A New New Global Auto Industry?

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1. Introduction

The subject of this paper is the auto industry seen from a global perspective in a longer time-frame. Its present predicaments in the macroeconomic crises are widely reported and addressed by policy makers in the United States, the European Union, and in other countries. Like textiles, mining, steel and ship building industries before, the auto industry exerts a considerable political influence, except it is much bigger. It was thus not surprising than that the policymakers rushed in to help when the bottom fell out of national auto industries.

The main purpose of these crises-inspired programs was saving jobs and "cash for clunkers" became a policy instrument of choice. In Europe, France moved quickly and decidedly, in fact it had run a similar program from 1994 to 1996. Germany, Italy the United Kingdom followed the French initiative. Usually, cars at least 10 years old would receive an incentive worth up to 3,500 Euro when traded in.[1] Strong sales returned, particularly of lower quality cars. Alas, the gains tended to dissipate rather quickly and the auto makers in deep trouble continued to struggle for their survival, sometimes without success. The United States has had a similar experience to the European Union. The cost of the U.S. program to the government was $3 billion and it did not prevent GM and Chrysler from bankruptcy.

Policy makers all over the world must have realized that they also needed to articulate and put into operation long-term plans for the auto industry. Increasingly, such plans are developed jointly with environmental policies. President Obama announced in May 2009 a new national policy intended to improve fuel economy and reduce greenhouse gas pollution created by all new cars sold in the United States. The U.S. administration is committing $27 billion to boost domestic production of electric cars and batteries required to power

[1] The maximum national incentive varied quite a bit. There were also different emission and age requirements.

them. The French government is investing $2.2 billion in the development of county-wide network of charging stations. The British government has begun granting loans for development of electric cars; the first one went to a subsidiary owned by Tata. Again, this is a part of the U.K. government's efforts to develop low-carbon vehicles and reduce CO2 emissions.

The car manufactures themselves realize that the industry is in for big changes and attempt to introduce low-carbon cars. For many of them it has become a matter of survival. In addition, newcomers to the industry see opportunities to capture a large share of a rapidly changing market.

This paper tries to gauge how the auto industry may change in its international dimensions. A number of existing trade models serve as our "walking stick". We identify two principal drivers of the change: income growth and the emergence of electric vehicles as an efficient and ecologically friendly means of transportation. China and possibly India may well be a centre of a new new global auto industry.

2. Modelling the Global Auto Industry

Modelling the global auto industry is an exceedingly difficult, perhaps even unachievable, task. Several reasons are responsible for this quandary. First of all, the industry does not produce a homogenous good but differentiated products and just casual observation suggests a multitude of the existing models, colours and options. This is of course observable at the level of the global mark and also at the level of individual manufacturers.[2] It is hard to think of a single mark that is offered in one vanilla flavour.[3] Fortunately, the economists have

[2] This is in contrast with imperfect competition models where a single firm produces a single model.

[3] In a report prepared in Bureau of Industry Economics, (1988) and focusing on the impact of microelectronics on competitiveness in Australian manufacturing the importance of product differentiation is stressed time and again with regard to automotive assemble. "The assembly industry produces a highly differentiated product for a mature and sophisticated market. Options, variants and models proliferate. Product differentiation as a competitive strategy can be tracked back to at least the early 1939s. Intra-plant agglomeration where more than one model or variant of a model is build on a single assembly line has been common since the beginning of the 1970s." p. ix.

developed models of product differentiation.[4] There are not easy to handle, but at last there are there to be applied.

The second obstacle to setting-up a one-size-fits-all model of the global auto industry stems from the fact that the minimum number of countries that such a model should consists of is greater than two. For many problems and situations trade models with just two countries is good enough to offer sensible answers to interesting theoretical or policy oriented questions. But for a whole range of issues that number has to be bigger than two, possibly much bigger. It all depends on the nature of the problem. Let me explain: If one is interested in consequences of Eastern Europe countries becoming open economies, one has to increase the modal dimension accordingly.[5] Similarly, the appearance of new players in Asia, such as India or China, calls for a modification of the traditional two-country model.

Since the question put forward in this paper deals with a possibility of the emergence of a new global auto industry we need to increase the dimensions of the base model. Only then can we figure out how the disruption such as new technology or rapid growth in one of the "new" economies will influence the established patterns of production, consumption and international trade.

In the traditional two-country model production of a good was confined to a country in the sense that he entire production process would be executed, **in toto**, within national frontiers. Of course, countries could and often did produce the same goods simultaneously; England and Portugal in the Ricardian model both produce cloth and wine.

However, in the contemporary global economy production of a good does not have to be confined to national frontiers. Fragmentation of production and international outsourcing have become symbols of globalization. An American,

[4] As the reader will see sortly, these models have the Ricardian and Heckschere-Ohlin flavour.

[5] As a starting point one would divide the global economy in two parts , say, the East European block and the Western bloc. There would have to be at least two countries within each of these blocks with intensive trade flows between them. Now we can investigate the effect of the planned economies undergoing liberalization and becoming market oriented. It follows that the minimum size of the model is in this case four and not two. But the reader should be reassured that the old England – Portugal model is sufficiently large for many issues.

French or Japanese car typically contain hundreds of parts and components coming from a multitude of countries, in addition to elements supplied by numerous domestic sub-contractors. The national frontiers blur. The process of internationalization of production is likely to continue although it might be slowed down somewhat as a consequence of the current economic recession and a subsequent build-up of protectionist pressures.

A sound and robust model of the global auto industry has to capture product differentiation, be set up in a multi-country world and take account of production fragmentation and outsourcing. It would also be desirable if it could incorporate alternative market structures.[6] Such a model does not exist yet and, in my view, is unlikely to turn up soon. However, there are well developed "parts and components" of it. I was fortunate to be involved in developing models of product differentiation and outsourcing during the last two decades and I am shamelessly going to review them as they shed light on the problem at hand.[7]

Let me begin with modelling product differentiation in the auto industry. In general a researcher has a choice of either horizontal or vertical differentiation. Both occur in the real world, but the new trade theory dealt primarily with the first one especially during the first decade of the development of the new trade paradigm. One could never contest that there is some horizontal product differentiation going on in the auto industry. After all we see yellow Volkswagens and blue Volkswagens but horizontal product takes a second seat to vertical product differentiation in this sector. It is worth keeping in mind famous words said by Henry Ford about the Model T in 1909 "Any customer can have a car painted any colour that he wants so long as it is black". It has to

[6] Irandoust (1999) examined the trade performance of the auto industry in the OECD countries and found that national market shares depended on differences in relative labour costs, cross-country income differentials and differences in market structure.

[7] I was very lucky to have great companions in this long journey. First of all, Rodney Falvey, then at the School of Pacific Studies at the ANU in Canberra, and I wrote a paper, in 1983, on product differentiation under (im)perfect competition. My second great co-author has been Ronald W. Jones with whom I did a lot of brainstorming in Vancouver in 1987 and wrote then and there our first paper on fragmentation of production . And since then we follow it up with another 12 joint papers on this subject.

be added though that in subsequent years Ford introduced more models and more colors.

Turning to the Falvey/Kierzkowski (1987) model, assume that there are four countries – Germany, the United States, China and India; two commodities (sectors) – Food (F) and Auto (A); and two homogeneous factors of production – capital (K) and labour (L). Assume further that sector F produces a homogeneous product and sector A a continuum of differentiated products called qualities and indexed by s ($0 < s < s_m$). The homogeneous product sector uses a Ricardian production function with labour being the only input. On the other hand, the differentiated product sector is of the Heckscher-Ohlin type. Constant returns to scale and perfect competition prevail in sectors F and A.

The analysis can be greatly simplified if it is assumed that production of each quality demands a fixed capital-labour ratio. All qualities need one and only one unit of labour but higher qualities require more capital. More specifically, production of one unit of A with quality s calls for s units of capital, in addition to one unit of labour. While there is no substitution between labour and capital for any particular quality, the capita-labour ratio for the sector as a whole varies in response to changes in the quality mix of the sectoral output. Finally, commodity Y's price is set to be one.

Given the above assumptions, two zero profit conditions are obeyed in the two sectors:

$$(1) \qquad bw = 1.0 \qquad \text{and} \qquad w + sr = p(s)$$

where b is labour required to produce one unit of food; w, r and p(s) stand for the wage rate, rental rate and unit price of A of quality s. The model outlined above also satisfies two full employment conditions:

$$(2) \qquad bF + A = L \qquad \text{and} \qquad \int sA(s)ds = K$$

This completes the description of the supply side.

Let's turn to the demand specification. Unlike in horizontal differentiation models, individuals have no preferred models and their tastes are identical. Thus every individual maximizes the same utility function containing the quantities of the two goods and the quality of the differentiated product.

However, individual incomes are not the same. It follows that utility maximization will yield different results depending on the budget constraint of a person. Where does unequal distribution of income come from? One could imagine that everybody makes the equilibrium wage rate and in addition gets some income generated by capital employed in the differentiated product sector. There is a fixed and large number of shares based on K and they were initially distributed by a lottery. At the end of the day, some workers/consumers have an income approaching the equilibrium wage rate, others enjoy much higher income. Although the distribution of the shares does not change, income of individuals are affected by changes in the equilibrium wage rate, return to capital, commodity prices, and technological change.

Bringing together demand and supply conditions will determine the values of all the endogenous variables. This kind of exercise can be done in a closed economy. But it can be repeated in an open economy context.

It was assumed that the world consists of four countries - India, China, the United States and Germany. Assume further that comparing the labour input coefficients in agriculture we establish that India has the Ricardian comparative advantage in agriculture and that it also is relatively well endowed with labour. Suppose that Germany has the greatest relative abundance of capital and that its Ricardian agriculture is the least efficient of the four countries. China and the United States are somewhere in between India and Germany when efficiency of agriculture and factor abundance are compared.

International trade will equalize commodity prices if commodity flows are not impeded by transportation costs, tariffs and other barriers. In spite of free trade and equalization of commodity prices, factor prices will not be equalized. Unsurprisingly the wage rate will be lowest in India, followed by wage rates in China, the United States and Germany. This result is a consequence of the Ricardian flavour of the model. If wages are not the same across the world then the rental rates will differ as well. Capital will be most expensive in India and least expensive in Germany.

India and possibly China will be food exporters while Germany and possibly the United States will be food importers. But who will have comparative advantage in cars? In order to answer this question let us draw four unit costs equations as a function of quality.

Figure 1 shows the unit output costs C(s) along the vertical axis and the quality measure, s, along the horizontal axis. Given equation (1) the vertical intercept represents the wage rate in the four countries in terms of the numeraire good. By the same equation, the slope of the four cost lines gives the rental rate in India, China, the United States and Germany. The inner envelope of the cost curves indicates which countries will specialize in production of cars of different quality. Thus India will produce cars of low quality up to the model s1, China will limit its production to models between s1 and s2 , the United States will enjoy comparative advantage in the s2 – s3 range, and Germany will capture the high end of the market.

One of the conclusions of the Falvey-Kierzkowski model is that every country will be a car exporter. India, for instance, will export some of its car production to China. But it will also export some cars to the United States and Germany because there are some poor people there. By he same token, India will import some high-quality models, say Cadillac or Mercedes, because some Indians are just as rich as rich Americans or Germans. On the whole, however,

India will be a net importer of cars. The average car quality in India will tend to be rather low given the average per capita income there.

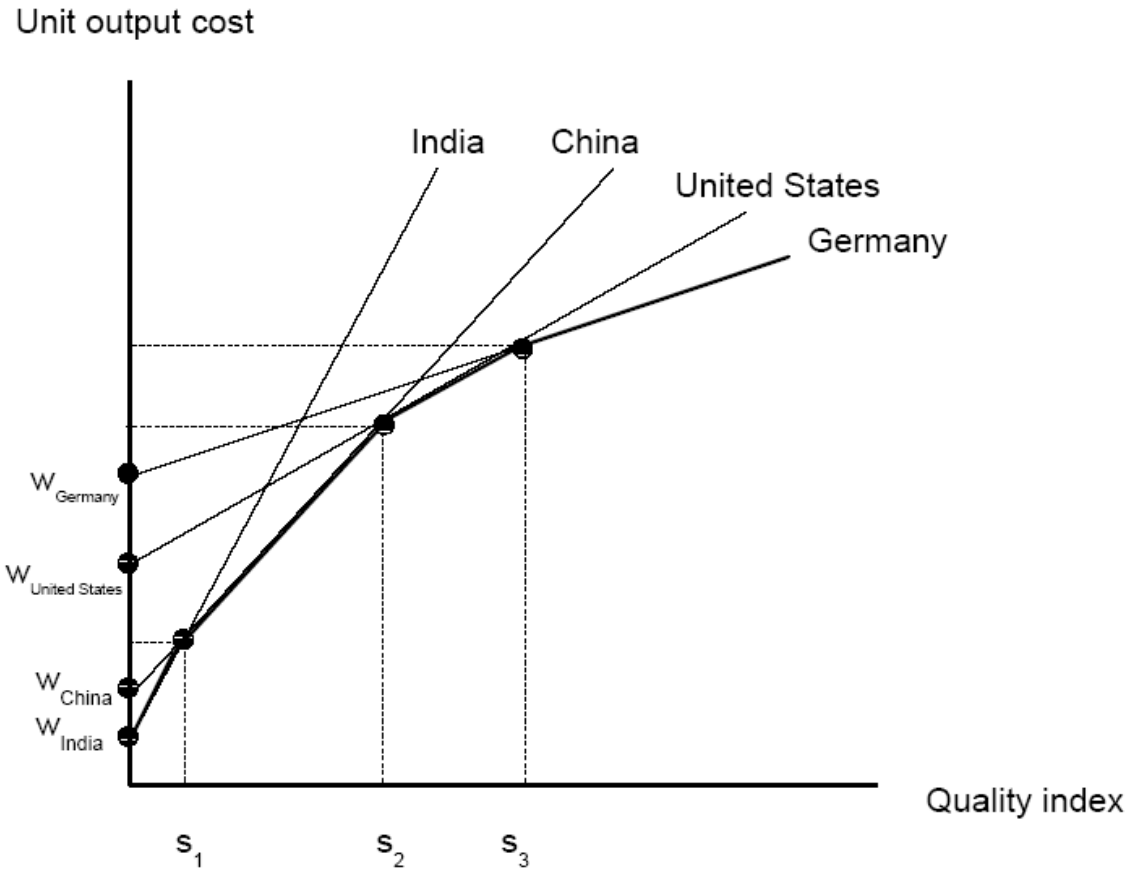
Moving to the other end of the quality spectrum, it can be said that Germany will export and import cars to and from the United States, India and China but on balance it will be a net exporter of cars. Its trade surplus generated by the auto industry will be exactly matched by food imports.

would become flatter. This effect would be primarily at the expense of American auto producers; it would also leave more room for Indian producers.

As we can see, introducing income distribution into the analysis opens up a way of modelling product differentiation and enriches our understanding international commodity flows. The Falvey-Kierzkowski model also demonstrates that integration of the Ricardian and Heckscher-Ohlin models can explain the coexistence of intra- and inter-industry trade.[8] Finally, countries with strongly overlapping income distributions will engage more intensively in exchange of differentiated products. So far, the analysis was limited to final goods. However, globalization has created a new phenomenon which is called outsourcing, international fragmentation of production, or slicing up the value chain to name just a few largely interchangeable terms. It has been observed that increasingly international trade involves exchange of not only final goods but intermediate products, parts and components, different stages of production, etc. This trend has been detected right across industries, with the automobile sector being no exception. Quite to the contrary, on entering a so-called German car, say Audi, one can quickly discover that the engine was manufactured in the Czech

[8] The reader may remember that one of the reasons of introducing imperfect competition and increasing return to scale into the new trade theory was the alleged failure of the traditional models to explain the so-called inter-industry trade. In the model explained above there is perfect competition and constant returns to scale in both sectors and intra-industry trade is generated. Moreover, trade in differentiated products (cars) coexists with trade in homogenous goods (food).

Figure 1. Unit production costs and car quality



Consider now the case of China. It is worth noting that its direct competitors in production and exports are India and the United States. German producers operate in the range that is beyond the reach of the Chinese auto manufactures. Can China, or India for that matter, expand their production range? This will be the central part of the analysis in the latter art of the paper, however, in order to whet the reader's appetite I can say that he answer is **YES**. In fact, there are several ways to bring this outcome about. Increase in China's capital endowment, for instance, would lower the rental rate and the units cost curve

Republic, the tires were made in France, the GPS system comes from Sweden and luxurious leather seats were produced in Spain, South Africa or Poland. One will also discover that the latest Nokia mobile phone installed in BMW was shipped from Finland but actually produced in Estonia, Hungary and China.

Let's now turn to the task of explaining the new dimension of many global industries and car industry in particular. Ronald W. Jones and I proposed some time ago a theoretical framework explaining the phenomenon of fragmentation of production leading to outsourcing.[9] Let me briefly present the main line of argument. Consider first a completely closed economy producing cars under integrated technology depicted in Figure 2. There are markets for inputs such as labour, raw materials, energy, etc. After inputs are bought in desired quantities and proportions they generate the final good which is then brought to the market and sold to consumers. Production itself is done in one geographic place and in "one go". This is what integrated technology is all about.[10]

Imagine now that the production process becomes fragmented – instead of a single production block, the production process consists of a number of stages as illustrated in Figure 3. The production blocks do not function independently but are connected through service links. A whole range of services may be required to coordinate car production in a fragmented process – transportation, design, quality control, insurance, R&D, telecommunications, and so on and so forth.

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[9] See Jones and Kierzkowski (1990) and (2001a). Alternative models of outsourcing have been put forward since our first article on the subject. The reader is referred in particular to Kei-Mu Yi (2003), Kohler (2004), , Grossman and Helpman (2005) and Grossman and Rossi-Hansberg (2007).

[10] This production structure that existed, more or less, in the auto industry prior to Henry Ford's appearance on the stage.

Figure 2. Integrated production in the auto industry

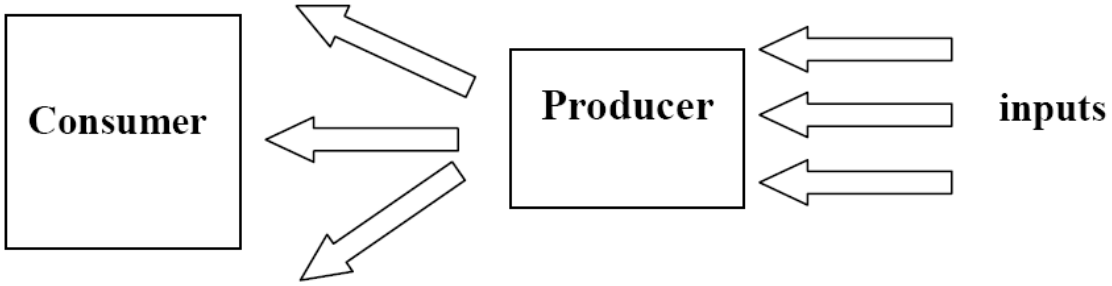
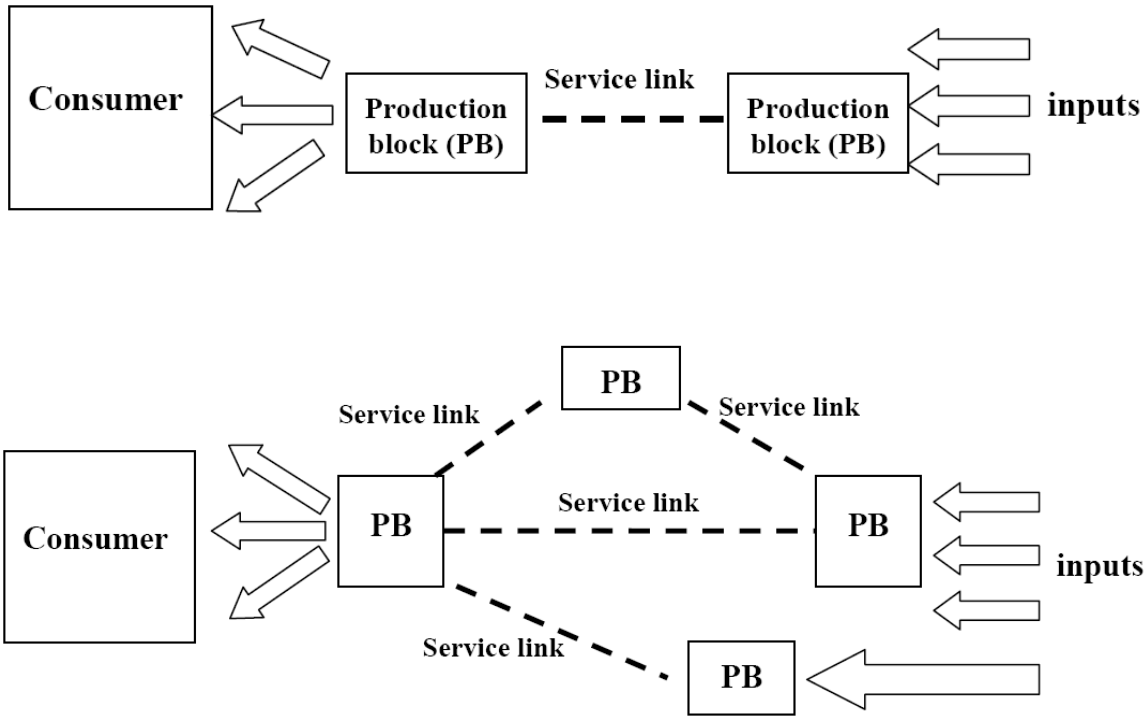


Figure 3. Fragmentation of production in the auto industry



It bears pointing out that the degree of fragmentation measured by the number of stages or production blocks could vary between industries and over time. It could also become more complex, as in the lower part of Figure 3. In an advanced economy a multitude of production stages could be required in the production process. Production blocs may be aligned in a linear or parallel fashion. As the degree of fragmentation increases, the importance of service links goes up as well.

Fragmentation of production can give rise to domestic outsourcing. It is no longer necessary to produce the whole product within one firm and in a single location. Different regions in the same country may have different endowments, labour conditions or represent different levels of technological advancement. Thus outsourcing is perfectly possible within the same country, indeed this is how it first started.

Fragmentation of production and outsourcing can sooner or later spill into the international arena. Competition forces producers to look for better organization of production in order to reduce costs and increase profits. Several factors can be expected to influence the extent of fragmentation. In the Jones-Kierzkowski framework the size of the market determines when the switch from integrated to fragmented production becomes efficient. Furthermore, as the size of the market increases so does the optimal degree of fragmentation.

Costs of service links are bound to weigh heavily in deciding whether production should be integrated or fragmented.[11] Deregulation of service industries undertaken in many countries helped to bring service links prices down. International trade negotiations made a further contribution towards increasing competitiveness of service industries across the world. Last but not

[11] The Jones-Kierzkowski model assumes that service links involve only fixed costs. The combination of constant returns to scale in production of individual blocks and increasing returns to scale is service links encourages fragmentation and outsourcing. Fragmentation allows producers to lower the marginal cost of the final good. Cost savings achieved this way must be compared with relatively fixed cost of service links. With a suitably large scale of output, fragmentation dominates integrated technology.

least, technological progress in telecommunications, banking, finance, transportation, just to name a few sectors, has changed the ways in which goods are produced and distributed.

Political and economic stability, property rights and protection of intellectual property have also bearing on the international spread of fragmentation and outsourcing. One can see immediate implications for the transition economies in Eastern and Central Europe as well as for the emerging economies in East Asia.

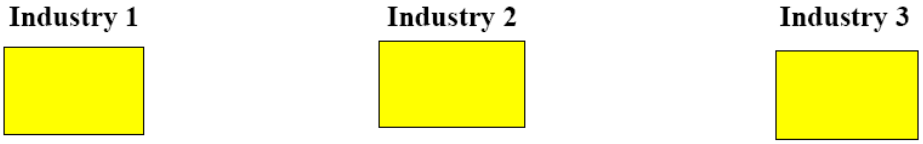
So far the process of fragmentation was considered in the context of a single industry but there is no reason to accept such a limitation. What is good for one industry may well be good for other sectors. Think now of cars, computer and mobile phones, called industries 1, 2 and 3, and imagine that they all apply integrated technology as shown in the upper part of Figure 4. Over time, however the three industries move to fragmented technology.[12] The process requires time and need not proceed at the same pace across the sectors. The sectoral extent of fragmentation may also vary but the purpose of Figure 4 is to simplify the analysis not to complicated.

After a new equilibrium with three production blocks has been established in the economy, the producers of cars, laptop computers and digital phones, always keen to reduce production costs, may discover that there is a part or component that they all use. It is not exactly the same but it performs similar tasks and is built based on the same principles. It becomes tempting to standardize the common element and produce a one-size-fits-all component. And that is what the bottom part of Figure 4 shows.

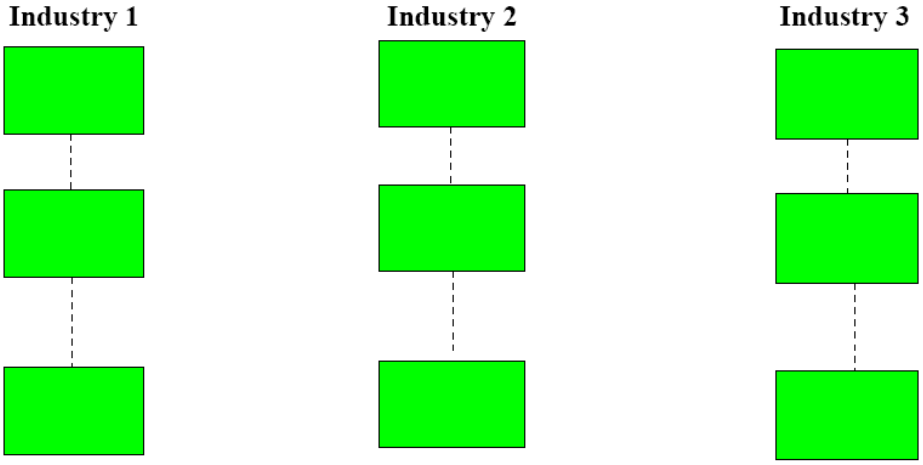
Figure 4. Fragmentation and technology convergence

[12]For a discussion of horizontal aspects of vertical fragmentation see Ronald Jones and Henryk Kierzkowski (2001).

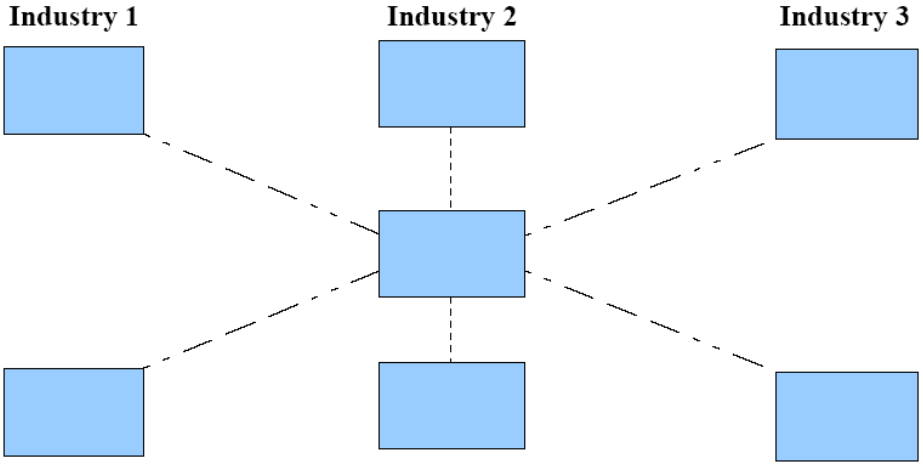
Integrated Production



Fragmented Production



Fragmented Production with Convergence of Technology



Later on, I will argue that there is technology convergence involving some production blocks in the auto and other industries.

3. Empirical Trends

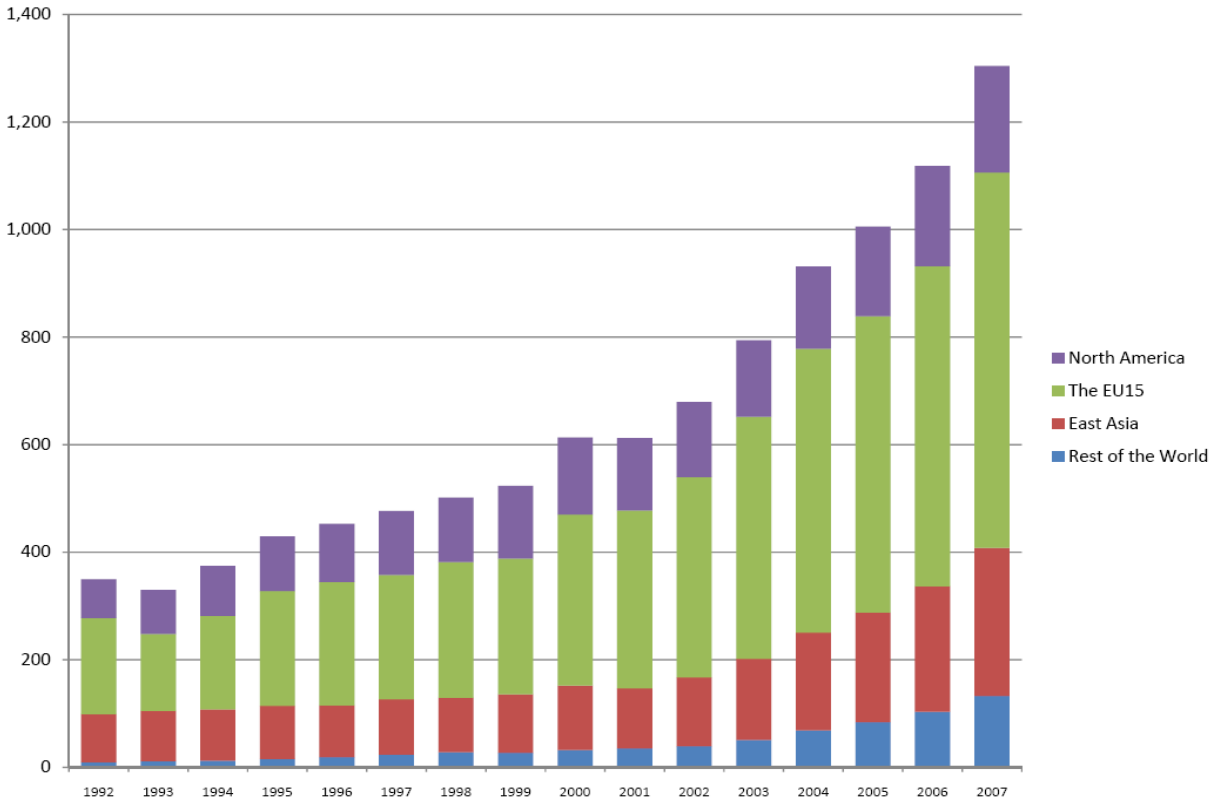
Chart 1 conveys a general picture regarding world exports of road vehicles between 1990 and 2007. It has expanded by 466% in nominal terms with interesting shifts in the composition of total exports. The European Union (EU-15) carved up 54.3% of the global market in the beginning of the period and held on to it by the end (53.5% in 2007). Perhaps surprisingly, East Asia and Nafta had their relative weights reduced somewhat. In the case of the former grouping the decline was from 23.9% to 21.3% while the latter trading block had an even bigger decline – from 19.6% to 15.2%. Who was the big winner hidden in the rest of the world category? It was counrtiers of Eastern Europe who later joined the European Union and are now called EU-12.

The old communist regimes of Easter Europe had often manifested their desires to give their people and elites cars they all aspired to possess. The Soviet Union bluntly copied an American 1950ish Buick and produced it for the government and military officials. In the 1960s Italian Fiat was asked to build an entire city in the Soviet Union to provide a modest car for privileged citizens. Other countries of the region mimicked the Soviet policy. There were Skodas in Czechoslovakia and Trabants in East Germany which had a major weakness that their chassis was eatable by rats.

It was no surprise that Eastern Europe was no exporter of cars under the old regimes. EU-12's exports of cars amounted to meagre US$ 400 million in 1990. It was only 0.1% of global car exports. However, the situation changed very quickly indeed. With new markets open to Western auto producers, big investments, transfer of technology and management skills combined with good wages for local workers, EU12 countries became formidable exporters selling.

Chart 1: World trade in road vehicles

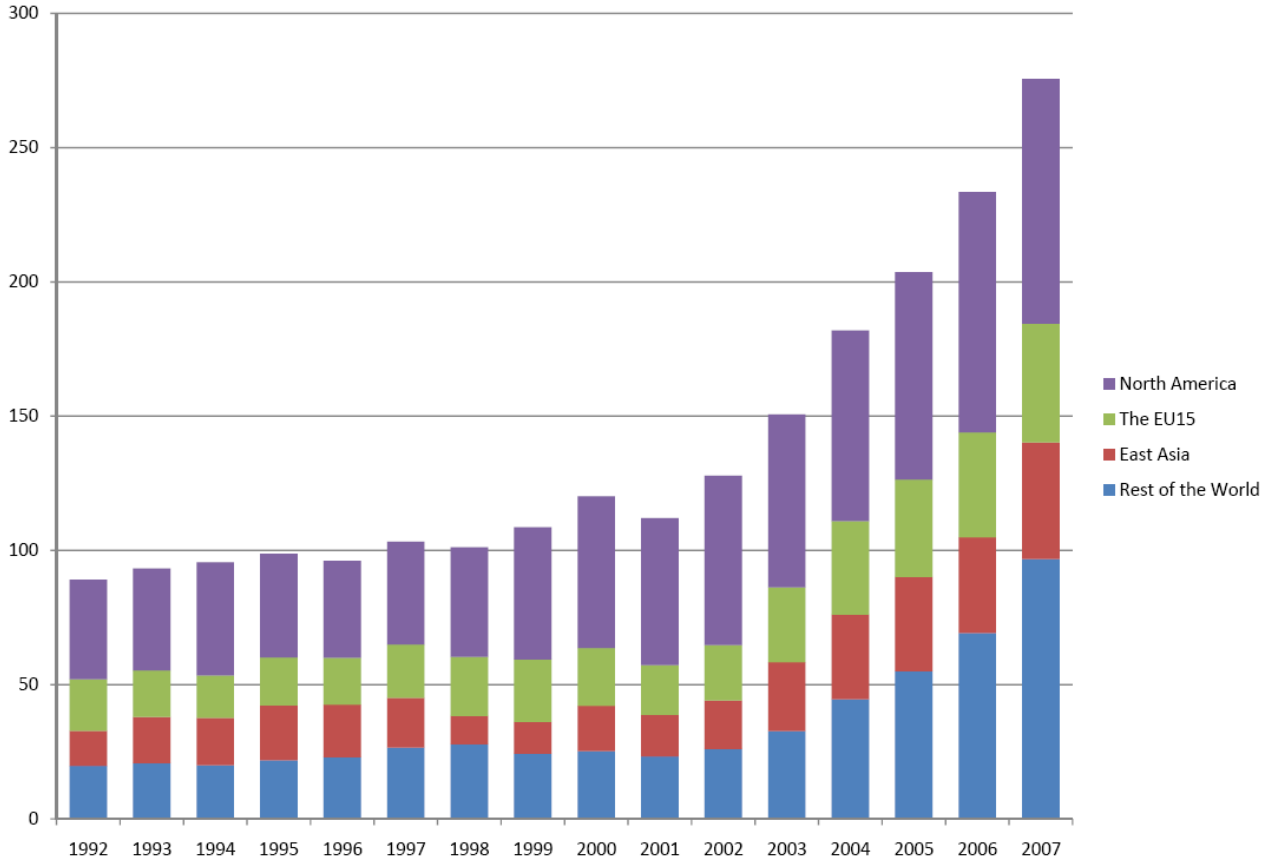
(Exports, billion US dollars)



Data source: UN COMTRADE database

Chart 2: Exports of road wehicles from East Asia

(Exports, billion US dollars)



the world US$73.5 billion worth of cars and capturing 5.6% of the world market Let's shift our attention to East Asia. Chart 2 shows its export expanding from US$ 89.1 billion in 1992 to US$ 275.6 billion in 2007. Almost half of East Asian car exports went to North America in the beginning of the period, and only a third in 2007. The share of exports going to the EU-15 also declined from 20.6% to 16.0%. It is the rest of the world that significantly increase its importance as a market for cars from East Asia.

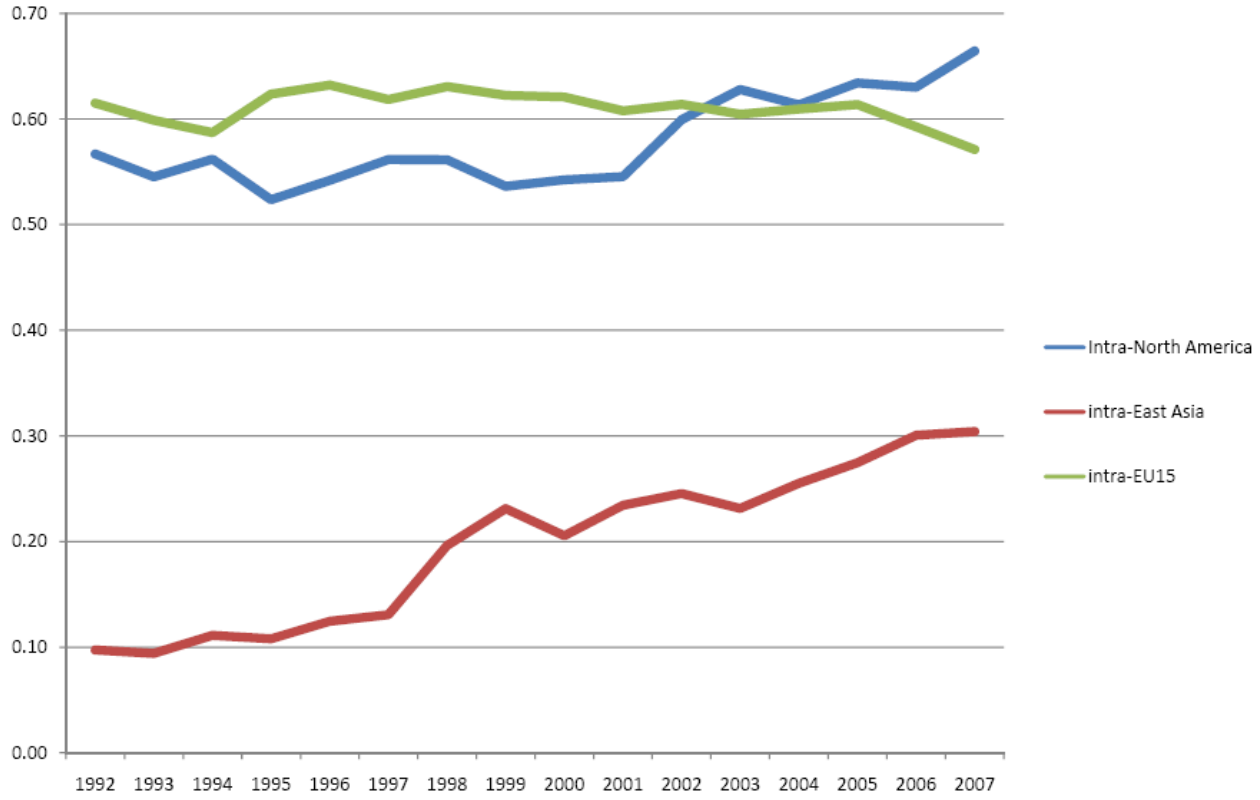
Taking into account recent experience of EU-12 and East Asia, it can be argued that one of the main predictions of our earlier theorizing holds up rather well. Countries with large differences in factor endowments can be exporters of cars. Our second prediction was that they can simultaneously be importers of cars.

Chart 3 shows the Grubel-Lloyd index for intra-regional trade of North America, East Asia and EU-15. Several features of the chart appear to be striking. First, intra-regional trade involving cars was far more intensive in North America and EU-15 that in East Asia, especially in the beginning of the period under consideration. The gap has substantially narrowed in recent years though. Second, The Gubel-Lloyd index does not show any clear-cut trend for EU-15. However, EU-15 -- EU-12 and EU-12-- EU-12 intra industry trade shows rapid increase as measured by the Grubel-Lloyd index. Third, North American trade has intensified and this can be attributed to the establishment of NAFTA.

Chart 4 shows the Grubel-Lloyd index for extra-regional trade, of North America, EU-15 and East Asia. There has been a decline in North-America – EU-15 trade for most of the period, except for more recent years. East Asia – North America and East Asia – EU-15 trade flows are in decline as well after 1994-95 as measured by the G-L index. Perhaps

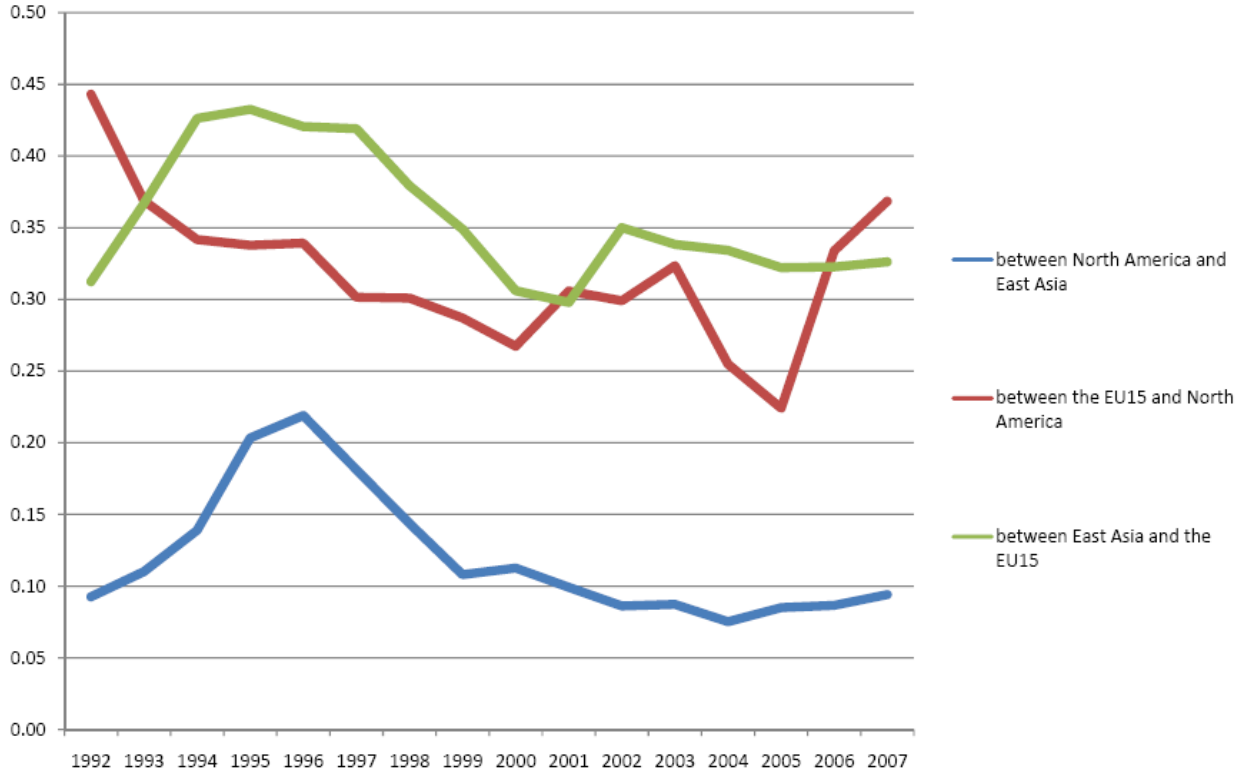
intra-industry investment flows have been replacing intra-industry trade flows for these two pairs of countries.

Chart 3: The Grubel-Lloyd intra-regional index



Notes:
North America includes USA, Canada, and Mexico
East Asia includes 10 ASEAN member states, Japan, South Korea, and China (including Hong Kong SAR, Macao SAR, and Chinese Taipei)
EU-15 refers to the 15 EU member states before the EU enlargement in 2004
Data source: UN COMTRADE database

Chart 4 : The Grubel-Lloyd inter-regional index



Data source : UN COMTRADE database

The final set of charts, 5 and 6, shows support for the thesis that production fragmentation and international outsourcing have greatly intensified in recent years. I shall be rather brief on this point. Beginning with pioneering work of Alexander Yeates (2001) refined and extended by Ng, F. and Yeats (2001), A. Prema-chandra Athukorala, (2006), Prema-chandra Athukorala and Nobuaki Yamashita (.:..), Chen (2008), and Nobuaki Yamashita (2008) there is very solid evidence in support of ever-growing trade in products and components.

One of the main conclusions of the current spade of the empirical research is that "there is clear evidence that fragmentation trade is expanding more rapidly than conventional final-goods trade. The degree of dependence on this new form of international specialisation is proportionately larger in East Asia compared to North America and Europe"[13]

The conclusion is based on total manufactured trade but it holds well for trade in auto parts and components.[14] Charts 5 and 6 testify to very rapid expansion of this type of trade, especially with regard to East Asia. This rapid expansion is also shared by EU-12 hidden again in the category "the rest of the world" One can argue that exports of auto parts and components are a "back-door" way of getting into the markets of advanced countries. Reaching far away markets does not have to limit regional flows, quite to he contrary – it may boost them significantly.

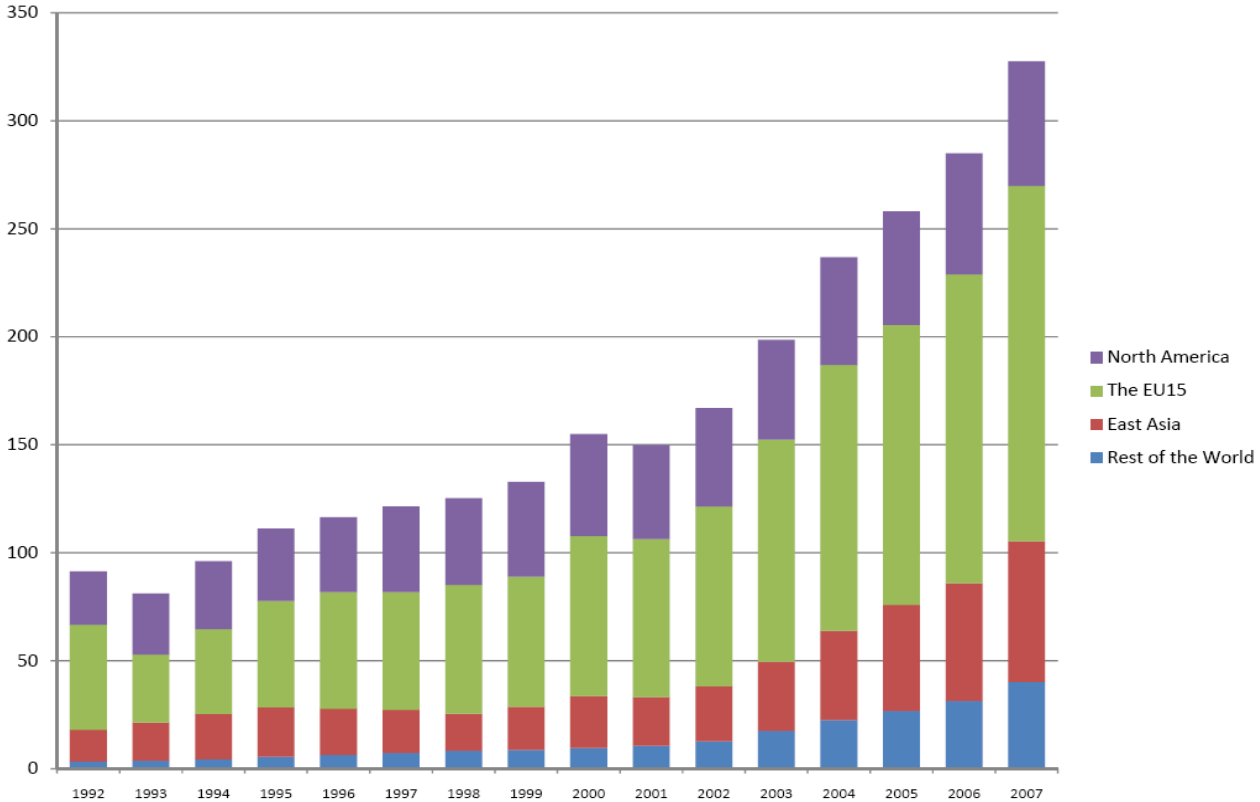
Empirical studies of intra-industry trade in auto parts in components are few and far between. One notable exception is provided by Nuno Carlos Leitão

[13] Quoted from **P**rema-chandra Athukorala and Nobuaki Yamashita, (2007), p. 1.
[14] The charts were provided by Lurong Chen; I also received an alternative set from Nobuaki Yamashita. I wish to thank both of them.

and Horacio C. Faustino, (2009). The authors look at Portugal's trade in this area with the European Union(15 + 12), the United States, and a group of big emerging economies – Brazil, Russia, India and China during the period 1995 – 2006. One of their main results is that the larger is the difference in GDP per capita of Portugal and its trading partners, the larger the auto parts intra-industry trade flows. Extentions of this research to more countries and longer time series would be most welcome, especially because when the authors replace GDP per capita with capital endowment, a negative relationship is observed.

Chart 5 : World trade of motor vehicle parts and components

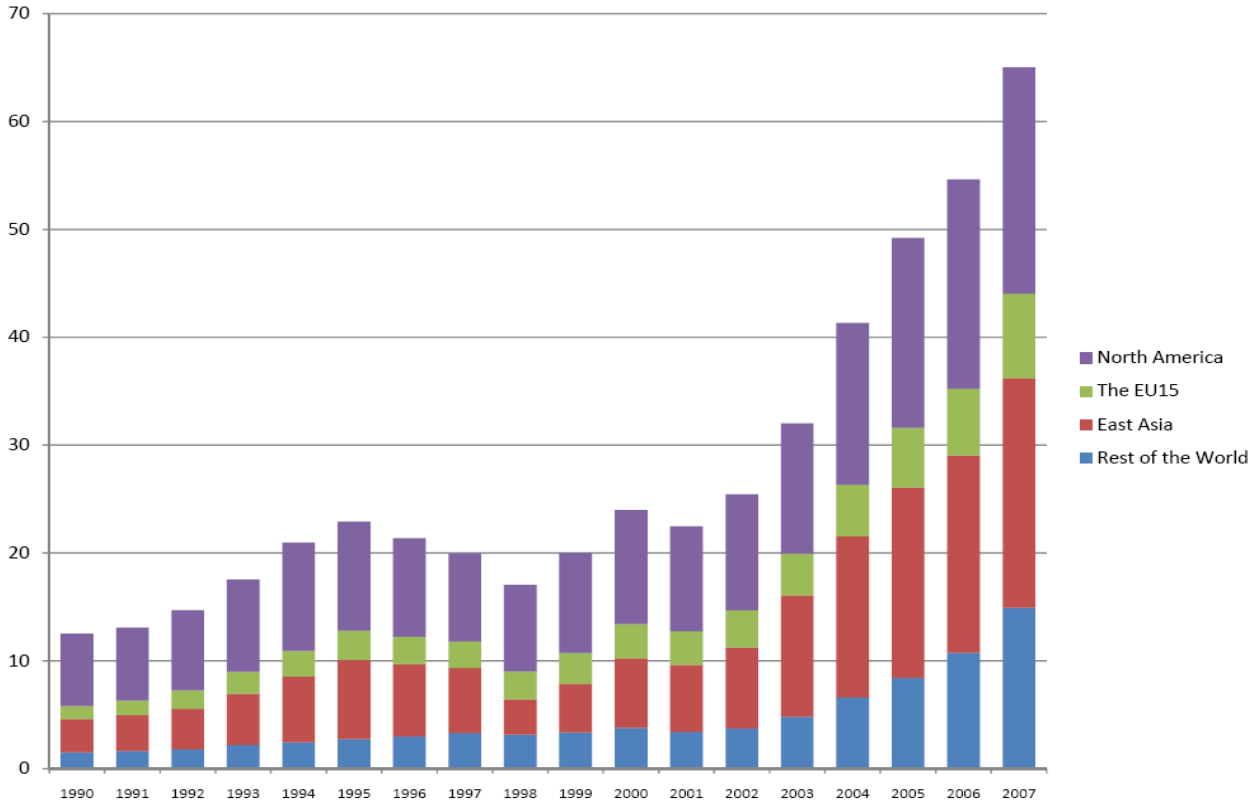
(exports, billion US dollars)



Data source: UN COMTRADE database

Chart 6: Exports of motor vehicle parts and components from East Asia

(exports, billion US dollars)



Data source: UN COMTRADE database

4. A new new global auto industry?

The theoretical models discussed earlier suggested how market forces can lead to the creation of a global auto industry with a multitude of producers and a multitude of products demanded by the consumers. Such a system was created in the second half of the 20th century and is still in existence now.[15] Its equilibrium depends on factor endowments, technology, tastes, and economic policy perused by various countries. Let's zero in on just two key equilibrium drivers.

Economic growth and demand for cars can affect the equilibrium of the industry globally and in individual counrtiers. Growth may stem from different sources – capital accumulation, technological progress, increase in human capital, better functioning of the economy, and a whole host of non-economic factors. Its obvious manifestation are rising incomes and GDP per capita, a key variable affecting the demand for cars and their quality. Of course, even without growth, changes in income distribution can exert impact on the range of cars demanded, quantities and prices, as well as trade flows.

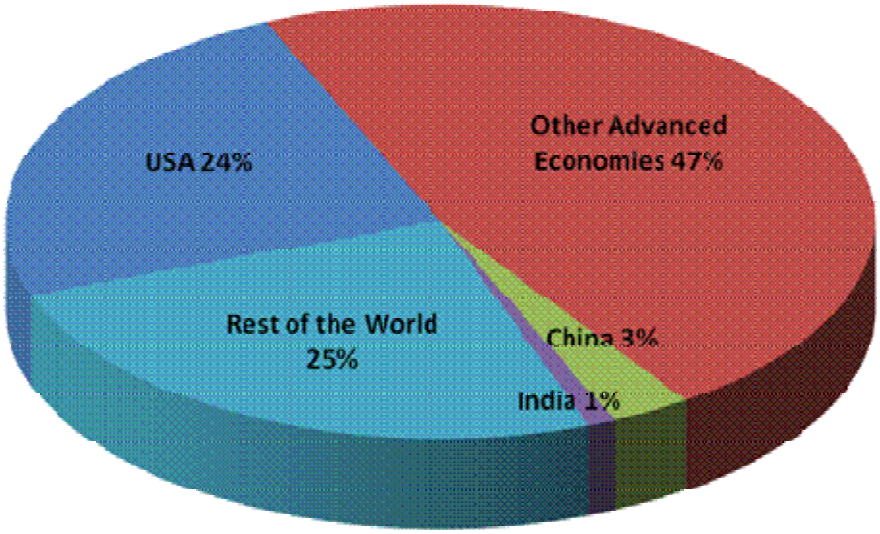
There is increasing evidence suggesting that China and other countries of East Asia will continue to expand their economies rapidly in the decades ahead. It is not always going to be plain sailing, economic turbulence encountered along the way may slow them down somewhat but short-term macro reverses should not significantly diminish the long-term performance. It is worth recalling that East Asia recovered rather quickly from the 1997 crisis and China was affected by it only to a modest degree. The current crises shows again great economic resilience of China, India and other emerging Asian economies.

A recent study by the World Bank analyses the consequences of income growth on mass car ownership in the emerging market giants.[16] It is pointed out

[15] An excellent description of how this came about is presented in James P. Womack, Daniel T. Jones and Daniel Ross (2007/.

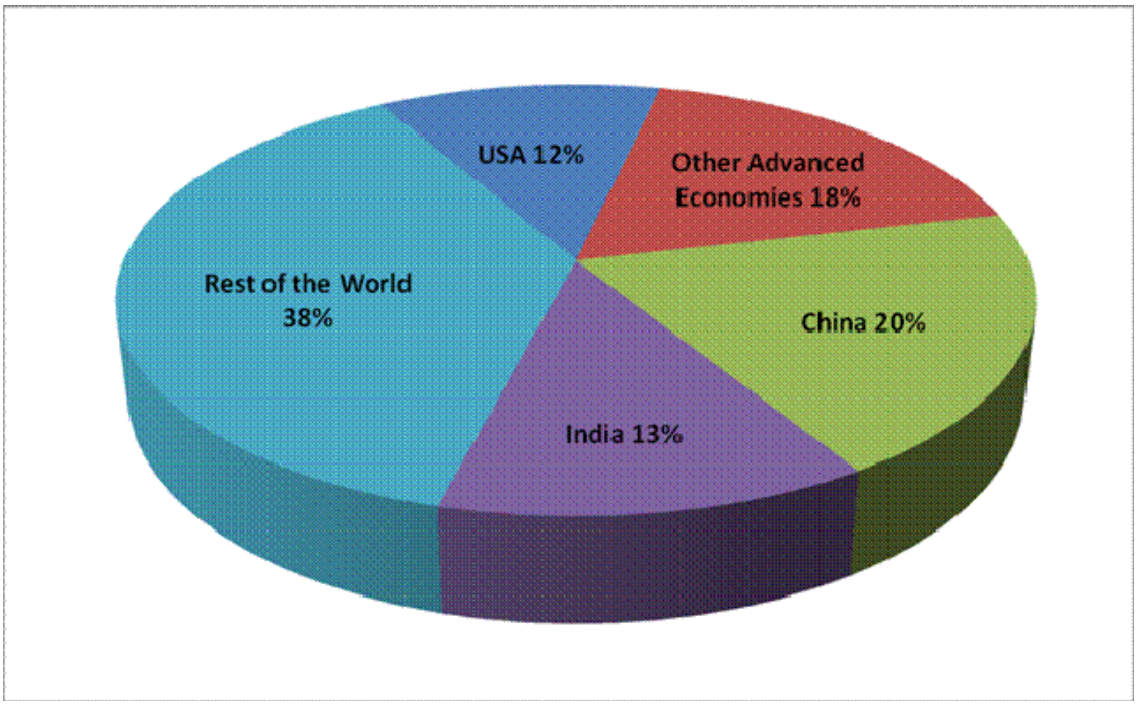
[16] See Chamnon, Marcos., Paolo Mauro and Yohei Okawa, (2009).

Chart 7 : World car fleet in 2005 (664mllion)



Source: See Chamnon, Marcos., Paolo Mauro and Yohei Okawa, (2009).

Chart 8 : Projected world car fleet 2050 (2.9 billion)



that many Chinese families already enjoy having modern home appliances such as washing machines and refrigerators. Many families also have TV and computers. But having a car is still an unfulfilled wish of countless Chinese, only 15.8 per 1,000 population are lucky car owners.[17] An even lower ownership indicator is observed in India – 6.5 cars per 1,000 population. But this is going to change in a big way very soon.

Based on in-depth household surveys, the World Bank researchers, Marcos Chamnon. Paolo Mauro and Yohei Okawa, demonstrate that there is "a remarkably stable relationship between GDP per capita and car ownership, highlighting the importance of within-country income distribution factors: ……..car ownership is low up to per capita incomes of about US$ 5,000 and then takes off very rapidly. Several emerging markets, including India and China, the most populous countries in the world, are currently at the stage of development when such takeoff is expected to take place."[18]

The consequences of economic growth will be stupendous. The number of cars will increase in the world from present 646 million to 2,906 million in 2050. Most of the increase will occur in developing economies. In particular, China with a car fleet of only 21 million in 2005 is projected by the World Bank to have 573 million cars by 2050, roughly the same number as the present stock of cars in the entire world. India is expected to have by mid-century a fleet of 367 million cars, about the size of the today's U.S. stock.

The two pie-charts above show more details regarding the car ownership in the world and its main regions. What is striking is an exact reversal of the 30-70% split of car ownership between developing and advanced economies. By 2050 a car will no longer be a symbol of economic success associated with the

[17] When Spain emerged from the dark age of the Franco period and went democratic only to become a new member of the European Union, it also had car ownership of about 10 per 1,000 population. A decade later that figure increased tenfold. A very similar pattern was observed in Eastern Europe following the collapse of economic planning and communism.

[18] Quoted from See Chamnon, Marcos., Paolo Mauro and Yohei Okawa, (2009), p.1.

North. It will become a proof of the South's success, or at least a large part of it. This is a good news and a bad news for the North, the South and the world.

Our earlier analysis suggests though that for the world as a whole there may be some lowering of the average quality demanded compared with the situation of economic growth occurring mainly in the advanced countries. To be sure, there will be scores of billionaires in China, India and other emerging economies (there are already there) and loads of millionaires demanding Ferraris, Audis etc, but most of car owners will have more modest demands than most of car owners at present in advanced economies. That means that cheaper cars will have to be designed if the auto makers want to capture new markets. They will also have to be more efficient to take into account the relative cost of running them in countries with modest incomes.

The impending demand changes will alone shake up the global auto industry. But there are also big shocks to be expected on the supply side. The car industry will likely go electric thus completing a circle that began more than a century ago.

It is generally not known that the beginning of the automobile industry clearly belonged to the electric car. The end of the XIX and the beginning of the XX century "were the high point of electric cars in America, as they outsold all other types of cars. Electric vehicles had many advantages over their competitors in the early 1900s. They did not have the vibration, smell, and noise associated with gasoline cars.Changing gears on gasoline cars was the most difficult part of driving, while electric vehicles did not require gear changes. While steam-powered cars also had no gear shifting, they suffered from long start-up times of up to 45 minutes on cold mornings. The steam cars had less range before needing water than an electric's range on a single charge. The only good roads of the period were in town, causing most travel to be local commuting, a perfect situation for electric vehicles, since their range was limited. The electric vehicle was the preferred choice of many because it did not

require the manual effort to start, as with the hand crank on gasoline vehicles, and there was no wrestling with a gear shifter."[19]

So why was the era of electric car brought to an end or at least suspended for a century? Four reasons seem to be responsible for this decline: First, the outstanding performance of the U.S. economy and the corresponding increase in the average income. Second, American sense of freedom and independence combined with the vastness of the country created demand for vehicles capable of being driven very long distances. Third, oil discovery in Texas substantially reduced gasoline prices. Last but certainly not least, the system of mass car production introduced by Henry Ford. Some authors also suggest that the invention of the electric starter also helped to kill the electric car as it was no longer necessary to use the hand crank.

Why is the electric car expected to make a comeback? There seem to be two primary reasons: 1) growing concerns with environmental issues manifested at the level of individual citizens, local communities, governments and even the world. This is a very powerful combination of interests, views and ideals. The strength of this wide and informal alliance has only been reinforced by recent oil price increases and economic crises; 2) greatly improved batteries have become available and a battery is the heart of an electric car.

New and highly efficient type of battery were introduced in the late 1980 and early 1990s in response to a new fad spreading through the world – mobile phones. Another rage – laptop computers and later digital cameras – boosted the demand for rechargeable batteries. Initially, the nickel-cadmium battery was often used in electronic devices only to be replaced by the nickel-metal-hybrid battery. Battery continued to find new applications, and ultimately fount its use in hybrid cars such as Prius.

[19] For a well-documented history of electric vehicles see inventors.about.com/library/weekly/aacarselectrica.htm. The quotation comes from this source.

While Toyota used the nickel-metal-hybrid battery in the 1997 Prius, other electric-car pioneers turned to the lithium-ion battery introduced by Sony in 1991. This new type of battery has a high energy density and with continuous improvements seems likely to be the preferred choice of automakers.

Today there between 50 and 100 electric cars in development, under construction or already in production. The precise number is difficult to pin down because some big car makers keep their plans in this sensitive area close to their chest while other producers are remarkably boastful, often in response to public expectations, political winds and possible inflow of public and private financing. In addition to the world-class automakers the field has been entered by very small companies that are, at least at the initial stage, high-technology and high-fashion designing outfits.[20] While most of these innovators will fall by the waysids, perhaps one or two, and that is all it takes, will change the history of the automobile industry.

Most of what is called today electric cars are hybrid vehicles. The only all-electric car on the market at present is Roadster produced by Tesla Motors company located in California.[21] Its production started in 2008 and so far less than 1,000 units were sold in the United States and Europe at the price of, well, US$108,000. But the buyer gets a lot of bang for the buck – the car accelerates from 0 – 100 in 3.7. Roadster is powered by 6,831 lithium-ion cells frequently found in laptops; they are combined in 9 blocks each containing 697 cells. The battery, weighting 450 kg, stores 53 kWh and it requires 31/2 hours for a full recharge.

To complete this technical specification for those readers of this paper who are interested in buying a Roadster, the car has 400 km range and the replacement of the battery cost US$ 36,000. However, given the expected

[20] It is interesting to note how many of these car boutiques have been set up by world-class designers either about to retire or already retired from most prestigious car makers.
[21] The information containing Tesla Motors and Roadster comes fromWikipedia.

progress in lowering battery costs, a forward contract for a battery in 7 years for US$ 7,000 is offered at the time of the initial purchase of the car.

The production of the Roadster follows the fragmentation technology discussed earlier. The motor is produced in a Tesla plant in Taiwan, chassis come from Norway, brakes and airbags are made in Germany, and the battery, initially made in Thailand, is now manufactured in California. All the car parts and components are put together at a Lotus factory in England.

It is obvious that Tesla's Roadster is not going to sell in big numbers but it would be a mistake to treat the car as a very expensive toy for very few very rich people with environmentally inclined mind or consciousness. The producer is a path breaker.[22] After all, we no longer dismiss possible applications of the Formula 1 technology or even space programs for more or less sophisticated products used in our daily lives.

As indicated earlier, all-electric cars are not what most of the auto producers are thinking of today. The are much more inclined to bet their money on hybrid cars at least in the near future. There are basically two types of hybrid electric cars: 1) the car has both a petrol engine and an electric motor and both are used to move the car along; 2) the car is only powered by a battery and electric motor does all the pushing. However, a petrol engine is installed to generate additional electricity when required.

Toyota Prius is an example of the former hybrid car and Chevrolet Volt of the latter. The Volt will be launched in 2010 and a battery power alone will keep it going for 40 miles before a generator kicks in. Volt will cost "only" US$40,000 with the user paying US$ 32,500 and the rest coming in as the Federal Tax Credit. The battery installed in the car weights 170 kg and consists

[22] He is Elon Musk, a co-founder of PayPal who also founded SpaceX, a space transport company that will be using his own reusable launch vehicles. The company recently won a US$ 1.6 billion contract from NASA.

of 220 lithium-ion cells storing 16 kWh of energy.[23] The US$ 8,000 battery is produced by LG in South Korea.

If we drove not more than 50 km a day, which actually is the case for 80-90% of the car owners in the world, and only occasionally had to cover a longer distance a battery-based car, rechargeable at night in our garage, supplemented by a range-extender would be an ideal solution. The battery would be light and relatively inexpensive.

And yet, it seems to me, the future belongs to a pure-electric car. Basically, one does not need suspenders and a belt to keep one's pants up. The incredibly high price of these cars today will dramatically come down in the years ahead because the battery cost and weight will decline. The batteries and the cars will be produced not by the hundreds but by the millions. So today's prices are not really of great relevance. Remember how much an IBM office computer cost weighted in the 1960s or 1970s and compare it to the computer sitting on your desk now.

Even at this early stage of the paradigm shift the superiority of the electric car over cars with internal-combustion engines appears quite evident. Consider first the running costs. Assume that it takes 8 l. of petrol to drive a traditional car 100 km and that 12 kWh will do the same job in an all-electric car. (The latter assumption is pushing the envelope a little.) A comparison of relative driving costs can be readily calculated for a number of countries. This is done in the table below. In addition, I calculated the cost arbitrage index showing the relative costs and saving opportunities that the new technology offers.

[23] The first electric car produced by General Motors between 1996-1999 was called EV1 and it was powered by a Panasonic lead-acid battery storing 18.7 kWh and weighting 530 kg.

Table 1. Petrol versus electricity: cost of driving 100 km in 2008

Country	Petrol car US$	Electric Car US$	Cost arbitrage index
United States	4.48	1.11	4.0
United Kingdom	11.52	1.34	8.6
Germany	12.5	1.58	7.9
France	12.16	1.02	11.9
Australia	5.92	0.85	7.0
China	6.37	0.79	8.1
India	8.72	0.65	13.4

Source: Data on electricity prices come from "**Key World Energy Statistics 2008"**, International Energy Agency, Paris, www.iea.org; fuel prices are super gasoline and Diesel retail prices as of mid-November 2008 reported on the GTZwebpage www.qtzde/fuelprices.

The lowest arbitrage index is, not surprisingly, in the United States. In other countries it is at least twice that high. For a price of one trip in a petrol car from Sydney to Melbourne you can make six trips in an electric car.

The numbers of Table 1 can be supported by real-life tests. Kele Baker and David MacKay report the performance of an electric car, the G-Wiz, run in London under varying driving conditions and the weather.[24] They established that "In money terms, the electricity cost of the G-Wiz is 2.1 pence per km (assuming 10 p per kWh)."

Another real-life test of running an electric car, the four-seat Stella produced by Subaru, was conducted at Melbourne International Motor Show in February 2009. Operating cost per 100 km amounted to AU$ 0.93 when the car was charged at off-peak rate and AU$ 1.88 when peak rates were applied.[25]

In general, electric motors are superior to internal combustion engines because they convert electricity to traction in a very efficient manner. Generally 90% of the electric power will be transformed into horsepower. In the case of

[24] This experiment is presented on http://withouthotair.blogspot.com/2008/07/performance-data-for-gwiz-in-london.html

[25] See http://www.ausmotive.com/2009/03/01/mims-2009-subaru.html

the conversion ratio does not exceed 35%, most of the energy generated by the combustion engine dissipates as heat. [26]

Electric car offers additional advantages – it generates no pollution though electricity production is not pollution free; it is silent, and its acceleration is astounding. There is no need for the gearbox and the engine block also disappears. As the electric motor can be placed inside the wheels, the geometry of the car will also change.[27] One can think of designs that will give a greater protection to the driver and passengers. The car makers have their work cut out for them.

The battery technology is constantly improving. New battery breakthroughs are reported almost every month. For instance, two MIT researchers, B. Kang and G. Ceder**,** report in the April 2009 issue of ***Nature*** that they succeeded in transforming the surface structure of lithium ion phosphate in such a way that the new material could conduct electricity extremely rapidly and would be very durable. If these initial reports turn out to be correct a battery in the cellphone could be recharged in about 10 seconds and the battery of an electric car could be fully recharged in 5 minutes which would signify a 100-fold boost in performance. The new generation of batteries could become available within two to three years. With that the biggest limitation of electric cars – long time required to recharge the batteries – would disappear.

Interestingly enough, researchers at the Chinese Academy of Sciences reported in August 2009 a new cathode material for high-power, high-energy lithium-ion batteries with greatly increased performance.

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26 The Economist commented in the September 3rd, 2009 issue: "The efficiency of internal-combustion engines is improving….. But propelling modern transport by means of serial explosions in an array of tin-cans does seem an incredibly primitive way of doing things. The time is ripe for a change."

27 Michelin, the giant tire producer, has developed the-so called active wheel system and intends to install it in a relatively low price electric car in 2010. It will have electric motors inside front wheels; an alternative version will house electric motors within all four wheels.

While a new generation of lithium-ion batteries is the main contender to power the green car of the future, there are some alternative technological solutions under intensive development. The most promising appear to be ultracapacitors – energy storage devices which can be charged and discharged extremely fast without being worn out.[28] With little physical degradation, a car powered by this device will accelerate just as fast after ten years of driving as on the day it was bought. Ultracapacitors contain no chemical substances to store energy, However, their storage time is relatively short.

It is hard to say whether the basic limitation of ultracapacitors could be overcome soon but even now they can have substantial impact on the industrial and public transportation system. For instance, city buses required to make frequent stops could be recharged as passengers alight to use the term heard by tourists going to Heathrow on the London underground.[29]

The application of the battery is much wider than the passenger car and buses. Other candidates include – bicycles, scooters, motorcycles, tractors, trailers, garbage trucks, pickup trucks, electric trains, and even locomotives. And one should not forget milk floats already popular in some countries.[30]

Convergence of technology between sectors using similar production blocs can further expand battery use, increase R&D and speed up technological progress in this field. Some rough numbers will suffice to suggest possible scale of scope economies: In 2007 there were 54 million cars produced in the world, global sales of mobile phones reached 1,15 billion units , world-wide shipments

[28] The ability of a storage device to be charged and recharged rapidly in very intensive bursts could be of great value in storing wind or solar energy and providing back-up to national or transnational electricity grids.

[29] Numexia, a Swiss company located near Lausanne, works on a prototype of an electric-power urban logisctics vehicle. Energy transfer would be contact-free based on electromagnetic induction, just like your electric toothbrush. Radio-controlled automated vehicles used at container terminals are also considered by Numexia as a possible beneficiary of this technology. Other applications include city taxis and buses. In both cases relatively short driving distances are combined with frequent stops at precise locations.

[30] The reader may be interested to know that milk floats run in England on electric batteries for a good part of the XX century.

of personal computers numbered 271,1 million units, and 131,4 million of digital cameras were produced.[31]

Can the process of transition to the electric car be accelerated and is there a room for policy measures? What role can emerging East Asia giants play in this process?

4. Policy issues and proposals

There is a multitude of policy issues related to the expected paradigm shift in the auto industry. Given the focus of the conference for which this paper is prepared, I will be very selective in my choice of matters to be discussed and rather forceful in expressing my own views.

Right off the bat, it seems to me that China and possibly India have an opportunity of becoming leaders in the new new global auto industry. As reported by the Motor Authority on March 30, 2009, China is expected to become the world's larger auto producer already this year with the projected output of 8.7 million vehicles, most of it destined for the domestic market.

However, being a leader means more than producing, exporting or importing a large number of cars. It means setting the pace and direction in which the global auto industry develops.

With the projected car fleet of 573 million by 2050 in China and 367 million cars in India, the two countries need to throw their weight behind the "green" car. The time to act is now. The most urgent task is to speed up improvements of batteries – efficiency, safety, durability, weight and recharging time – and bring about their truly massive use not only in cars, but buses, trucks and other means of transportation.

Given our discussion of convergence of common production blocks between industries, the promotion of the new energy devices should be far and wide. This is the way to capture scale and scope economies.

[31] The list could be further extended. Think of cordless power tools used in the garden, vacuum cleaners using rechargeable batteries and boats that run on electric power.

Battery standardization would speed up the changeover. The basic battery units is at present and should remain in the future relatively small and easily expandable to much bigger blocks (remember, Roadster combines 6,831 cells). A peasant driving an electric bicycle, motorcycle or tractor in the countryside would have the same chance to profit from the new technology as a city dweller driving to work, or a wealthy individual enjoying his speed boat.

Standardization should be preferably achieved through an international agreement but having lived in Geneva for 32 years I am less than enthusiastic about this solution. Alternatively, the market should be allowed to solve this problem through merciless competition among innovators. Alas, the market does not always pick up the best technology, and the uncertainty about the outcome slows down the progress.[32] An alternative way would involve China's unilateral declaration of a new standard. Markets would have to realize that the government action is credible, or they would ignore it.

The way to make the markets listen is to declare the willingness to buy, preferably through public auctions, huge numbers of standardized new batteries. That commitment would be executable in a few years, say in 2015 to give innovators time to double and double again their efforts. It can be expected that a lot of R&D efforts would indeed be stimulated across the world if a non-discriminatory treatment of the innovators could be assured. In order to increase further the effect of its initiative, the authorities would also make a commitment to repeated public auction, say in 2016, 2017, 2018, 2019 and 2020. Lastly, the government would clearly state the quantities it was going to purchase in terms of a basic units. (for instance, the basic unit could be a battery capable of driving a medium-sized family over at least 80 km using not more than 10 kWh per 100 km.)

[32] Imagine one battery would be twice as big as an alternative, be installed in the trunk rather than underneath the car and relay on a completely different recharging technology. Buying a car with either battery would lock in the consumer for 7-10 years.

Make an arbitrary assumption that the auction would involve 10 million battery units per year. (I know this number is incredibly large, that's what I want.) With the current battery cost of, say, US$ 5,000 - 10,000, the government would be putting US$ 50 - 100 billion into the pockets of battery producers for five successive years. This is not the end of the story, given the relative share of the battery in the unit car cost, the multiplier effect would be of the order of US$100-300 billion per year. This kind of number would certainly catch the attention of battery and car producers alike. And if the battery costs would decline, all the better.

Further positive effects could be achieved if China and India acted jointly. The two countries are in the same boat on this matter, if not in the same car. If the government of India made a similar commitment for, say 5 million battery units annually during the 20015 – 2020 period, there would be little doubt who are the leaders shaping the future of the global auto industry. Well defined standards and flexible technology should allow the two countries to transform the forward purchases into their preferred national combinations of cars, motorcycles, city buses, tractors, etc.

If China and India were to act in a strategic alliance in setting global battery standards, there would be an additional reason for an added flexibility in defining the basic unit. India and China are already a major force in the market for motorcycles, in terms of production and in terms of domestic use. The world stock of motorcycles is over 300 million, 80% of it in Asia and 50% of the total in India and China alone. They could force the motorcycle industry to start to converging to batteries rather easily by 2015. No special infrastructure and a network of recharging/swapping batteries stations would be required as a home-based system would emerge spontaneously. Environmental effects in terms of pollution and noise would be soon noticeable. Other populous countries of the region, such as Indonesia, could follow the path as well. And that's what leadership of an industry really means.

One can make a number of objections in connection with the above proposal. Even if the scheme is acceptable, should it star in 2015? If the policy makers waited longer there would be even better technology. Perhaps better technology would come about without encouragement from policy makers. There will always be a better technology later. But that does not prevent you or me from buying a new laptop even though we know there will be a better model next year. As Yogi Berra famously said:" If there is a fork in the road, take it." Fortunately, we know what the right decision is in this case.

One could wonder whether this kind of support should not: 1) be limited to domestic firms, 2) cover only auto-makers and 3) be provided up front as a R&D subsidy. The answer is three times NO. New innovations can come from anywhere; a great battery could be invented in China, India but also in Finland or Argentina. Limiting domestic consumers to domestic technology, apart from the question of fairness of the proposed auctions and their legality under international rules and obligations, could not make them better off, they might only lose.

It is also important to prevent automakers from monopolizing the auctions. This would happen if the government committed itself to buying green cars with batteries embodied in them, rather than batteries alone. This action would half and possibly half again the real purchasing power of the scheme. More importantly, auto-makers have no natural advantage in inventing new batteries. Established big car producers, especially in the United States, have reasons to slow down the process. In fact, they are not a solution to the problem; they are a big part of the problem.

Compensating winners at the finish line rather than subsidising possible innovators at the start of a technological race would save a great deal of money

and prevent excessive lobbying at the cost of making real R&D efforts.[33] I certainly would not favour a policy of "picking winners" by the government which tend to pick up well-connected losers.

The programme being outlined here advances an idea of fragmentation of sales. Earlier, I discussed the concept of fragmentation of production developed jointly with Ronald W. Jones and benefits stemming from it. The corresponding concept of fragmentation of sales introduces flexibility and a potential for gains on the purchasing side. A consumer does not have to buy a car produced by X with a battery produced by X. He can buy a car from X and a battery from Y as long as a basic compatibility and standards are guaranteed.[34] Perhaps the consumer does not have to buy a battery at all! Let me explain.

Once the government of China buys 10 million standardized batteries in 2015, and then again another 10 million a year later, and then again, and again….the question what to do with these purchases can be legitimately asked. The question should be raised even before 2015. The government certainly

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[33] Unfortunately, governments are generously spending public money on firms they consider possible winners. Helen Hughes and Olivier Marc Hartich give an excellent example ": This week the US government announced its support for little-known car manufacturer Fisker. The company will receive more than half a billion US dollars in subsidised loans to build a hybrid sports car.
Never mind that at a retail price of US$89,000 the car will be out of reach of most consumers. Ignore the fact that sports cars are not really green cars. And forget that Fisker does not have much experience in building cars anyway.
What matters more than a viable business plan in these days of reborn socialism are your political connections. Or was it just a strange coincidence that one of Fisker's top investors is former US Vice President Al Gore? It doesn't hurt that his quest to save the world from climate change is incidentally helping fill his coffers with taxpayer cash.
The socialism of times past we have buried, but its flawed ideas are still haunting us from its grave." Quoted from "**Car socialism alive and well**", www.cis.org.au.
I am in agreement with the main argument, especially because Fisker produces a car driven by petrol engine/electric motors which is a lose-lose technology. This is exactly what happens when the government unwisely opens its purse to private firms. However, it does not mean that all interventions are socially undesirable, and they all represent a return to socialism.

[34] Here is a another example of fragmentation of sales: Buying a car usually implies a long-term commitment to purchasing spare parts. If alternative suppliers of standardized and quality-certified suppliers of parts were allowed to operate, the customer may wish to buy a car from one producer and future maintenance services from somebody else. The attitude of the existing car makers creates an obstacle to implementation of such schemes. Unfortunately, insurance firms do not help either, when they use an excuse of non-original-part-supplier to walk away from obligations. This attitude can be seen more in the case of car accidents rather than a regular maintenance service.

should not become an auto maker. It does not have to. If the announcement of future auction led to the expected reaction, the principle purpose of the intervention would be achieved. Under this circumstance, the government should sell what it just bought to whoever is willing to repurchase the batteries.[35] This may well include auto makers. But new actors may well appear on he stage.

Imagine that a company called Schnell has recently been created; its mission is to make a lot of profits by buying batteries, renting them to owners of electric cars, and building a network of stations where batteries could be recharged in a relatively short time or extremely quickly replaced by already recharged ones. Schnell raised so much capital that it can easily persuade a number of auto makers fighting for the market in China to design their cars accordingly. It can even ask for cars that would have an extra battery space for drivers making long trips or those who suffer from the "range syndrome". Other firms or individual may have other ideas how to use the readily available stock of available batteries. The existing petrol station and big companies behind them may decide to convert their businesses using the existing infrastructure.

One would expect that the price of an average car without a battery would be significantly lower than an average price of a petrol-engine car sold today. In fact, a car without an engine block and a gear box should be a lot less expensive. The consumer would pay for the whole product as he recharges or swaps batteries at electricity stations that Schnell would have to set up. Some people may buy a car with a battery included and recharge them in their own garage. All possible arrangements should be best left to the market to sort out.

Can we expect a ccompany like Schnell to emerge?[36] I judge the probability of this event happening rather high. After all, companies such as the

[35] Keeping in mind the principal purpose of the intervention – creation of a new technology – the government should not be tempted to corner the market and make money- This should a zero-budget-implications policy.
[36] Such companies have already been set up for instance **Better Place** in California which proposes to separate the ownership of cars and batteries. The company intends to establish a network of battery-swapping stations in Israel and Denmark to test the soundness of the basic idea.

giant British-Dutch Shell came to existence. In fact, Schnell would be buying from the Chinese government an equivalent of drilling rights for oil off-shore with a guaranty of a success plus a licence to set up a network of petrol stations.

The balance in favour of the all-electric car could be further tipped by a commitment to impose appropriately high taxes on petrol cars bought in 2015 and afterwards. In this manner the relative price of electric cars would be reduced. Parking rights in city centres could be restricted to pure-electric cars only. Taxes on combustion-engine cars entering high pollution zones could be envisaged as well. The list could be longer, but, in principle, market-oriented measures would be preferable.

Admittedly, the scheme presented here does not strike one as being excessively modest. But the auto-industry is a big industry facing big problems. And there is still a larger picture to consider, especially the environmental impact of a new new global auto industry. I shall do it only briefly.

The all-electric car creates no pollution so positive effects will be felt in big cities already facing severe environmental problems. Alas, electricity creation will be generating pollution somewhere else, hopefully in locations with low population density. Will there be any net gain at all, or will benefits in one site be exactly offset by losses in another place? Much depends on the technology used in electricity generation. It turns out, however, that even present coal-based electricity will give an overall positive effect.

Economist have to listen to what scientists tell them on this matter and one of the greatest authorities issues a clear verdict: “Assume the electric vehicle’s energy cost is 20 kWh(e) per 100 km. (I think 15 kWh(e) per 100 km is perfectly possible, but let’s play sceptical in this calculation.) If grid electricity has a carbon footprint of 500 g per kWh(e) then the effective emissions of this vehicle are 100 gCO2 per km, which is as good as the best fossil cars …. So I conclude that switching to electric cars is already a good

idea, even before we green our electricity supply."[37]

The policy towards electric cars should be embedded in a much larger framework of national energy and environments policies in countries such as China and India. National interests and concerns over own citizens' health should be the main motivator. Of course, attention should be paid to international considerations as well. However, it serves no purpose to use international pressure and trade threats to bring about "right" energy and environmental policies.[38]

But how serious is the environmental threat that China poses to the entire world? The general public perception is that there is a cataclysm in the making. This general attitude was reinforced by TV films and commentary from Beijing prior to the opening of the Olympic Games there. But we need facts and not perceptions. I can do no better than to turn to an author in the know and quote him at some length:

"We conclude that China's urban air quality, although low by current international standards, seems quite typical of circumstances in fast-growing economies during peak periods of industrialization. China's urban air quality has improved substantially during the past quarter-century. This improving trend begun at an earlier stage of the development process than in Japan or Korea. The cost of further improvements in air quality seems well within the reach of China's economy …….. China's recent ban on leaded gasoline and promulgation of auto emission standards beyond those currently in force in the United States indicate that the Beijing authorities are both aware of the problems

[37] Quoted from David JC MacKay, (2009)

[38] This is why I find puzzling Paul Krugman remark made in the New York Times on May 14, 2009: "As the United States and other advanced countries finally move to confront climate change, they will also be morally empowered to confront those nations that refuse to act. Sooner than most people think, countries that refuse to limit their greenhouse gas emissions will face sanctions, probably in the form of taxes on their exports. They will complain bitterly that this is protectionism, but so what? Globalization doesn't do much good if the globe itself becomes unlivable. It's time to save the planet. And like it or not, China will to do its part"

posed by the spread of car ownership and are prepared to take remedial action. In China, as elsewhere, we cannot yet predict the environmental consequences of humanity's love affair with the automobile."[39]

There seems to be some exaggeration in general assessment of China's environmental record. However, because we cannot fully predict the impact of people's love for car, the policy makers would be wise to act decisively now to meet the worst-case-scenario. I have already said *ad nauseam* that with about 2billion cars on the roads of developing countries alone, about three times the present world's stock, the magnitude of the problem is far greater than when a single country, such as Japan or South Korea, industrialized and made the car affordable to their peoples.

Introducing the electric car on a massive scale according to a well defined and binding schedule, could be China and India's contribution to reducing global greenhouse gas emissions. In return, the advanced countries could contribute mightily in terms of capital, technology and management skills to greening of the coal mining industry in both countries. (Or in other developing countries willing to introduce the elctric car.) The initial production should be targeted for the domestic market in China and India. But as the two courtiers develop comparative advantage in the new new auto industry, they should expand their car exports without any impediments. This might me a better strategy for the forthcoming Copenhagen conference on climate than imposing emission limits on countries without taking into consideration their present population, expected demographic trends, historical role in creating the global pollution problem as well as expected economic growth in decades ahead. Of course, greening of the auto industry for greening of the coal-based electricity should not prevent introduction of other programmes.

[39] Quoted from Thomas G. Rawski, (2006), p. 10.

References

Prema-chandra Athukorala , (2005) **"Product Fragmentation and Trade Patterns in East Asia"** Asian Economic Papers, fall, Vol. 4, No 3, pp. 1-27

Prema-chandra Athukorala and Nobuaki Yamashita, (2006), **"Production fragmentation and trade integration: East Asia in a global context"**, North American Journal of Economics and FinanceVolume 17, Issue 3, December 2006, Pages 233-256

Prema-chandra Athukorala and Nobuaki Yamashita, (2007), **"Production Fagmentation in Manufacturing Trade: The Role of East Asia in Cross-border Production Networks"**,Working Papers Serries, Nihon University, CCAS, No. 003.

Prema-chandra Athukorala, (2009) , **„The Rise of China and East Asian Export Performance: Is the Crowding-Out Fear Warranted?"** World Economy, February.

Bureau of Industry Economics, (1988), **"The Impact of Microelectronics on Scale and Competitivness in Australian Manufacturing"**, Australian Government Publishing Service, Canberra.

Lurong Chen, (2008), **"Production Sharing and Economic Integration" ,** Ph.D. thesis, Graduate Institute of International Studies, Geneva.

Leonard Cheng and Henryk Kierzkowski, eds., (2001), **Globalization of Trade and Production in South-East Asia**, Kluwer Academic Press, New York.

Falvey Rodney and Henryk Kierzkowski (1987), "**Product Quality, Intra-Industry Trade and (Im)perfect Competition"**, in Henryk Kierzkowski, ed., Protection and Competition in International Trade: Essays in Honor of W.M. Corden, Editor and co-author, Basil Blackwell, Oxford,

Ministère de l'Économie**, (2009), "Groupe de Travail sur les Infrastructures de recharge pour les véhicules électriques ou hybrides rechargeables", 1er octobre, Paris.**

Chamon, Marcos., Paolo Mauro and Yohei Okawa, (2009), **"Cars. The Implications of Mass Car Ownership in the Emerging Marker Giants",** unpublished manuscript, World Bank, Washington, D.C.

Manuchehr Irandoust, (1999), **"Market Structure and Market Share in the Car Industry"**, Japan and the World Economy, 11, pp. 531-544.

Ronald Jones and Henryk Kierzkowski, (2001), **"A Framework for Fragmentation"** in S. Arndt and H. Kierzkowski (2001).

Ronald Jones and Henryk Kierzkowski, (2001), **"Horizontal Aspects of Vertical Fragmentation"** in L. Cheng and H. Kierzkowski (2001).

Ronald Jones and Henryk Kierzkowski, (1990), **"The Role of Services in Production and International Trade: A Theoretical Framework**", in R..Jones and A. Krueger, **The**

Political Economy of International Trade: Festschrift in Honor of Robert Baldwin, Basil Blackwell, Oxford.

Fukunari Kimura, (2001), **"Fragmentation, Internalization, And Interfirm Linkages Evidence from Micro data of Japanese Manufacturing Firms"** in Leonard Cheng and Henryk Kierzkowski, eds., **Globalization of Trade and Production in South-East Asia**, Kluwer Academic Press, New York.

Fukunari Kimura and Mitsuyo Ando, (2005), "**Two-dimensional Fragmentation in East Asia: Conceptual Framework and Empirics."** International Review of Economics and Finance (special issue on "Outsourcing and Fragmentation: Blessing or Threat" edited by Henryk Kierzkowski) Vol. 14, Issue 3, pp. 317-348 .

Nuno Carlos Leitão and Horacio C. Faustino, (2009),"**Intra-Industry Trade in the Automobil Components Industry: An Empirical Analysis",** Journal of Global Business and Technology - Vol. 5 No 1, April.

David JC MacKay, (2009), **"Sustainable Energy — without the hot air**", UIT, Cambridge, England.

Francis Ng, and Alexander Yeats, (2001**)."Production Sharing in East Asia: Who does what for whom, and why?"** In L. K. Cheng & H. Kierzkowski (Eds.), *Global production and trade in East Asia* (pp. 63-109). Boston: Kluwer Academic Publishers.

Thomas G. Rawski, (2006), **"Urban Air Quality in China: Historical and Comparative Perspectives"**, unpublished manuscript, University of Pittsburgh.

James P. Womack, Daniel T. Jones and Daniel Ross (2007), **"The Machine that Changed the World"**, Simon & Schuster, London.

Nobuaki Yamashita, (2008) **"International Fragmentation of Production, Trade Pattern and the Labour Market Adjustment in Japanese Manufacturing",** Ph.D. thesis, Austalian Natonal University, Canberra.

Alexander Yeats, (2001), ***"Just how big is* global production sharing?"** , Sven Arndt and Henryk Kierzkowski, eds., (2001*),* **Fragmentation: New Production and Trade Patterns in the World Economy**, Oxford, Oxford University Press.