Carolina and Wisconsin (via higher oil prices) exceeds the benefits from trade (an extra unit of furniture)?**

I remember in graduate school thinking comparative advantage was pretty cool. But, like many things in neo-classical economics, comparative advantage relies on a battery of assumptions, many of which prove problematic in the real world. Josh Farley and Herman Daly succinctly

describe some criticisms of the assumptions that underpin comparative advantage in their textbook "Ecological Economics"(1),

1. "No extra resources" simply means no additional labor or capital - there IS commensurate resource depletion and pollution accompanying the extra production.
2. The neglect of transportation costs. Transportation is energy intensive, and currently energy is not only directly subsidized, but, in addition, many of its external costs are not internalized in its price. Consequently, international trade is indirectly subsidized by energy prices that are below the true cost of energy.
3. There are two important *costs of specialization*. First, all cheese makers (cheesesmiths?) in North Carolina must become furniture producers and vice versa for furniture makers in Wisconsin. Making such a shift is costly to all whose livelihood is changed. Also in the future the range of choice of occupation has been reduced from two to one - likely a welfare loss and assuredly an occupational risk.

Furthermore, after specialization, countries lose their freedom not to trade (the chinese finger trap). They have become vitally dependent on each other. . . Remember that the fundamental condition for trade to be mutually beneficial is that it be voluntary. The voluntariness of 'free trade' is compromised by the interdependence resulting from specialization. Interdependent countries are no longer free NOT to trade and it is precisely the freedom not to trade that was the original guarantee of mutual benefits of trade in the first place.(1)

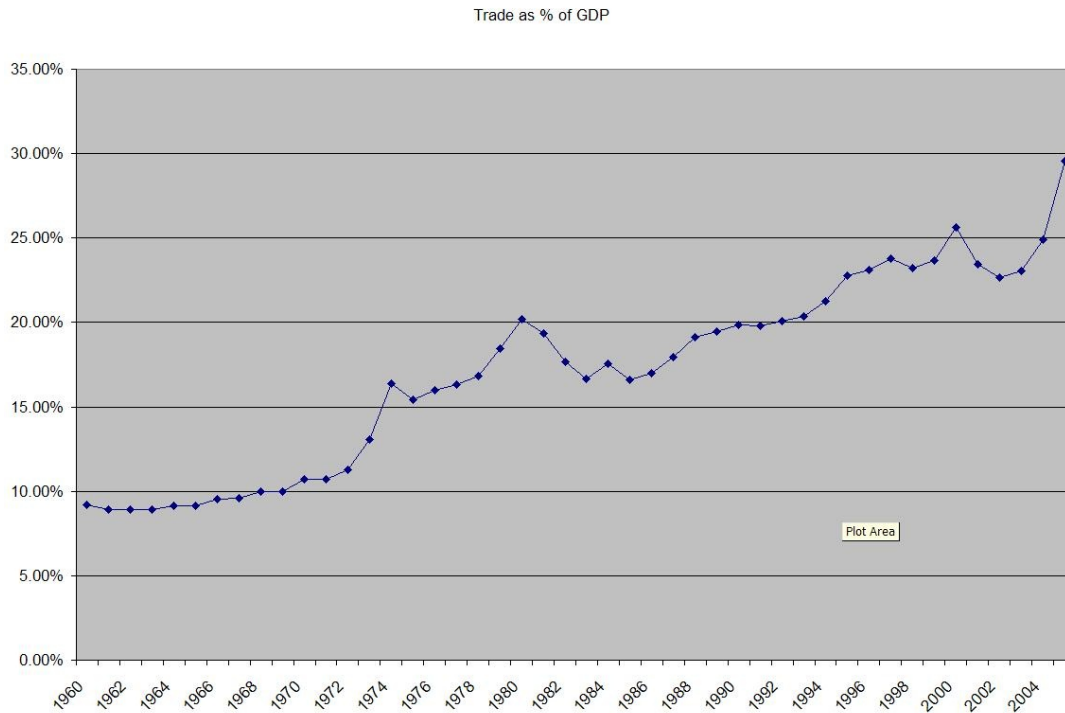
## **CAPITAL MOBILITY**

An often overlooked provision of Ricardian comparative advantage, but one of extreme relevance in today's world, is that of factor immobility (factors other than cheese and furniture). In reality, today's borders are porous to billions upon billions of dollars of capital movements moving to the areas of the world with the cheapest production. In effect, the rich countries have a comparative advantage in 'money' and are trading it for the labor and resources of other countries.

A country's current account is the difference between the monetary value of exported and imported goods and services. When the imports are greater than the exports, the account is in deficit. If exports are greater, the current account is in surplus. So, comparative advantage, with the assumption of immobile factors relaxed has effectively resulted in the erasure of national boundaries for economic purposes.

Some people call this globalization.

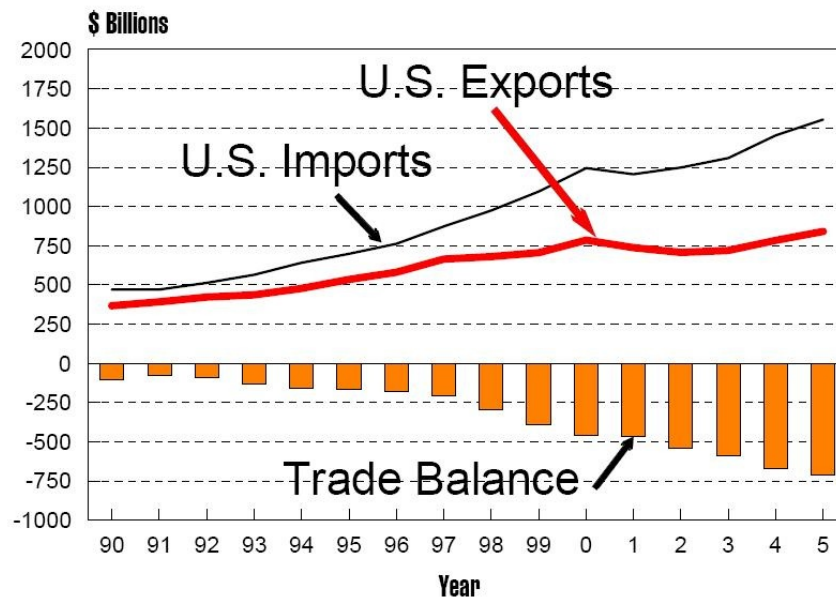
The following graph shows the increasing percentage that trade is out of total US GDP:



US International Trade as % of GDP- [Source US Census Bureau](#) [Click to Enlarge](#)

Below is a chart of US imports and exports and our trade balance:

**Figure 3. Real U.S. Imports, Exports, and Trade Balance of Goods (chained 2000 dollars), 1990-2005**

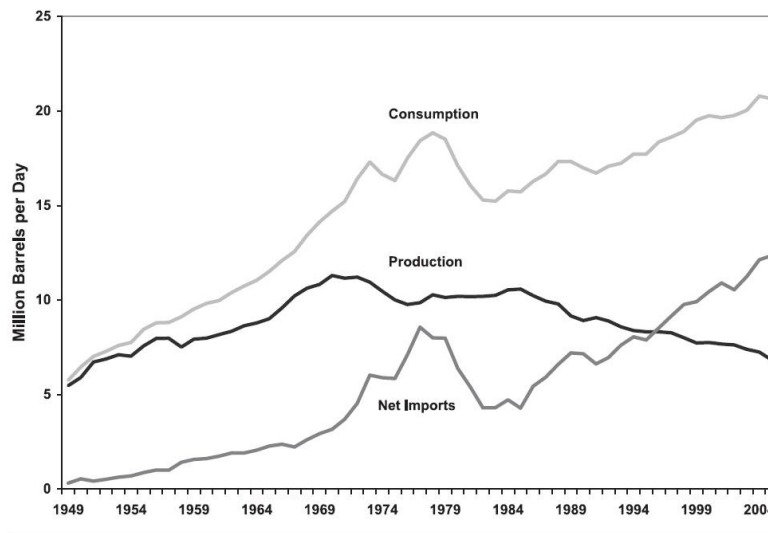


Source: U.S. Bureau of Economic Analysis

*US Imports and Exports - [Click to Enlarge](#)*

As can be seen above, imports have been outpacing exports for some time and the pace has

Figure 2: U.S. Consumption, Production, and Imports of Oil, 1949–2005



Though the basic goods vs luxuries trade mix is a complicated analysis, one thing is clear - oil now makes up 10% of the dollar value of our imports:

**Table 11. U.S. Imports of Crude Oil by Selected Countries, 2005**  
(Quantity and Customs Value)

Country	Quantity (Thousand barrels)	Customs value (\$million)
Total World	3,753,088	175,563
OPEC Total	1,818,357	88,303
Saudi Arabia	524,129	24,739
Venezuela	535,718	24,074
Nigeria	396,918	21,904
Kuwait	80,396	3,702
Algeria	82,383	4,670
Other OPEC	198,813	9,214
Non-OPEC Total	1,934,732	87,260
Canada	567,676	24,148
Mexico	552,076	23,096
Angola	161,507	8,161
Ecuador	99,128	4,223
Norway	43,107	1,947
Gabon	55,792	2,759
Other Non-OPEC	455,446	22,926

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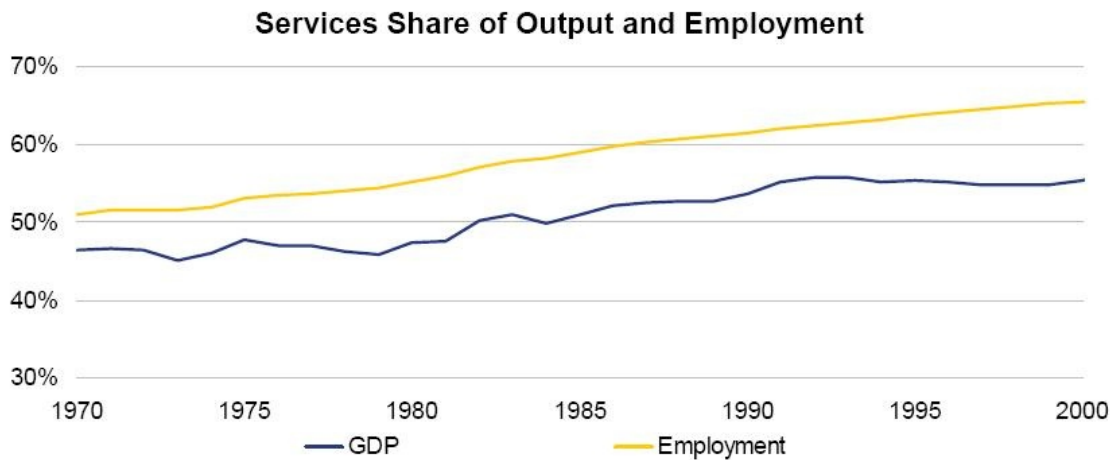
Source: U.S. Census Bureau, *U.S. International Trade in Goods and Services*, FT-900, issued monthly.

*US Oil Imports by Country - Click to Enlarge.*

Finally, it is of some concern that 'services' continue to increase as a percentage of our national

ledger (implying that 'goods' are becoming less). We still do produce huge amounts of food for export, but that is increasingly being accompanied by movies, massages and things higher up the 'discretionary' hierarchy (more on that below). Here is a graph indicating the growth of services vs goods in our Gross Domestic Product and Employment. America seems to have a comparative advantage in 'services'. The counter-argument is that more services naturally arise as economies become less energy intensive - this view ignores energy as a unique input, and therefore all countries can't become less energy intensive over time under a growth regime.

## The services industry is an increasing part of the economy



Source: NIPA tables 1.5.2 and Bureau of Labor Statistics CES Survey, total nonfarm employment and private service-providing employment.

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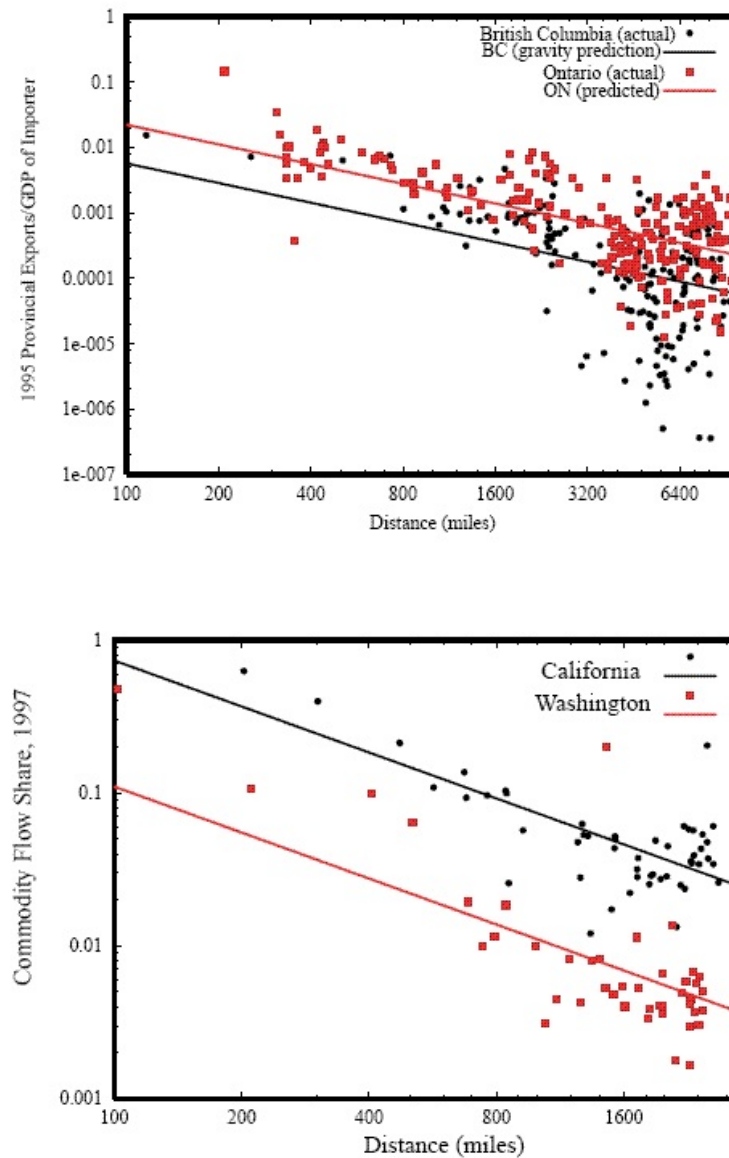
[www.bea.gov](http://www.bea.gov)

*US Goods and Services- Click to Enlarge.*

## THE GRAVITY MODEL OF TRADE

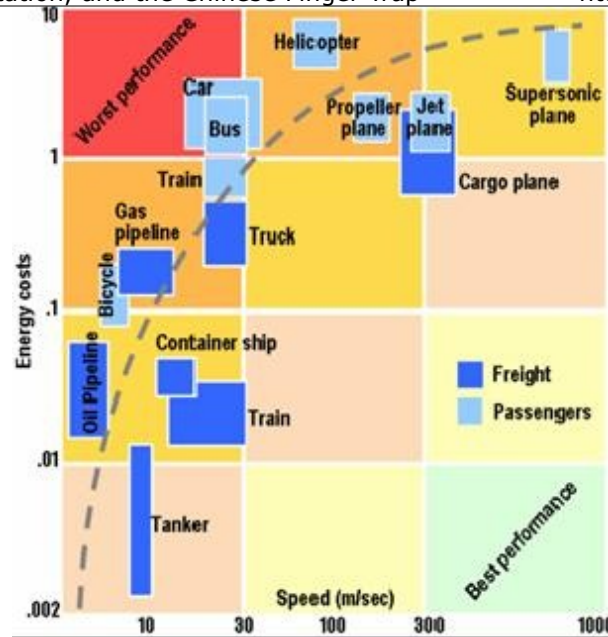
The Ricardian model is not the only economic model dealing with trade. The [Gravity model](#) of trade gets more at the heart of this post - that of the relationship between trade and transportation. It presents a more empirical analysis of trading patterns rather than the more theoretical models discussed above. The gravity model, in its basic form, predicts trade based on the distance between countries and the interaction of the countries' economic sizes. The model mimics the Newtonian law of gravity which also considers distance and physical size between two objects.

Figure 1: Trade is Inversely Proportionate to Distance



*Gravity Model of Trade-Commodity Flow Correlation with Distance (2)- [Click to Enlarge](#).*

Here is another graphical illustration which incorporates speed (which increases energy return on time) and energy intensity:



Energy costs vs speed

Jean-Paul Rodrigue Hofstra University (hat tip H.K.)

It makes sense that trade is inversely correlated with distance because even at today's cheap oil prices (remember - oil is cheaper than water, milk, orange juice, YooHoo, etc), things cost more to ship further. As oil prices increase, this inverse correlation should strengthen.

## A PALEO-ECONOMIC PALATE CLEANSING SIDEBAR BEFORE WE MOVE TO TRANSPORTATION

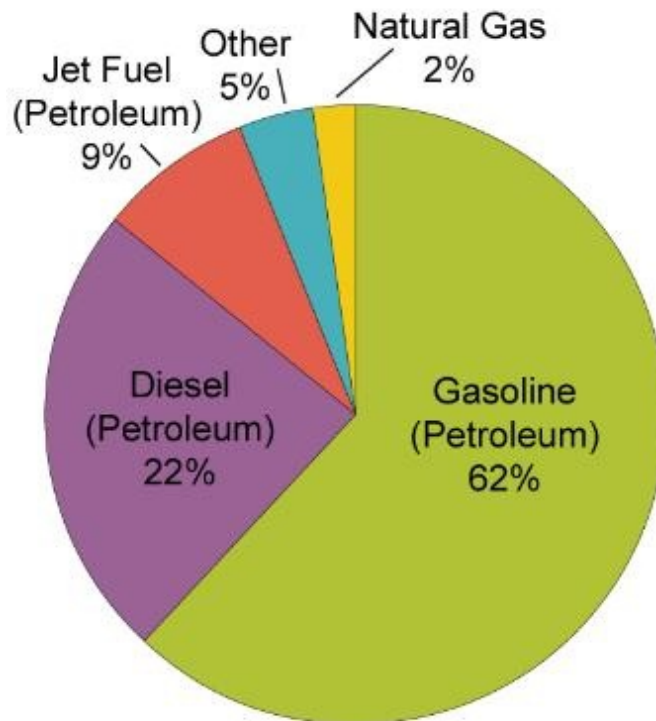
[A recent article in the Economist](#) points out that comparative advantage also works at our most basic level of trade (male/female) and was of historical significance:

In existing pre-agricultural societies there is, famously, a division of food-acquiring labour between men, who hunt, and women, who gather. And in a paper just published in *Current Anthropology*, Steven Kuhn and Mary Stiner of the University of Arizona propose that this division of labour happened early in the species' history, and that it is what enabled modern humans to expand their population at the expense of Neanderthals.

With Peak Oil likely being in 2005, perhaps I should brush up on my woodchopping and carcass dragging skills...;-)

## TRANSPORTATION

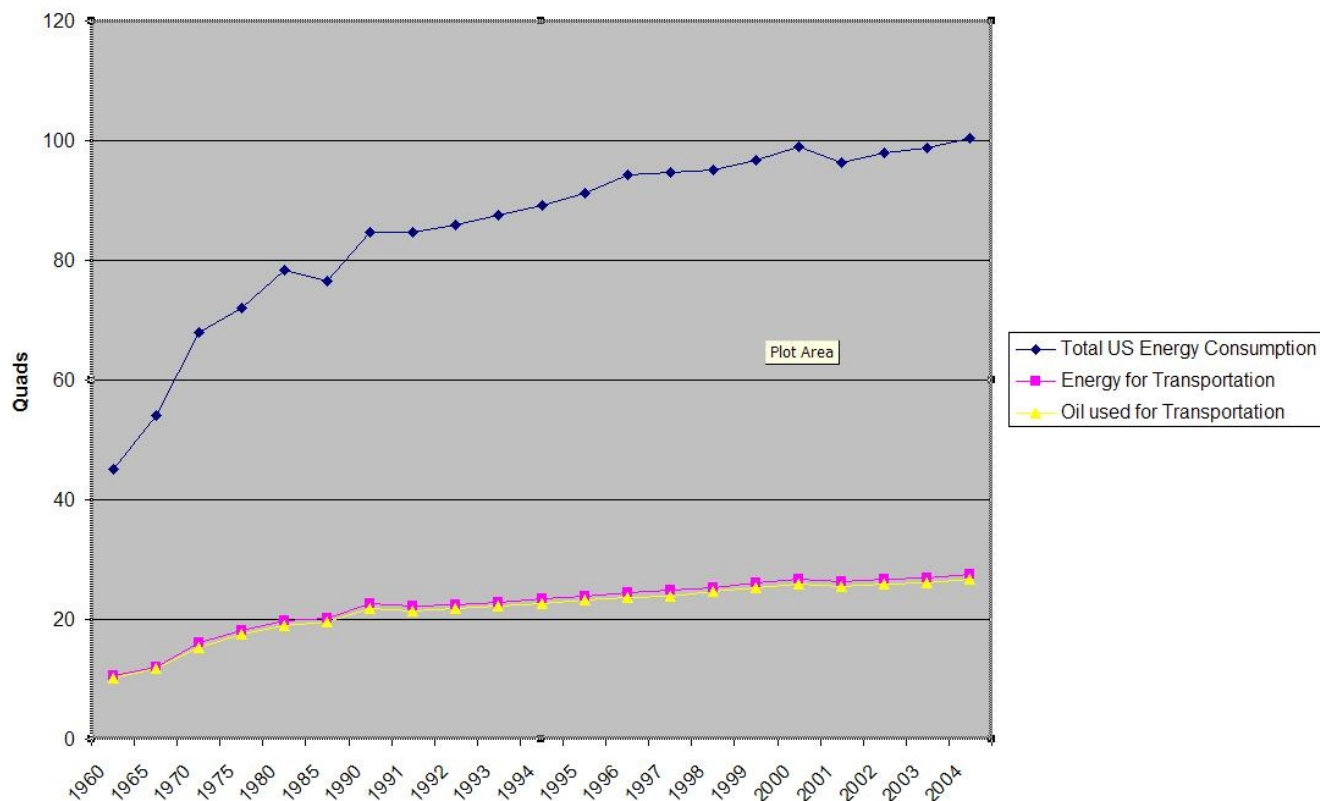
## Fuel Used for Transportation, 2007



Note: Due to rounding, data may not sum to exactly 100%.

Source: U.S. Department of Energy, *Transportation Energy Data Book Edition 28* (2009).

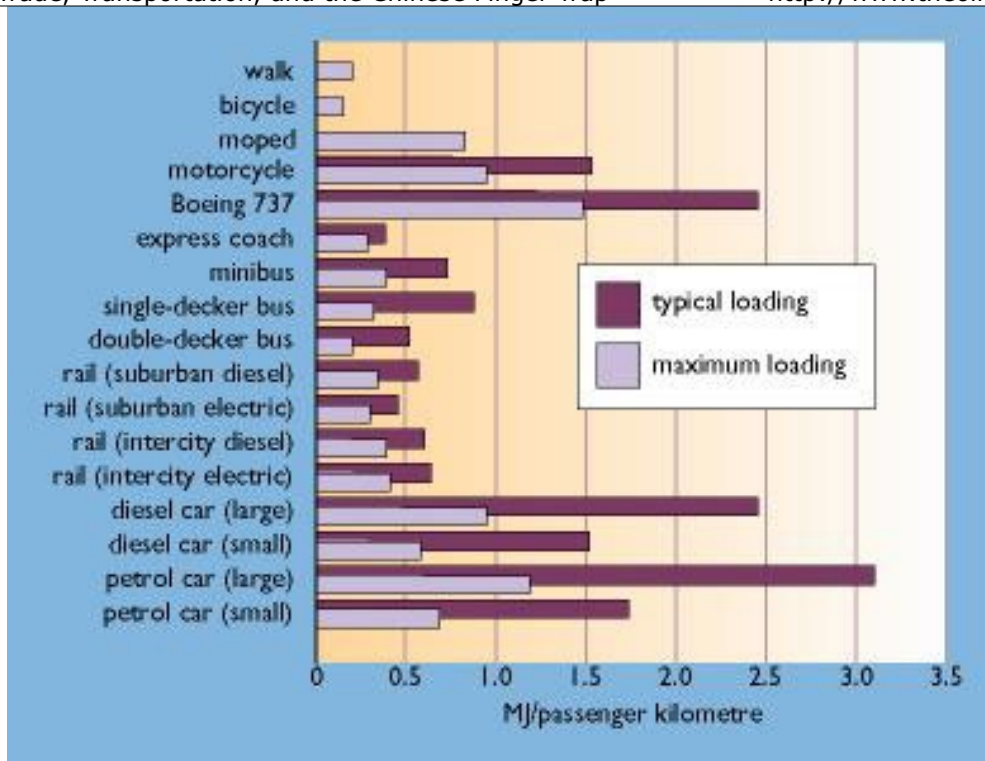
Our modern society is structured around just-in-time delivery of people and things. And petroleum makes up the vast majority of getting things around. Fuel represents 35% of operating expenses for airlines; the direct fuel cost is 20-40% of the total cost of trucking and fuel costs amount to 20-30% of cost for sea freight. And transportation itself comprises an increasing amount of total energy use:

**Transportation and Energy in US**

*Transportation as percentage of total energy use- [Click to Enlarge](#)*

In the 1960s transportation accounted for about 23% of all energy expended in the USA- now the figure is approaching 28%. The yellow line (almost on top of the pink line) shows that of the transportation, 99% of it is oil (there is some electrical, natural gas and coal usage) (3). We are really dependent on oil!

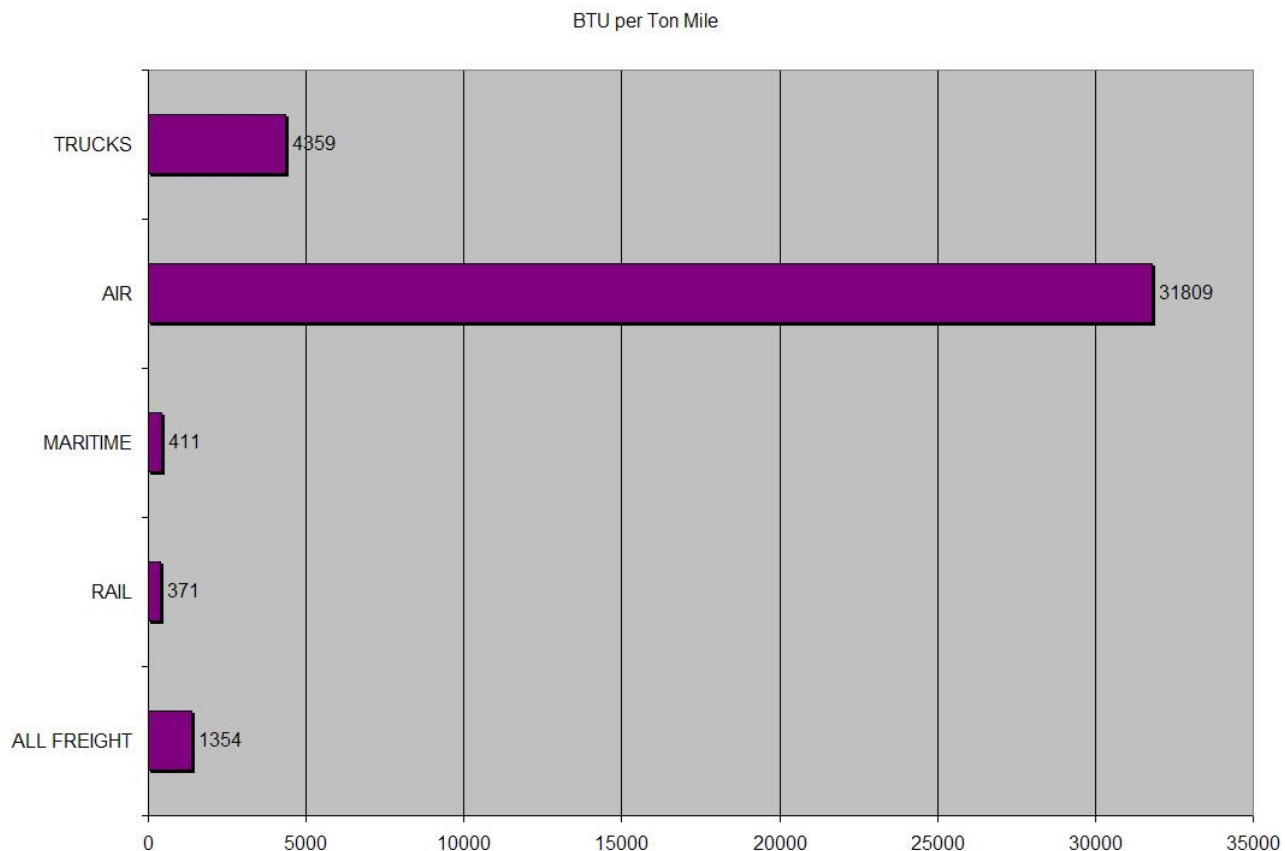
The following two graphs show the energy efficiencies of various modes of transportation first for people and then for goods. This first graph is from Richard Heinberg's book "The Oil Depletion Protocol" and is based on data from Britain (which Richard tells me is fairly universal):



*MegaJoules per passenger- Click to Enlarge*

As can be seen, the bicycle is the most energy efficient mode of transportation - even better than walking. The other insight from the graph is we gain quite a bit of efficiency from packing a lot in one vehicle. (This is a concept [used often in China.](#))

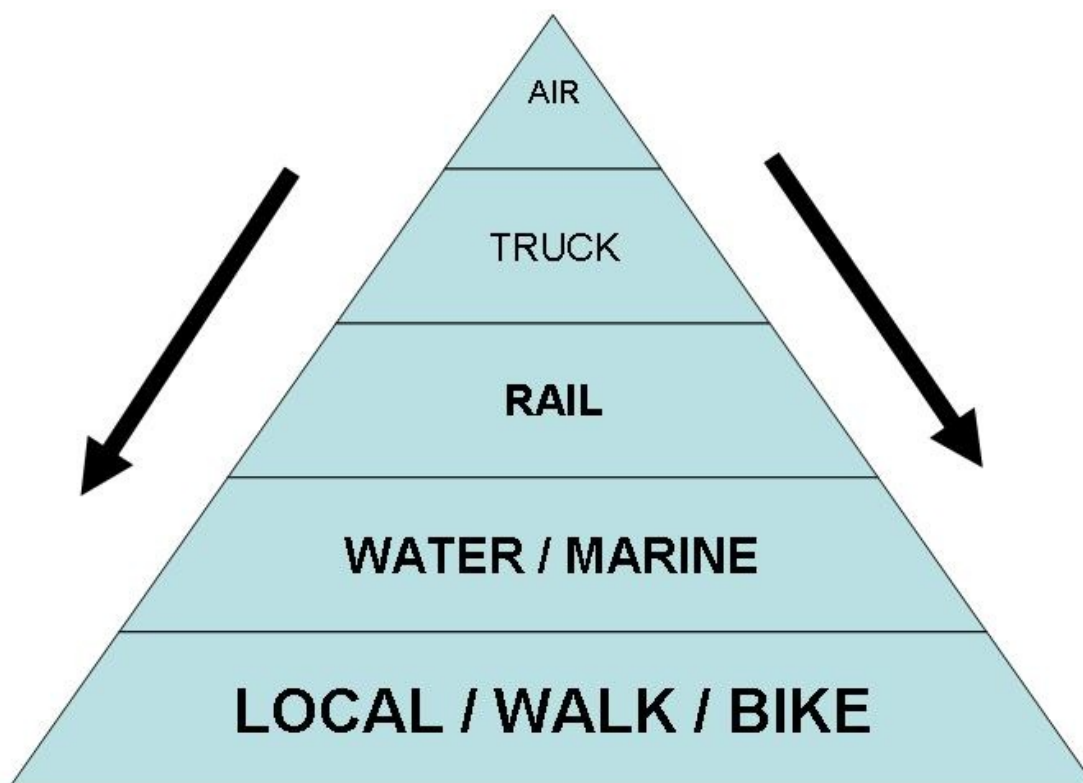
As far as transporting goods, there is a large disparity in energy efficiency per ton mile for different transport methods:



*Energy Intensity per ton mile by freight mode. [Source - EIA](#) [Click to Enlarge](#)*

The above graph is somewhat dated (1991). Though there have been efficiency improvements across the board, the general model of water/rail/truck/air in order of efficiency seems to still be intuitively correct, though some argue that rail is more efficient than water. It is actually quite a complicated issue as it depends what one is transporting and the sequence of steps. Alan Drake recently did a study showing rail transport to be [8.3 times as efficient as trucking](#).

One can visualize the energy efficiency/footprint of various transportation modes as something like this pyramid:

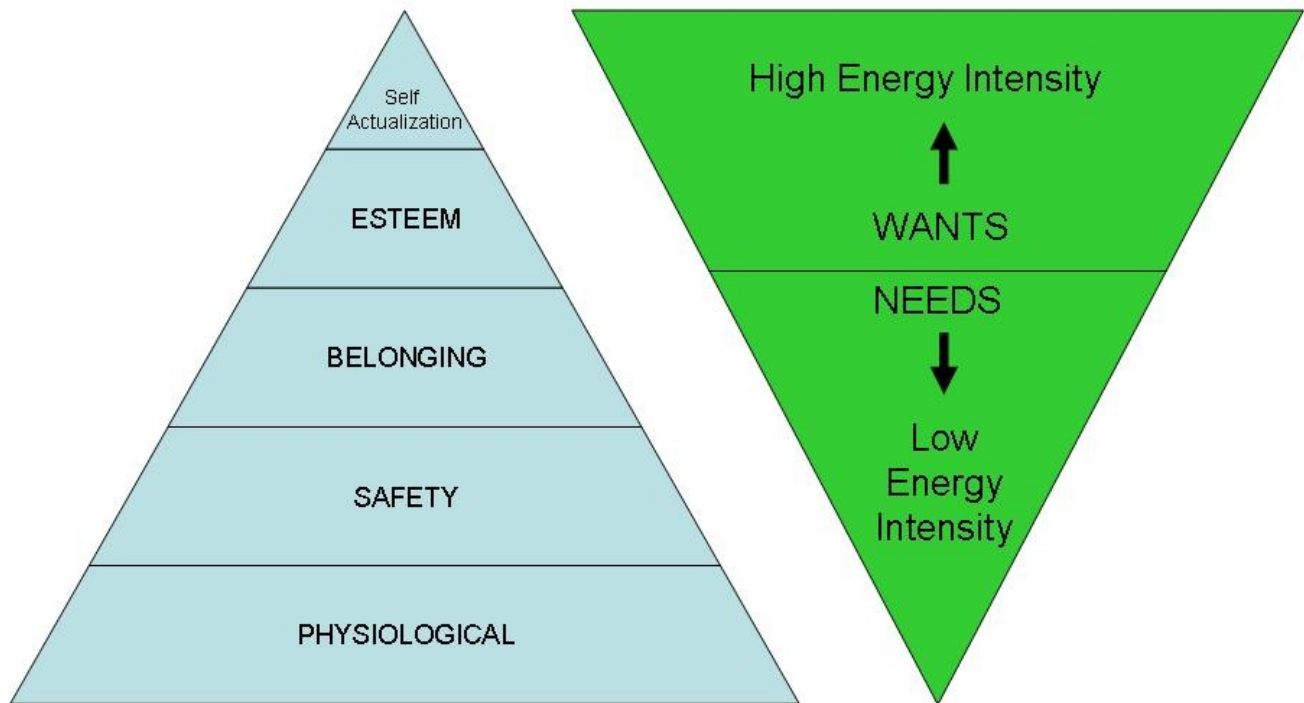


*The Transportation Pyramid. Click to Enlarge*

As transportation costs increase, communities and regions that are able to effect movement downwards on the pyramid towards its base will have comparative advantages, due to savings on energy costs, and availability of products.

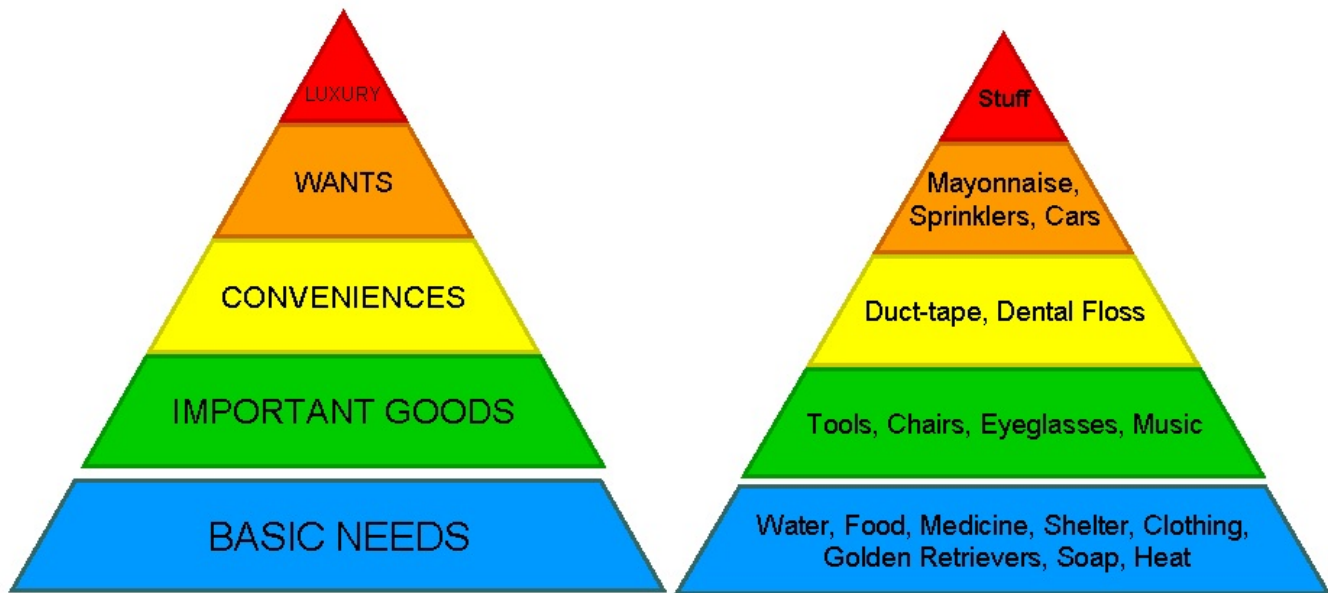
## ENERGY USE AND HUMAN WANTS AND NEEDS

Let's now shift gears just a bit. Psychologist Abraham [Maslow](#) theorized that humans meet basic needs in a hierarchical fashion. Once basic needs are met, we seek to satisfy higher needs such as self actualization and fulfillment. In the current era of cheap oil, at least for western society, a very small percentage of energy is spent on basic needs compared to the energy intensive 'desires' that drive western society:



*Maslow's Hierarchy of Needs-----Nate's Intuitive but Made Up Hierarchy of Energy Use. Click to Enlarge*

This concept can be expanded upon. We sometimes take for granted the things that we really need, and make us happy - I am 90% as happy eating fried fish from a local lake as I am driving to Chicago to my favorite sushi restaurant (well at least 80%). Higher personal consumption efficiencies in an energy challenged world are lower on the pyramid.

**Consumption Pyramid****Examples of such**

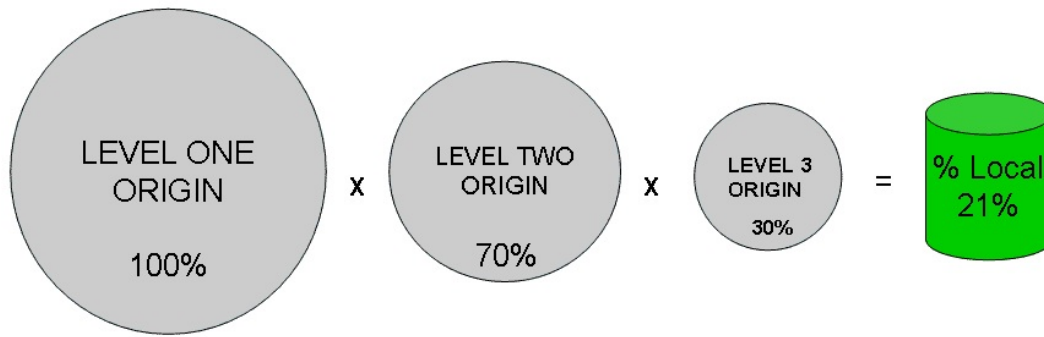
*The Consumption Pyramid - Click to Enlarge*

We finally come full circle to the spark plug question. There is a great movement (at least in the peak oil circles, not yet in the peak credit circles) towards *relocalization*. But 'local' labels in many cases are misleading due to the insidious reliance on foreign parts at different moments in the supply chain.

One of my best and oldest friends is an entrepreneur from China. He owns a business in Connecticut that seeks out American companies that need nails, screws, and small metal parts at their factories - he then signs contracts for 5 million screws at 2.5 cents each - screws that in the US would cost 6 or 7 cents due to higher labor etc. He pockets half the difference--the point being that our basic goods might ostensibly be made here, but their component parts may not.

I have not seen a way to measure this so have come up with my own "Embedded Transportation Chain". First Order Origin represents where you buy something (in your town would be 100% local). Second Order Origin represents where the components and parts came from on the product you bought. And Third Order Origin represents where the raw materials came from for the parts to make the Second Order Origin parts. To determine how 'local' (in the sustainability and security sense) a product is, one would multiply Level 1 \* Level 2 \* Level 3. Of course, there is very little that is truly local, as a world of increasing international trade has increased 'Third Order Origin' percentages dramatically. (I don't have accessible data on this--the amount of work would be closer to an academic paper - here I just wanted to lay out the idea). True to the field of economics, I have made these terms up. However, also consistent with economics, one can grasp the common sense implications. When looked at in this 3-tiered light, the phrase "Made in America", takes on different meaning.

# HOW LOCAL IS LOCAL?



## EMBEDDED TRANSPORTATION CHAIN

*The Transportation Origin Chain- Click to Enlarge*

I currently reside in Wisconsin. To eat local is cheese curds, fried fish and venison. All these things can be bought (or harvested) locally. But the cheese company gets milk transported from around the state, and uses packaging made overseas from natural gas. Its employees drive to work using cars made in Japan and oil from Nigeria and eat food imported from New Zealand. Although the dairy farmers themselves use largely local inputs for feed and bedding, their milk buckets are made from steel processed in China, and the wood for the barn comes from a mill in Canada. It is not easy to decipher the 'localness' of a product, unless one walks out and picks a [wild mushroom](#). Use your imagination however to consider WHAT IF oil doubles triples or more in price, what sort of domino effects might occur in the production supply lines. It is hard to predict what "Liebig's product of the month" might disappear from the store shelves - Charmin bath tissue one week and Stihl chain saw blades the next.

A quick example is footwear. [98% of all shoes in the United States](#) are made somewhere else, many in China.

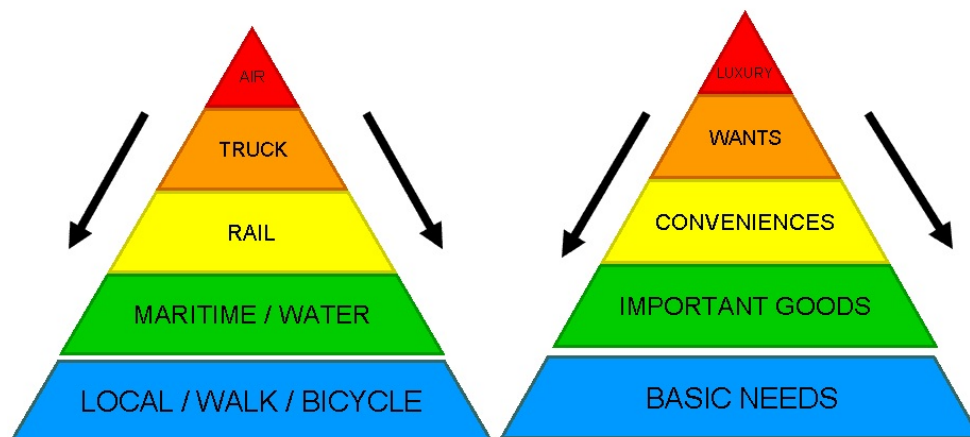
## CONCLUSIONS

Increases in efficiency of goods production in a global context are considered a good thing, as they raise respective countries GDP, and allocate resources wherefore the total pie gets bigger. Once on this track, however, participants continue to strive for more and more efficiency, more trade advantage and cheaper production. If taken to its natural extreme, every place on earth will specialize to the maximum profit of corporations. Implicit in this path is the forgoing of expertise and local resources that are lower down the pyramid of human necessities. If transport costs are 20% of a products value and oil doubles or triples, they become upwards of 50% of a products cost. Certain products then become uneconomic to ship. Some of those products are components of larger products which do not have local substitutes.

High quality and abundant oil has obfuscated the difference between wants and needs. At a Walmart or a Safeway, young people today see quilted bathroom tissue, pork chops, colorful shoes, dental floss, and avocados as a natural smorgasbord, without internalizing the complex energy/trade chain that put them there. This plethora of choices that globalization offers us could just not be possible in local or regionally based economies. In some sense, to revert the global

network of specialization back towards less complex, more regional networks is kind of a chicken-or-the-egg dilemma. Unless we change the consumption drivers, there will be little incentive for the manufacturers of [nascar lunch boxes](#) to move downwards the production/transport and global/local pyramids.

When (and in my opinion, it's only a matter of when) oil becomes less available/affordable, centralized forms of energy command will not be efficient because different regional blocks and localities possess their own comparative energy and resource advantages and disadvantages. National umbrella energy policies treat all states the same. Corn ethanol roll out is a prime example - what might be great for communities in Iowa and Minnesota has different math for California and Vermont. We know that distance impacts energy efficiency and costs. We also know that different states (and countries) have different indigenous energy resources (Quebec has hydro – Arizona has sun, Montana has wind and coal, etc). It is likely there will be decentralization of energy production as regions move toward building blocks of basic needs in safer spatial scales. The magic of comparative advantage can still work in the second half of oil. But it ultimately will differentiate between basic needs and unnecessary desires - and take advantage of water and railway access.



## THE BOTTOM LINE

1. We need oil for more than just driving. It is embedded in almost everything. Unless you're Amish, [Aleutian](#), or have *alot* of friends, oil is life in the USA (at least currently).
2. Higher oil prices combined with lower credit availability will eventually make certain types of trade prohibitive.
3. Those nations, regions, communities and families that produce lower on the left graph and consume lower on the right graph will have an advantage when transportation costs increase. Those communities using predominantly rail and water transport will have advantages over those more dependent on truck and air, everything else being equal.
4. As is occurring in some South American nations currently (Peru and Venezuela come to mind), a return to the [import substitution model](#) away from the so-called [Washington consensus](#) seems inevitable. However, remember the supply/demand wedges in the Hirsch/Bezdek report showing

how rapidly production shortfalls could occur. Local, regional and national action needs to be taken soon because of the required long lead times.

5. In rich nations, in addition to conserving, it will be advantageous to begin to be happier with 'less' because the *delta* of 'desires' may change more slowly than that of 'things' available in the future, relative to other countries (e.g. Europe and Africa) that exhibit lower energy footprints. In other words, though the USA can easily get by with half as much energy-intensive stuff and conveniences, an abrupt change to this level will be much more mentally painful than a gradual one.

In conclusion, as a thought experiment, the next time you go to your nearest box store, look at the gazillion products on display. Try to imagine where they come from, where their parts come from, and how that supply chain might change when new oil production fails to match decline rates of older wells. While you are there, you might notice how many of the myriad products improve the lives of you or your friends, and how many do not. This 'demand' side view of Peak Oil will be the subject of my next post.

Next post (if I successfully defer my addictions): *"Evolution, Discount Rates and Addiction"*

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Resources cited:

(1) *Ecological Economics - Principles and Applications*, [Herman Daly](#) and [Joshua Farley](#) (in my opinion, a textbook that should be used in every college in America)

(2) "Gravity for Beginners" Keith Head. <http://pacific.commerce.ubc.ca/keith/gravity.pdf> (.pdf warning)

(3) [National Transportation Statistics 2006](#)(pdf warning), US Department of Transportation

*Note 12/28/2009 - I intended to update this analysis with a) statistics on fuel cost/intensity relative to cargo value/necessity, and b) the transport substitutions that may become available for oil, but other projects became more pressing (read: interesting). Also, though I mentioned credit in the essay, many of the advantages of trade may disappear even with plenty of oil, if significant currency reform/reset occurs or if credit becomes generally unavailable. If anyone has expertise in those areas they'd like to share as a guest post, please submit an abstract, or summarize in comment section below.*



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