

# Chinese innovation and competition: an industry case of the global telecommunications equipment industry

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**To cite this article:**

Hans W. Gottinger. Chinese Innovation and Competition: An Industry Case of the Global Telecommunications Equipment Industry. *International Business and Economics Research*. Vol. 2, No. 2, 2013, pp. 22-32. doi: 10.11648/j.ijber.20130202.12

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**Abstract:** In this paper we trace the industry development of Chinese suppliers and competitors in the telecommunications industry. The observation period goes from the mid 1980s to about today. In the first stage we observe that Chinese startups targeted the basic need for infrastructural development in telecommunications in Western and rural China in supplying low cost telecommunications gear to those areas which were less lucrative for foreign vendors and joint ventures and were heavily encouraged by the Chinese national government in a sort of nurturing its own infant industry. This kind of asymmetric competition separated the startups from the established players in the Chinese market. We call it the separation stage. In the course of this stage the initiating 'three horsemen' underwent technological learning either through indigenous innovation or imitation of some sort, therefore gaining competitive strength and competing against foreigners on large scale projects in the Chinese market. This led to the convergence stage. When asymmetric competition turns symmetric we observe competitive convergence, in which each technology's development is directed at expanding its appeal not only in its own home market but in its rival's as well. While the Chinese companies with the implicit support of the Chinese government continued to gain market share against foreign competitors and as their technological learning advanced product quality at lower cost they expanded in actively seeking to bid successfully for telecommunications projects in developing and emerging economies where they gained further strength by competing on given product quality and lower prices. This is the globalization stage.

**Keywords:** Business History, Strategy, Technology (Innovation) Management, Industry Development, Globalization

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## 1. Introduction

We examine the three largest Chinese suppliers of telecom equipment (TE): Huawei Technologies (Huawei), Zhonxing Telecommunication Equipment (ZTE) and Datang Telecom Technology (DTT) in that order of size, growth and market positioning, ranked in that order over a period of about 25 years. The tale shows how these three Chinese suppliers competed against the two largest TE manufacturers that had foreign joint venture partners Shanghai Bell, an Alcatel joint venture, and Beijing International Switching System (BISC), a Siemens joint venture, and further how they competed globally against well established suppliers of TE such as Alcatel-Lucent, Cisco, Ericsson, Fujitsu, NEC, Nokia, Siemens, and more recently, Nokia-Siemens Networks.

First, the fast growth in the period after 1985 of two suppliers, Huawei and ZTE, requires appropriate attention. Their success threatens well established incumbents' plans to dominate the global and China markets for TE. ZTE started operations in 1985, and Huawei in 1988. In slightly

over ten years, Huawei became the number one supplier of TE in China. In 1998, Huawei's annual revenues exceeded those of the top two TE suppliers that had foreign joint venture partners: Shanghai Bell and BISC, and since then had the gap growing. Still, in the mid eighties, the possibility that any of the three Chinese suppliers could pose a serious threat to established global suppliers seemed very improbable. Today, Chinese suppliers compete aggressively against these well established global suppliers and their joint ventures in China. They have expanded their product portfolios to the global smartphone and tablet market and in Q 4 of 2011 Huawei and ZTE were Number 3 and 6, respectively, in a massively dynamic Chinese smartphone market (Wall Street Journal (WSJ), March 8, 2012).

For the record, reputable market share tracking firms such as Gartner, Forrester and Strategy Analytics (WSJ, 2004) ranked Huawei the Number One supplier in the global market for new extended switching equipment in 2003, the Number One supplier in the global market for new generation networks in 2004, the Number Two supplier in the global market for digital subscriber line (DSL) access

multiplexers in 2003, the Number Three supplier in the global market for long distance wavelength division multiplexers, and the Number Four supplier in the global market for optical transmission (Economist, Sept. 22, 2009). ZTE's development overall was relatively more modest (Economist, Oct.14, 2008).

Huawei and ZTE have been ranked the Number Three and Eight suppliers in the global market for integrated access networks. In the top 100 list of Chinese Electronics Firms in 2011 Huawei was listed Number One and ZTE among the top Ten. As the Wall Street Journal reported repeatedly in 2003 to 2005 (WSJ, 2005) executives of North American and European vendors of TE have become increasingly concerned about the head-to-head competition from Chinese suppliers. In a US congressional report, Huawei, in particular, has been singled out as the dark horse in the Chinese telecom industry (WSJ, Oct. 9, 2012; Economist, Aug. 2, 2012).

(Very recently, because of alleged security concerns, Huawei has been barred from bidding on public infrastructural projects in Australia and from company acquisition in the US).

From a specific technological perspective the overall success of this industry has been analyzed by Fan (2006) and Li(2006), from a business history evolution in a broader context of Chinese industry development we like to mention K. Lee et al. (2009) and Li Sun (2009). Our emphasis here is on a novel strategic assessment in view of dynamic technology competition and innovation racing (Scherer, 1992; Gottinger, 2006)

In view of development of dynamic competition we trace empirically the various stages of competitive strength in this strategic industry.

In the first stage we observe that the three startups targeted the basic need for infrastructural development in telecommunications in Western and rural China in supplying low cost telecommunications gear to those areas which required less sophisticated equipment and were less lucrative for foreign vendors and joint ventures. In reducing regional disparity, entry in those markets were heavily encouraged by the Chinese national government also in nurturing and protecting an emerging hightech industry. This kind of asymmetric competition separated the startups from the established players in the Chinese market, call it the separation stage.

In the course of this stage those Chinese firms underwent technological learning either through imitation and indigenous innovation through R&D, therefore gaining competitive strength and increasingly competing against foreigners on large scale projects in the entire Chinese market. This is termed the convergence stage. When asymmetric competition turns symmetric we observe competitive convergence, in which each technology's development is directed at expanding its appeal not only in its own home market but in its rival's turf as well.

While the Chinese companies with the tacit support of the Chinese government continued to gain market share against

foreign competitors and as their technological learning advanced product quality at lower cost they expanded in actively seeking to bid successfully for telecommunications projects in developing and emerging economies where they gained further strength by competing on given product quality and lower prices. This starts the globalization stage.

However, whether Chinese companies keep on growing sustainably outside their home market will largely depend on whether they turn into genuine innovation leaders rather than followers. So far they have not gained a notable footage in advanced markets for smart networks or other smart network products.

From a strategic perspective it appears that Chinese companies adopt some sort of Go or Wei'chi strategy (Yasuyuki,1995) that emulates improving their market position in a spatial 'board game'. While very little of such strategic make-up would be covered in the seminal work of Michael Porter(2004) on 'Competitive Strategy', it could be matched and traced to Scott Boorman (1969) on military strategy and invites a matching in technology races and business wars (Gottinger, 2006, 2009).

In his biography 'On China' H. Kissinger (2011) put Wei'chi strategies as a cornerstone of Chinese geopolitical objectives.

The strategic aspect warrants further exploration as a vehicle of industry evolution and corporate growth. In a related industry analysis this has been less specifically referred to as a 'Maoist strategy' (Economist, Aug. 2, 2012) or as a 'Sideward Crawl Crab Strategy' (Nakai and Tanaka, 2010) but more specifically they both are embedded in Wei'chi.

## 2. Key Concepts of Competition for Network Industries

One of the most important results from the industrial organization literature is the suggestion of an analytical distinction between product market competition and competition in innovation. In this regard we follow major concepts in Varian and Shapiro (1998) and J. Tirole(1989)

Product market competition can be understood as competition between firms in the supply of existing products. This competition can be conceptualized as the rivalry between firms in terms of marketing, and notably pricing, of their products taking as given the characteristics of products (including production processes and costs). In markets that are considered relatively 'static', product market competition is the main channel through which the competitive process takes place.

Competition in innovation can be understood as the competition between firms to develop new products and production processes; this competition is often associated with the ideas of a competitive threat from innovation. Two firms are competing in innovation if they are undertaking (uncoordinated) innovative activity that can be identified with the

prospect of introduction of products or services that will compete in the future. This innovative activity could be investment in R&D or less formalized activity such as product improvement through a process of learning-by-doing. Where two firms are competing in innovation, we expect their decisions regarding innovative strategy to be influenced

significantly by the innovative strategies employed by rival firms — failure to innovate successfully will lead not just to loss of potential profit but also risk falling behind innovative rivals.

Mainstream economics also makes use of the terminology of 'static' and 'dynamic' competition. Along the same lines as above, the static dimension of competition is usually related to price competition, which takes place given the set of products or services that are marketed by firms. Dynamic competition, on the other hand, refers to the process whereby new and improved products, services and production processes are introduced. However, in the context of 'innovation and competition' we consider it more appropriate to use the terminology of 'product market competition' and 'competition in innovation' as this is more specific and seems more conducive to the development of guidance for competition policy practice.

Indeed, the distinction between product market competition and competition in innovation is particularly well suited to taking innovation and market dynamics into account for the purposes of competition policy. This is because competition policy practice is well accustomed to the analysis of product market competitive constraints through analysis of competition within a relevant market. Thus explicit consideration of competition in innovation can be seen as an additional dimension to this analysis, rather than a fundamental change in the concepts of competition used for assessment.

An important aspect of the tools and guidance developed in subsequent sections is to relate these dimensions of competition to practical concepts used in competition policy assessment, in particular to market definition analysis.

### **2.1. Winner-takes-all Markets**

Industrial organization models, and the review of studies of network industries, suggest that competitive interaction in innovative activities may take different forms according to the structure of payoffs of innovative activities to 'winners' and 'losers'.

In some organization models, and the review of studies of network industries, suggest that competitive interaction in innovative activities may take different forms according to the structure of payoffs of innovative activities to 'winners' and 'losers'.

In the first case, competition in innovation may be the essential, or at the limit the only dimension of the competitive process, i.e. winner-take-all markets. Persistence of monopoly may be observed in a winner-take-all market, but provided that competition in

innovation is effective, this does not necessarily imply that competitive forces are muted. On the other hand, in these markets, competition in innovation is the area where the current dominant firm may be more likely to abuse its dominance (since, by definition, such markets are not conducive to sustained product market competition).

These considerations suggest that it is useful to distinguish between different economic environments, according to the relative importance of competition in innovation and competition at the product market level that can be expected in the market. The literature on network industries is particularly useful in explaining why a market may exhibit winner-takes-all properties.

### **2.2. Network Effects**

The review of the industrial organization / network industries literature relating to innovative markets has suggested that network effects may be an important factor in determining the competitive environment .

A (positive)direct network externality exists where the demand for a service increases as an extra unit is consumed. In order for this effect to be "direct" the reason for the increase in demand must come directly from the additional consumption of the service in question, without need for a strategic response by suppliers in the same or related market. For example, the demand for PSTN telephony services (i.e. the demand for subscriptions to networks) may increase as more users consume this product (e.g. enter into subscription agreements with PSTN network operators) simply because more users allows a greater number of potential connections to be made of the network.

By contrast, a (positive) indirect network externality exists where the demand for a service supplied in one relevant market has a significant effect on supply or another product (typically in a different relevant market) such that this in turn increases demand in the first relevant market.

An example of indirect network effects is that of computer software for a particular operating system platform. An increase in consumption in the market for supply of operating systems is likely to bring benefits to the markets for supply of compatible software, by expanding the market such that a greater variety of software is offered or the unit price decreases (since fixed costs of software development can be spread over a greater number of potential buyers). In turn, the benefits to the software markets render the same operating system more valuable, and thus increase demand for it. But the effect is indirect because it relies on a strategic response of software suppliers to the increase in the consumption of operating systems.

### **2.3. Horizontal and Vertical Innovation**

The study of industrial organization and endogenous growth models suggests that the distinction between "horizontal" and "vertical" innovation may be useful. Horizontal innovation entails the discovery of a new product which, setting aside price considerations, is considered

better than existing products only by some users (or for some uses). By contrast, vertical innovation entails the discovery of a new product which, setting aside price considerations, is considered better than existing products by all users (for all uses); hence the idea that products can be ranked according to a “quality ladder”.

The importance of this distinction derives from the differences in market dynamics that are associated with the two types of innovation. In particular, horizontal innovation generally results in the creation of new product groups that can coexist with older product groups.

Vertical innovation, on the other hand, is generally associated with a process whereby new and better products displace older obsolete products from the market. In markets subject to vertical differentiation, a firm (or more accurately a product) that does not follow the pace of technological advance may be driven out of the market. In other words, in order to survive, a firm needs some basic capabilities, and the need to improve these capabilities over time as its competitors improve theirs (hence the idea that a rising “quality window” exists, outside which firms cannot survive in the market). This economic process can guide on the nature of market dynamics that may affect a particular industry.

#### **2.4. Step-wise Innovation Versus Incremental Innovation**

Step-wise innovation involves a relatively substantial degree of novelty, e.g. a new product or

production process that is substantially different and/or better than older products. By contrast, incremental innovation is characterized by minor cumulative changes to products or production processes.

The extent to which an innovation is novel may be an important factor in assessing whether incumbent firms have an advantage over potential entrants or vice versa. In fact, industrial

organization models suggest that incumbent firms may have different incentives to innovate than entrants. Similarly, given the difficulties that incumbent leading firms may have to deal with drastic changes – a form of intra-firm systemic inertia – the opportunities for step-wise innovation may relatively favor incumbent firms.

#### **2.5. Intensity of Competition and Innovation**

There is little consensus about the relationship between intensity of competition (however defined) and innovation. At a general level, there is some evidence in favor of an inverse-U shape, indicating that innovation may be relatively less rapid at both very low and very high intensities of competition.

However, there is insufficient guidance from the literature to develop these ideas into a general theory. For example, the question of “at what point is more competition worse?” does not seem appropriate to be analyzed at the generic level, given the current level of understanding of these effects. Much of these problems derive from the difficulties

involved in understanding the link between product market competition and innovation. Therefore, we do not consider there to be guidance from the literature on this issue, which is perhaps best addressed on a case-by-case basis.

### **3. Dynamic Markets and Competition**

Every market is dynamic to the extent that we expect changes over time, for example in the quality and characteristics of the goods and services produced, their prices, the processes used in their production and the firms engaged in their supply. Innovative actions of firms affect all markets in the economy.

In line with the fundamental distinction we have drawn between product market competition and competition in innovation, we discuss how a more explicit consideration of market dynamics can inform on each of these dimensions of analysis.

First on the product market dimension, in dynamic markets time matters. A snapshot of the market observed at the time of the investigation is likely to be very different from a hypothetical snapshot of the same market taken in the near future. Such changes may be due to innovation undertaken by the firms in the market, or due to factors outside the market such as external technological developments, or shifts in consumer tastes. The result may be either more competitive or less competitive market conditions over time.

Second, in dynamic markets, the production, assimilation, and commercial use of new knowledge is central to the competitive process, i.e. it is a fundamental determinant of firms’ success and failure. Thus, in some cases innovation (i.e. activity related to the supply of new services in the future) may be a crucial dimension along which the process of competition takes place.

Of course, anticipation is subject to great uncertainties. The view that the markets of telecoms, computers etc. converge was largely anticipated but it turns out to be different than expected and therefore may run contrary to anticipated market definitions. Example: G3 was the name of the game more than a decade ago where billions of dollars/euros through UMTS were skimmed off from anticipating market participants, only to know later that rival standards based on new technologies (Wi-Fi) bypassing UMTS, would create completely new markets not being anticipated.

#### **3.1. Market Dynamics and Product Market Competition**

If analysis of competition in a current relevant market is to provide guidance on dynamic effects in that market, we require some understanding of how this current relevant market is likely to evolve in the future. In areas of economic activity where the relevant markets are expected to remain stable, analysis of competition in the current relevant markets, with due attention to likely entry to that market, could be broadly informative on future competition in those

markets.

However, market dynamics will often mean that analysis of competition in the current market may not be a reliable indicator of competition in the future. Technical change may affect market definition, for example by widening the range of possible substitutes. In addition, technical change may affect the structure of the market as defined, for example, by making economies of scale more or less important. Such changes may be due to innovation undertaken by the firms in the market, or due to factors outside the market such as external technological developments, or shifts in consumer tastes.

Taking account of these factors is not simply a question of examining entry possibilities. Indeed it requires consideration of how the market to which entry applies, and the barriers to entry that may exist in this market, changes over time.

This concern has various practical implications. For example, in analyzing a merger, the two merging firms may currently be operating in completely separate relevant markets, thus raising no current competition concern. But product development may mean that the relevant markets converge in the future, such that these firms are expected to be competitors in the future. This does not mean the merger should be blocked; simply that competition analysis may need to be forward-looking as to how current markets are likely to evolve in future.

Furthermore, in an extreme case of the 'stability' problem highlighted above, a firm may not be active on any current markets but may be developing products that would compete in the future.

### **3.2. Market Dynamics and Competition in Innovation**

By focusing on competition in defined product markets, be these current or future, analysis may miss the effect of competition in innovation. In some instances this will not hinder successful examination of a competition case, either because competition in innovation is subordinate to competition in the product market, or because analysis of the effects on competition in the product market may act as a "proxy" for analysis of the effects on competition in innovation.

However, where innovation is clearly an important part of the competitive process, the effect of a merger or anti-competitive conduct on competition in innovation may be significantly different to its effect on competition on the product market. For example, if a market seems to exhibit "winner-takes-all" properties, such that it can only sustain one firm at a point in time, an abuse of dominance case may need to explicitly consider whether conduct by the dominant firm affects competition in innovation rather than product market competition.

As such, competition in innovation may need to be considered in its own right.

One caveat is that even if no competition in innovation is observed, this could in fact be due to from explicit

consideration of dynamic effects and the potential for competition in innovation. Therefore the underlying issue should be competition, or potential for competition, in innovative activity.

### **3.3. Identification of Dynamic Markets**

The identification of a market as broadly dynamic or static is an output of the competition analysis itself, rather than a feature that can be established a priori before the investigation on the basis of some pre-defined indicia. Nonetheless, it is possible to identify some initial indicators of dynamic markets that would suggest the benefits of the further analysis proposed in this study.

We are interested in observable market features that relate to either the importance of competition in innovation or the potential instability of competition assessment in the current relevant market. The main indicators identified can be classified respectively into inputs to

innovation (e.g. R&D), outcomes of innovation (e.g. changes in product performance) and changes in relative prices; these features are discussed briefly below.

### **3.4. Inputs to Innovation**

R&D and patent data are the most commonly used quantitative measures of innovative inputs

and outputs and both could be considered proxies of the extent to which innovation is important in the sector considered.

A large R&D expenditure (say relative to other costs) or substantial labour input to R&D would indicate that a firm is investing a significant amount of effort in developing new products, or improving old products, both of which would suggest (but not prove) that competition in innovation is important.

Patent data would indicate the measures a firm is taking to protect innovations, be they product or process innovations. Since the granting of patents is dependent on some form of novelty, innovation is necessary (although the relative importance of innovation in the competitive process is not fully established).

Thus both R&D and patent data are potential indicators of whether competition in innovation is an important part of the competitive process. In addition, by implication, if competition in innovation is found important, it is likely that the competitive assessment in the current relevant market is not sufficient for assessment of product market competition since the new products and new technologies could render this assessment unstable into the future.

Despite their common use, however, these indicators are imperfect for several reasons, notably the excessive focus on formalized activities as a source of innovation and patented inventions as a measure of commercial innovations. In a competition policy investigation it is normally possible to access more specific measures of innovation in the market, notably related to observed changes in products' technologies, characteristics and prices.

### 3.5. Outcomes of Innovation

While R&D and patent data essentially relate to the inputs of innovations, observations on changes in product characteristics reflect the outcome of innovation. In this sense these are a more direct measure of the importance of innovation and the instability of competition assessment in the current market.

Where products embodying new technologies or significantly improved characteristics have been introduced recently, or are expected to be introduced, it is unlikely that the competitive conditions today reflect closely those in the near future. Indeed, observation of the specific nature of technologies used in the market may suggest that this is going through a drastic change of the technological paradigm that may entail profound changes in its structure, and hence require particular care in its analysis.

Indicators of significant changes in product characteristics include evidence (or expectation) of the following:

- introduction of products that embody a new technology;
- short product life-cycles;
- high proportion of market turnover accounted for by new products (i.e. products introduced, in say the previous 6 months); and
- rapid improvements in products' performance.

Nonetheless, one area where looking for changes in product characteristics may fail to pick out dynamic markets is where a period of market stability (in terms of products supplied) is accompanied by firms undertaking product development that has yet to bring products to the market. In this case no discernable changes in products would be observed today, but we may predict competitive conditions to change in the future. R&D data, or discussion with industry experts, could inform on the importance of such innovation for future market dynamics.

## 4. The Chinese Telecom Industry and Market Dynamics

In the early takeoff phase of the Chinese telecommunications market of the early nineteen-nineties it was observed that subscriber satisfaction was low, the installation of a fixed line often took six months and longer.

Installing a single fixed line carried a 5,000 Remimbi (RMB) cost, and often another 5,000 RMB was needed as an expediting fee (DeWoskin,2001).

As part of planning infrastructural reform and growth in China it was decided to use telecommunications equipment suppliers to promote the development of non-joint venture capability in China as early as market transitioning was targeted (Noughton,2007, Chap.14).

In the fast growing network equipment market originally four companies were identified as key exponents of this strategy: Julong (GDT), Datang (DTT), Zhongxing (ZTE)

and Huawei. Among those, in the course of development, really only three DTT, ZTE and Huawei have become internationally of concern, and they are the dominant focus of this study.

Zhang and Igel (2001) studied these four Chinese suppliers with two joint ventures, Beijing International Switching System (BISC), a Siemens joint venture and Shanghai Bell, and Alcatel-Lucent joint venture. They found that low cost products and government assistance were important to Chinese suppliers' strategies while foreign joint ventures relied on foreign companies.

All six manufacturers (Shanghai Bell, BISC, GDT, DTT, ZTE and Huawei) emphasized cost control because of decreasing product prices and rising R&D costs. The price of Store Program Control (SPC) switches was in 2001 only one tenth of what it was in the early 1980s. On the other hand, Huawei and ZTE spent 10 pc of their sales on R&D activities and 70 pc of ZTE's R&D budget was invested in software design and development. Because of higher manufacturing costs of lower capacity network equipment joint venture firms BISC and Shanghai Bell

could not compete with Huawei's and ZTE's products at a capacity of less than 6,000 lines (Cheng and Liu, 2003). BISC, therefore, lost its markets in rural and remote areas to the products designed by Chinese-owned firms that were cheaper (with the active support of the Chinese government). In addition, the government has tried to decrease the import of SPC switches. It encouraged telephone operators to use products from national manufacturers.

According to Zhang and Igel (2001), in the early 1990s Chinese-owned firms held only about 1 pc of the market share of central office exchanges. Since then in more recent years domestic firms have increased their market share substantially. Chinese designed SPC switches have gained more than half of the national market since 1997. Facing strong challenges from domestic firms and lower profits some leading Japanese firms, such as Fujitsu and NEC, have withdrawn from China's SPC market, and some leading Western SPC producers have been considering leaving as well.

While Chinese domestic firms have been competitively successful against joint ventures and foreign competition in rural and remote Chinese markets which we call the separation phase of competition they have been learning on 'course, conviction and capability' (IBM Business Institute on Company Growth) through catchup driven innovation to the extent that they could compete head on with major foreign suppliers or their joint ventures in major urban areas along the coastal crescent of China, stretching from HK, Shenzhen, Shanghai and Beijing. This may be called the convergence phase.

We consider the competitive positioning of high technology firms as a technology race in which falling behind, getting ahead and catching-up to industry leadership is the name of the game (Gottinger,2006,Chap.1). We may come across specific situations that would be connected with new product development in 'appropriate' technology that

could lead to a paradigm shift of that race.

In terms of the Chinese market indigenous firms came up with simpler, sufficient performance level of network gear at a much lower price for use in rural China which could be identified as appropriate technology. This established market separation that formed two different tiers of market segmentation applying to rural and urban/metropolitan areas. Interestingly, the same tools of market penetration were applied by Chinese firms later on in other emerging and transitional economies

virtually all around the world. The type of innovation targeted at rural and remote areas of China, clearly in a developing economy, could be termed 'reverse innovation' in the meaning of Govindarajan and Trimble (2012) since they originated in the needs and requirements of this infrastructural sector that was separate to the advanced urban areas in China.

We may categorize two aspects of these innovations that relate to the dichotomy of the telecom market in China in the early 1990s:

(1) new markets and (2) quality characteristics.

(1) Products offered are too expensive, too complicated, too difficult to maintain.

(2) Product quality characteristics are appropriate, 'good enough' with

significantly lower pricing. New entrants compete profitably, learn and R&D invest while pricing at deep discounts.

#### 4.1. Competitive Phases

Thus, in explaining the phases of market development for Chinese firms,

in terms of history we may identify the separation phase roughly with the period of mid 1980s to mid 1990s, the convergence phase from mid 1990s to early 2000s and the globalization phase for the rest until now. This applies not only to specific network technologies (like SPC switches) but also to broad product groups as network routers and servers as well as to consumer end products such as smartphones and tablet devices though those markets have emerged only recently. These phases seem to be more technologically motivated through innovation but may be supported by strategic direction or other factors such as government directed industrial policy.

First, in a competitive separation phase technologies do not interact (in terms of being replaceable) in the course of their development.

Then, in a competitive convergence phase, technologies evolve to compete head-on for the same customers. In a competitive globalization path competition evolves through technology performance and local market characteristics such as regulatory requirements of developing economies, foreign government support and subsidization including potential corruption schemes in tendering.

The Chinese suppliers' introduction of high capacity SPC switches in 1995 for sale into the Chinese urban and rural

markets signalled the start of the competitive convergence path. Chinese and foreign suppliers competed head-to-head for the urban and rural Chinese market and then in the global market. By early 2004 ZTE and Huawei sold greater numbers of digital subscriber lines (DSL) in China than foreign suppliers including their joint ventures did (WSJ, 2004; Dittberner, 2004). Moreover, top executives of established suppliers were becoming concerned about the fierce competition from Chinese suppliers in the global markets.

This signalled already a transition from the competitive convergence path to the competitive globalization path for Chinese suppliers. In a competitive convergence path technologies evolve to compete head-on for the same customers.

From about the mid 1980s to the mid 1990s, Chinese suppliers operated in separation from established foreign suppliers. Chinese suppliers (with the support of their government), prominently Huawei and ZTE, aimed to satisfy the needs of Chinese rural areas, a market largely ignored by the established foreign suppliers.

There were three main rationales for the separation.

(1) Chinese suppliers sold low capacity SPC switches to satisfy the needs of rural Chinese areas while foreign suppliers sold high capacity SPC switches to satisfy the needs of large, fast growing cities.

(2) Because of their restricted use, capacity limitation and poor reliability low capacity switches could not be used in the urban market that existed at the time.

(3) Chinese suppliers targeted the infrastructural, non-consumer market and added value to facilitate growth prospects in underdeveloped Chinese regions.

Statistical information about the installment of SPC switches could be sourced from the Chinese Ministry of Information Industry (2003, 2004) and the relevant suppliers websites.

For example, in 1995, 90% of Huawei's products and 100% of ZTE's were sold to county switching centers (level 4) and terminal switching centers (level 5). In contrast, Shanghai Bell's products were sold to large district center (level 1), provincial switching centers (level 2) and city switching centers (level 3). Levels 1 to 5 go from large to small geographic units.

In 1995, Chinese suppliers accounted for 22% of sales telecom equipment in China, established foreign suppliers and their joint ventures accounted for 78% (MII, 2004)

Another reason for the separation between Chinese suppliers and established suppliers was that regulatory requirements by the Post and Telecommunication Bureaus (PTBs) in rural areas were quite different than the requirements of the PTBs in the cities. PTBs in the rural areas required cheap, low power, easy to operate switches with basic functions so that Chinese interfaces did not depend on trained professionals to operate them. In contrast, PTBs in urban areas required high capacity, stable performance switches that could also act as switching platforms (Edquist, 2003).

#### **4.2. Product Development , Manufacturing Capability and Innovation Drive**

Chinese suppliers developed SPC switches in China. Requirements of Chinese rural customers were incorporated into their product development efforts. Foreign suppliers deployed advanced products developed outside of China. These advanced products were designed to meet the needs of large service providers in North America, Western Europe and Japan. For example, Siemens' Technology Division was tasked with modifying the German version of the software to deliver a Chinese version. Product development was undertaken in Germany. Foreign suppliers operated in much the same way. Foreign suppliers' SPC switches led Chinese demand for services. Typically, foreign companies invited their Chinese customers to visit their home countries and showed them what the telecommunication equipment of the future looked like (Zhong, 2002). (Now bankrupt) Canadian Nortel Networks was the first foreign supplier to establish an R&D facility in China. In 1994 Nortel Networks and Beijing University of Post and Telecommunications established an R&D center in Beijing. The lab focussed on the development of wireless technology.

Foreign companies were experienced in the manufacture of high capacity switches prior to starting to service Chinese cities. For example, Ericsson started manufacturing its switch exchanges in 1975 and Alcatel and Siemens started manufacturing their switches in 1980. In contrast, Chinese suppliers did not have experience manufacturing high capacity switches. In 1994 GDT became the first Chinese supplier to establish a line to manufacture high capacity switches.

In the separation phase survival in the rural market was the first priority for Huawei and ZTE. Thus they avoided head-to-head competition with foreign suppliers servicing the needs of Chinese cities (Cheng and Liu, 2003).

The second priority was to invest large parts of their revenue in R&D required to develop high capacity switches. In 1988, ZTE invested all their profits generated over the previous four years to develop its HC switch. Similarly, in 1992, Huawei invested all their profit sales and additional borrowings to develop its HC switch. The development of high capacity switches was considered an important break-through to transit to the convergence phase. (Cheng and Liu, 2003; ZTE, 2003)

In the competitive convergence phase suppliers DTT, GDT, Huawei and ZTE had their strongest competitors inside China with Shanghai Bell and BISC. 3Com, Alcatel, Cisco, Ericsson, Fujitsu, Lucent, NEC, Nortel Networks and Siemens were the strongest competitors outside China.

For Chinese suppliers priorities were given as to reduce technological gaps with foreign suppliers, increase equipment reliability, displace foreign companies and their joint ventures in China and grow market market share in multiple product lines outside China and above all maintain low cost leadership.

In the competitive globalization phase the intent was to

attack the global market share in switching, global systems for mobile communications, code division multiple access and optical transmission.

#### **4.3. The Competitive Globalization Phase**

In 1995, established suppliers held 90 pc share of the Chinese SPC switch market and Shanghai Bell and BISC were the major providers of telecommunications equipment in China. In 1997, however, they fast dropped to 50 pc market share (MII, 1991-2003).

If one looks at the annual revenues in the time frame 1993 to 2003 for both joint ventures, Shanghai Bell and BISC, as compared to the four Chinese suppliers one could deduct the striking result that from 1997 onward for Huawei and from 2000 onward for ZTE annual revenues skyrocketed, with Shanghai Bell sharply increasing from 1998 to 2001 and dropping off afterwards. The remaining suppliers staying relatively flat. Further, by 2003, Huawei and ZTE sold more than Shanghai Bell and BISC becoming the top suppliers in China.

In addition to the SPC switch market, Huawei and ZTE, in particular, competed aggressively with other multinational telecom companies in a variety of other product markets, both domestically and internationally (Li, 2006, Fan, 2006)

### **5. Conclusions**

We show how the innovation drive of indigenous Chinese telecom equipment companies, over several paths – separation, convergence and globalization – engulfed well established Western suppliers and their joint ventures in China. Technological learning, innovation and competition led them to topnotch performance in international markets

While expanding their product varieties and portfolios. While catching up technologically with their competitors in the domestic market and achieving success in markets of emerging and transitional economies competition in the global industrial race has become much tougher. The rationale behind is that competition in products is very much helped by low pricing, low costs and substantial government subsidization. However, competition in innovation, as outlined in Sec. 2 and 3, is much less sensitive to pricing. If we look at a competitive situation in network markets where there is uncertain technological development in product/process technologies. Firms 'price' compete in those markets to gain market share before any of them succeeds in getting an innovation to move ahead of its rival(s). If the firms are in a technology race and the probability of innovation success is small, then a firm with a bigger network advantage is likely to attract more customers in the absence of innovation. If, however, any of those firms expect a drastic innovation with a high probability, then after realization this firm will get ahead of its rivals and gain market share on its brand independent of pricing. (Apple in the smartphone and tablet market is a good example)

Thus, if Chinese telecom companies want to attain a



leadership position

they have not only to catch up but also to leapfrog their rivals. This hasn't happened yet. After catching-up the technology frontier it is a much more difficult thing to do. Still today, the undisputed worldwide leader of network gear, Cisco Systems, considers Huawei as its toughest rival (WSJ, 2012d).

Another aspect is the strategic positioning of the indigenous Chinese firms. It looks as if their catch-up behaviour as reflected through their competitive phases followed the rules of Go or Wei'chi, a territorial game designed to subdue your rival by spatially encircle and corner him and capture his position by dominating him over the board. In this regard, the Chinese market looks like a Go board which when expanded to emerging and transitional economies entails the global market. In this respect, the game is not over yet. The analogy is compelling but needs further research.

## 6. Appendix

### 6.1. Brief Company Profiles

#### 6.1.1. Datang Telecom (DTT)

DTT is a state owned company founded in 1998 by the China Academy of Telecommunications Technology (CATT). DTT took over the assets that belonged to Xi'an Datang. CATT is a research institute of the Ministry of Post and Telecommunications (renamed Ministry of Information Industry), DTT is a telecommunication equipment supplier which can provide switching, mobile, optical transmission, wireless, integrated circuits and software products. DTT is the Chinese company mostly involved in the development of 3G wireless standard TD-SCDMA which originally partnered with Siemens to develop the TD-SCDMA standard. In 2003, however, Siemens contracted with Huawei for the R&D of the TD-SCDMA. DTT is ranked among the top 100 Chinese electronics/IT companies, in 2002 it was ranked No. 40, in 2006 No. 91.

#### 6.1.2. Huawei

Huawei is a worldwide company that develops and sells switching products, transmission equipment, optical access, mobile and wireless products, ATM, intelligent networks, support networks, power supply and environmental monitoring, videoconferencing and CATTV equipment. In recent years it has expanded aggressively into smartphones and tablets (on Android OS). Huawei has about 100 branch offices in major countries on all Continents, and has established R&D centers in Europe and the US, reinvesting major parts of their profits into R&D. Huawei's products have been deployed in many emerging economies as well as in Germany, The Netherlands, Russia, Brazil, Thailand, Singapore, Egypt, India, Indonesia, Turkey, South Africa and South Korea.

Huawei's Beijing Research Institute, in 1996, developed a Signal Transfer Point (STP) product at a time when the

Chinese STP market was dominated by Shanghai Bell and Nortel. By 1996 all Chinese provinces deployed Huawei's STP equipment. It became part of the national backbone network in 1997. In 1998 Huawei became the Number One supplier of telecommunications equipment in China., its annual sales exceeded those of Shanghai Bell and BISC.

In 2003, Huawei established joint ventures with 3Com to develop routers, with Siemens to develop TD-SCDMA standard, with Infineon Technologies to develop a low cost R&D platform for WCDMA mobile phones.

In 2011, for the first time, Huawei was ranked Number One among the top 100 Chinese electronics/IT companies.

#### 6.1.3. Zhongxing Telecommunications Equipment (ZTE)

ZTE first produced electronic watches, electronic pianos and a small capacity switch exchange. Today ZTE is an important global supplier of telecommunications equipment with products deployed over 60 countries, mostly emerging and transitional economies but also several OECD countries. Its product portfolio includes switches, access networks, optical transmission equipment, CDMA and GSM systems, and mobile terminals for CDMA, GSM and PHS. Like Huawei in recent years they ventured into smartphone and tablet computers.

ZTE established research institutes in Nanjing and Shanghai to develop large capacity SPC exchange and access network equipment in 1993 and 1994, respectively.

In 1996 ZTE announced that its mission is directed toward three strategic priorities: (1) Develop from being a single switching product company to a multi-product company, (2) address the needs of the urban market as well as those of the rural market and (3) address the needs of international

Markets.

In 2001, ZTE's revenue from mobile products exceeded those from switching and access products.

By 2004 ZTE had 13 wholly owned R&D centers worldwide and engaged in research partnerships (RJVs) with large, well-established firms such as Texas Instruments, Motorola and Agere Systems (ZTE's annual report of 2003).

In 2011 ZTE was ranked within the top 10 of the 100 Chinese Electronics/IT companies (Bloomberg, 2012)

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