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TELEVISION PRODUCTION: ITS CHANGING GLOBAL LOCATION, THE PRODUCT CYCLE AND CHINA

ABSTRACT

This article concentrates on the global location of production of television receivers as a case study. The aim is to see if this accords with Vernon's international product cycle theory or whether some modifications of the theory are required. The historical evolution of the global television industry is outlined and the global pattern of demand for television sets is explored, partly to relate the location of demand to the location of television production. Production cycles involved in television manufacture and its international location are then carefully explored both for black-and-white sets and for colour television. China's rise to become the world's major producers of television sets is given particular attention. Conclusions are drawn about the continuing relevance of the international product cycle and the need to modify Vernon's original perceptions about it.

Keywords: China, flying geese models, international product cycle, Japan, multinationals, technology transfer, television, USA.

TELEVISION PRODUCTION: ITS CHANGING GLOBAL LOCATION, THE PRODUCT CYCLE AND CHINA

1. Introduction

Following the discovery of the Leontief paradox (Leontief, 1953), two important models have been developed to examine the evolution of technologies and their transfer between nations: the product cycle model and the flying-geese model. Vernon's product cycle model (1966, 1979) it attempts to explain the pattern of product innovation and the diffusion processes involved in technology transfer and production internationally associated with international investment, as well as changing trade patterns. The "flying-geese" model models the interaction of a group of countries at different stages of industrialisation and the changing patterns of their product advantage and market situation. The flying-geese title portrays an analogy with the changing pattern of leadership in a flock of flying geese (Korhonen 1992: p.69, Blomqvist 1996). It seeks to explain the dynamic international movement of production, trade and capital flows, especially their connections with direct foreign investment.

This study outlines the evolution of the production of television (TV) receivers, giving particular attention to the international product cycle. The changing global location of the production of TV sets is examined as well as factors influencing the demand for TV sets in different countries. Three factors prompted the choice of production of TV receivers as a case study. First, the product has undergone substantial technological change in recent time-period. Secondly, the patterns of international trade in this product have changed substantially over the time-period. Thirdly, major changes have occurred in production locations as between nations.

TV sets first became a popular consumer product in the post-World War II era in the innovating countries of Britain and USA. Since then there have been remarkable technological advances in TV sets, colour being the most prominent. There have also been major changes in trade patterns. The TV product cycle in innovating countries is now complete and TV production has shifted to less technologically advanced imitating countries. Some production will probably only return to the innovating countries if they develop major, radical, new technologies, as with digital TV.

Previous studies of the product cycle theory have concentrated on OECD countries, especially USA. Few systematic studies have been made that include LDCs, even a large LDC such as China. This study rectifies this situation.

2. The Product-cycle Theory and Flying Geese Models Reviewed

According to Markusen et al. (1996), both Vernon (1966, 1979) and Hirsch (1967) used the product-cycle model to explain dynamic patterns of international trade. Vernon constructed an explicit and fully developed product-cycle hypothesis. According to Vernon, a new product goes through a full life cycle from innovation to standardisation. The innovation of a new product typically begins when it is designed and made in a high-income country like the USA. The second phase is the maturing stage and occurs when the product and technology for production have become relatively stable, and demand in other high-income and middle-income countries has risen to the point where entrepreneurs in those markets find it profitable to produce locally. Production arrangements between the innovating firms and local entrepreneurs may involve various mechanisms such as foreign direct investment (FDI), technology licensing trade, science and technology agreements and technology import. After some time, the product may be re-exported to the innovating country which, in turn, may have moved on to develop newer advanced versions of it.

The third phase of the product cycle, often called the standardised stage, occurs when production of the original product becomes routine and involves unskilled labor-intensive production. In this stage, consumers have become familiar with the product and the market will have broadened with competing producers introducing their versions of the original product. Demand is, therefore, likely to become much less price inelastic. At this stage the location of production by countries is again likely to move, mostly as a result of FDI, this time to low wage developing countries. Such a move could enhance the ability of such countries to develop domestically competing products.

In latter years, however, Vernon admitted that due to international institutional changes, his theory was becoming less useful for analysing technology and trade relationships between industrialised and developing countries (Vernon, 1979). This he attributed to the development of multinational companies (MNCs) with an integrated global network of subsidiaries.

Markusen et al. (1996) divides the product cycle into three phases in line with Hirsch (1967, pp.23-45). The first phase is characterised by a low volume of production. When a new product is first introduced into the market, production and sales tend to be low as the producer does not want to commit to large-scale production at an early stage and market penetration takes time. This initial production is skilled-labour intensive and results in high unit costs. Furthermore, learning by doing is not yet significant in the initial phase. As learning by doing occurs the quality of the product improves and the firm's per unit costs of production decline.

The second phase is characterised by a sharp increase in volume if the product is a success. The growth rate is higher at the beginning of the phase, and tends to slacken later. As a product progresses through this growth phase, mass production and mass distribution are introduced, and special purpose machinery may be utilised to reduce unit costs. Assembly line methods and other mass production techniques may be introduced. The ratio of labour to capital is reduced and the production process becomes more capital-intensive. Increasing numbers of firms are attracted to the industry to take advantage of a growth market; close substitutes are developed and the widespread acquisition of relevant manufacturing skills makes entry technically possible. Demand becomes more elastic as far as the individual producer is concerned, since customers have a large number of suppliers to choose from.
The standardised phase is characterised by a plateau and then a downturn. The market nears saturation point. Production/sales plateau in home markets though the market share of individual firms may vary. Product specifications are now quite standard. The sequence of operations and their scale are more or less fixed, and innovations in the product or refinements to the production process become less frequent with maturity. The manufacturing process becomes more capital-intensive than in the previous phases and the optimal size of the manufacturing unit tends to increase. Consequently, economies of scale become important factors in determining the competitive strength of an individual manufacturer. The proportion of unskilled and semi-skilled workers rises in comparison with previous phases.

The basic theoretical notion of the product life cycle has not changed during the last four decades or so. Nevertheless, some industrial researchers (Ronstadt 1977, Lall 1979, Pearce and Singh 1991, Granstrad et al. 1993) suggest that innovation might be geographically dispersed at a faster rate within multinational companies (MNCs) than suggested by earlier product cycle theories. They point out that the demand-led view of innovation, prevalent in

the 1960s, is now acknowledged to be one-sided and potentially misleading when assessing the spread of technology. Others believe that shortly after product innovation, many multinationals now build assemble/production plants in developing countries with the intention of lowering operational costs quickly. As a consequence, the relevant stages (mature and standardised) occur much earlier than previously. Furthermore, the competitive race involving product innovation is now very rapid and so new products may never reach the standardised or even the mature stage. Continuing improvements to the product may mean that the technological lead remains with the innovating country for an indefinite period (Grimwade 2000, p.65).

Both Vernon's product cycle theory, and the majority of his critics, focus on the product/technology development in a developed innovating country and other high-income countries. Very few systematic studies have been made of technology/production transfer to and development in developing economies (lower wage countries) and their contribution to the product/technology development. Thus the movement of production, international trade and investment is always treated in models such as Vernon's as involving a one-way process, from more developed countries to less developed ones. These analyses, however, may be inadequate in explaining current international industrial experience, especially rapid industrial development in NICs, such as China.

The international product life cycle model may still be particularly relevant to the development of production and exploitation of markets according to analyses by Baranson (1978), Oman (1989) and Roman (1986). By acting in accordance with this cycle, companies possessing market power due to their new technologies, dominant trademark designs and so on are able to maximise their gains from their intellectual knowledge and retain their market power.

2.1 Flying-geese model

As a refinement of the product cycle theory, the flying-geese model was proposed to analyse the catch-up process in Asian NICs. It describes the life cycles of industrial sectors and is related to dynamic changes in industrial structure and location (Chen 1989, Yamazawa 1990, Kwan 1994). The model outlines how each industry can pass through five stages: introduction (stage I), import-substitution (stage II), export (stage III), maturity (stage IV) and reverse-import stage (V). The theory focuses on the shifting of industries from relatively advanced countries to less advanced countries. The model assumes that there is a product life

cycle and that industrialised countries participate in production at different stages of the cycle in accordance with their comparative advantages. However, because of the rapid development of globalisation and the increasing importance of FDI in this process, product life cycles tend to vary.

The resemblance of the flying-geese model to Vernon's product cycle theory is striking at the micro-level. However, Blomqvist (1996) argues that the two models are different. Firstly, interplay between production, demand, export and import varies. Secondly, Vernon's theory is based on a framework of imperfect competition whereas the flying-geese model assumes perfect competition. Nevertheless, the flying-geese model was developed from the product cycle theory and can be seen as a complementary to it.

With this review in mind, consider technology transfer and diffusion in the TV industry and resulting production patterns. This is done to determine the extent to which the product cycle theory applies to the changing location of global production in this industry.

3. Some Historical Features of the Global TV Industry

The TV manufacturing industry started in the late 1930s in U.K. and USA. TV sets became an important consumer product and production developed rapidly in the post-war era. The television industry has been one of the largest segments of the consumer electronics market in the USA and other developed economies for many years (Chen 1994). It is an important electronic consumer product for middle-income countries and LDCs and many of these countries have been involved in producing the product, from its new to standardised stages (Chen 1994).

Television is primarily a medium of recreation, and it is known that the income elasticity of demand for recreational services is high. Innovation and initial production of black-and-white (B&W) television began in Britain and the United States. The first crude television system was demonstrated in 1926 in England, and in 1927 in the United States. The first regularly scheduled TV broadcasts were made by the BBC in 1936. Commercial broadcasting in the United States was authorised in 1941. In both cases, television development was interrupted by World War II. The beginning of television as a consumer product may, therefore, be placed at 1946. Colour television was innovated in the United States, with commercial broadcasting under current transmission standards commencing in 1954.

The major European countries adopted B&W television in the early 1950s. This early adoption by affluent countries accords well with the product cycle pattern.

Levy (1981, p.187) mentions two major influences on the development of the market for television sets. The first is the initial cost of sets: if this can be lowered, the rate of diffusion will be faster. The second influence is the organisation of broadcasting. Since demand for receivers is dependent upon the availability of suitable broadcast programmes, availability of suitable transmission channels will affect the diffusion rate of receivers. This is an industry dependent on networks.

Broadcasting may be organised 1) as a public service, administered directly by the government through a public corporation; 2) as a commercial enterprise; or 3) as a combination of these. When broadcasting is run on a commercial basis, strong incentives exist to enlarge the size of the audience to maximise advertising revenue.

TV receivers before World War II were the expensive novelties of the rich. The B&W TV industry grew rapidly in the post-World War II period spurred by domestic prosperity and the availability of wartime technology and production experience. In the 1950s, the industry in the USA enjoyed a technical and capital advantage. This allowed it to develop and market its product free of effective foreign competition. But at the same time, US firms in order to expand their market share and exploit their lead in production and technology, were compelled to invest in production facilities in Europe (thereby avoiding European tariff barriers), or to license their technology overseas to obtain marginal earnings in markets closed to foreign imports.

In the 1960s, the American TV-manufacturing industry was turned upside down by the Japanese acquisition of its technology through licensing arrangements. The Japanese acquired transistor and B&W production rights from the Radio Corporation of America (RCA) and General Electric (GE). This enabled Japanese firms to rapidly achieve economies of scale in B&W TV production. By the late 1960s, their major factories were on average twice the sise of those of West Germany and no less than six times those of the biggest UK production unit. Full utilisation of automated assembly methods gave Japanese producers a cost advantage of up to 30 per cent compared to US manufacturers (Sciberras 1985, p.23).

To lower their cost so as to compete with Japanese firms, US manufacturers began transferring B&W assembly and intermediate component production offshore and started to move domestic production to more technologically sophisticated TV sets, and higher value-added colour TVs (Tysmen & Tyson 1983, p.267).

The advent of colour TV broadcasting in the USA launched colour TV into the first growth stage of its life cycle with rapid expansion of domestic colour production from 750,000 sets in 1963 to over 5 million sets in 1966. When the licence to produce colour TV was obtained from RCA, Japanese firms quickly adopted this product using their experience gained in their B&W production. By 1970, the USA's boom in demand for colour TV had not yet completed its first stage when Japanese firms secured 17 per cent of US sales of colour television sets (Chen 1994, pp.23-24).

Well before any American firms had fully converted to all solid-state colour TV in response to imports from Japan, the American firms encountered competition from an unexpected source. The USA itself emerged as the most important offshore site for Japanese TV production. In 1986, Japanese companies produced 6 million colour sets in the USA. This was about 40 per cent of Japanese domestic production and 18 per cent of the level of Japanese worldwide production (U.S. Industrial Outlook 1987).

By the second half of the 1980s, Japan had become the major payer in the global TV market displacing the US. China now is (or seems to be poised to become) the major player in the global market for TVs. Consider the pattern of development of China's television industry in the evolving global pattern.

China's electronics industry was very backward before 1978 and the development was sluggish due to an economic/technological embargo by Western countries and internal policy. China's industrial development was almost isolated from the rest of the world in the period 1950-1978 and it had no participation in the international technology_transfer cycle. Consequently the technical gap between China's industry and that of developed countries, as well as its fast growing neighbouring NICs, enlarged considerably. In 1975, there were only 1.185 million TV sets in use in China, less than half the number in Mexico.

This fundamental technological lag of China can be attributed to endogenous and exogenous weaknesses as well as problems on both the demand and supply sides. These include China's

focus on military products rather than on civilian consumer products until the late 1970s; high production costs due to small-scale production; political restrictions on broadcasting, public media systems and TV programmes; shortages of electricity and TV transmission facilities in rural areas, low indigenous technology and manufacturing capacities; lack of sufficient capital and suitable material and component supplies; foreign trade blockades and social and political crises. Another important factor was that the low level of income in China in the pre-reform era did not allow a sufficient civilian market to develop for TV sets. China's development, as a low-income imitator, was therefore severely retarded.

Due to its low level of production and outdated technical standards, China had to import TV sets from Japan, USA, Germany and Hong Kong when domestic demand grew in the early 1980s. Imports of B&W and colour TV sets in 1982 reached 0.8 million and 4.96 million respectively. However, these sets were expensive and some designs did not suit China's local conditions. Their import was also a drain on China's foreign currency reserves. The government realised that China needed to build up its own modern TV industry and so started to import embodied technology: assembly and production lines as well as equipment for manufacturing picture tubes, integrated circuits (IC) and other key components.

The Chinese government played an important role in the development of China's TV industry in developing China's TV production, the Chinese government decided to adopt two approaches. One was to accelerate the process of China's integration with world TV development so as to obtain up-to-date technology. The second was to develop its own technology using the country's factor endowment. Its long-term strategy was to strengthen its own technological capability, reduce its technological dependence and reach the global technological frontier in this industry.

Various policy measures were adopted to achieve these objectives: These included:

1) institutional adjustment to promote more effective cooperation between enterprises, research institutes and industrial management bodies stimulated by financial incentives, technological support, and taxation deductions; and 2) incentives such as financial assistance (especially in foreign currency availability), tariff deductions or waiver on imports of locally needed technologies, export tax rebates and tax concession on profits, direct and indirect intervention (e.g. changes in industrial structure, and government direction in important trade negotiations). Restrictions included import restrictions.

Following the development of local TV industry, the Ministry of Electronics Industry (MEI) encouraged enterprises to utilise existing facilities more effectively and develop local technology rather than depend on imported facilities. 3) localisation of production. Due to large local TV demand and foreign currency constraints, localisation was seen as the key step for further TV industry development. Steps were taken to increase local final goods assembly; component production and design; 4) design localisation was undertaken by several research institutes, universities and some large enterprises. The purpose was to pool and co-ordinate available R&D resources to develop this strategic industry. As a result, the cost of Chinese TV sets was significantly reduced. Some components makers not only began to supply local production, but also commenced export. By the early 1990s, the industry had shifted from producing only import substitutes to independently developing its own technologies; and 5) standardisation policy. This approach was effective when Japan overtook US TV manufacturers. From 1985, the MEI organised hundreds of enterprises, institutes and universities in a co-operative effort and spent three years establishing China's "Television Aggregate Standards". It promoted standardisation, systemisation and rationalisation. This resulted in economies of scale, cost reduction, improved product quality and enhanced competitiveness. And 6) large company/enterprise promotion strategy was adopted. Particular Chinese companies/enterprises were selected to receive technological and financial priorities to develop them as the backbone of the domestic TV industry. Other less competitive companies/enterprises were closed down or merged.

These measures significantly improved China's TV production capacity and the international competitiveness of its TV industry. After a few years, the majority of components and materials for TV sets were produced in China, thereby considerably reducing the cost of sets as well as reducing China's imports of TV components.

4. Changes in the Global Pattern of Demand for TV Sets

The product-cycle theory includes sub-hypotheses about: 1) changes in patterns of demand for new products; and 2) location of innovation and first production. The theory suggests that international demand for a new product will roughly be proportional to per capita income. In addition, according to Vernon, production gravitates as time passes from high to lower income countries gravitating towards countries with the lower income. It further suggests that when the product reaches the standardised stage, demand becomes more price-sensitive for the individual producer. Consider these aspects in the light of changes in the international demand and national stocks of TV sets, as well as some data about production.

From the 1960s to the 1980s, there were three major groups of B&W TV producers distinguished by their geographical location. They were North America (USA and Canada), European countries (U.K., France, Germany and Italy), Japan and Asian NICs (including Taiwan, Singapore, Hong Kong and S. Korea). The latecomers, such as the second-tier NICs: Malaysia, Thailand as well as the third tier NICs such as China and India started production in the late 1960s. Table 1 shows the dates when and where broadcasting and production (B&W and colour TVs) first commenced in 15 countries. The dates for the first broadcast provides a good indicator of when domestic demand for television sets began in the various markets.

Table 1

Year of TV broadcasting and production of TV sets began in selected countries

	Production	**Broadcasting**	**Production**	**Broadcasting**
	B&W	**B&W**	**Colour**	**Colour**
USA	1927(1946)*	1946	1954	1954
Canada	1952	1952	1966	1966
U.K.	1926(1946)*	1946	1967	1967
France	1949	1949	1967	1967
Germany	1952	1952	1967	1967
Denmark	1953	1954	1968	1969
Sweden	1956	1956	1968	1970
Italy	1954	1954	1969	1974
Mexico	1951	1951	1967	1968
Japan	1954	1953	1962	1960
Taiwan	1956	1960	1967	1964
S.Korea	1966	1957	1973	1964
China	1957	1963	1971	1972

Note: * USA and U.K. commenced experimental TV production in 1927 and 1926 respectively; commercial production dates from 1946.
Source: UNESCO Statistical Yearbook

Table 2

Stocks of TV receivers in selected countries and years (1000 units)

	1960	1965	1970	1975	1980	1985	1990	1995	1996	1997
USA	55600	81000	84600	121000	155800	190000	203000	215000	217000	219000
U.K.	11076	13516	18000	20200	22600	24425	24900	26000	30000	30500
France	1902	6489	12000	15000	19000	21500	22800	34250	34500	34800
Germany	4635	11379	16675	19226	20762	22705	44000	46000	46300	46500
Italy	2124	6045	12000	15000	22000	23600	24200	25500	---	---
Mexico	650	1218	1800	2700	3820	8500	12350	20010	25000	25600
Japan	6860	---	35000	40000	62976	70000	75500	85500	85900	86500
Taiwan	0.1	---	---	---	---	---	---	---	---	---
S.Korea	8.0	45	600	2500	6300	7721	9000	15000	15258	15900
Malaysia	0	53	130	452	1200	1800	2640	3300	3500	3600
China	0	---	660	1185	9020	69650	150000	250000	393630	400000
India	0.4	0.8	28	515	3000	10000	27000	47000	57700	63000

Note: --- not available.
Source: UNESCO Statistical Yearbook, China Statistical Yearbook, Statistics Yearbook of Republic of China

The prominence of European countries and Japan initially as TV imitators is underlined by Table 2 and Table 3. Table 2 presents data on the national stocks of TV sets. A previous study (Levy 1981, pp.123-134) showed that in 1960 around 91 per cent of all sets were in USA, European countries and Japan. Even in 1975, these areas still accounted for more than 79 per cent of all sets in use. Thereafter the pattern changed once Asian NICs rapidly developed their TV manufacturing capacity. This significantly increased their domestic consumption as well as exports.

Table 3 presents further data on the diffusion of ownership of TV sets within countries. Again, the USA is seen to have the largest market penetration followed by Japan and European countries. However, early NICs significantly raised their levels of TV ownership from the late 1970s onwards.

Table 3

TV receiver sets per 1000 inhabitants in selected countries and years (unit)

	1960	1965	1970	1975	1980	1985	1990	1995	1996	1997
USA	310	362	403	550	676	786	799	805	805	806
U.K.	211	248	324	359	401	431	433	446	513	521
France	41	133	236	285	353	390	402	589	592	595
Germany	83	193	275	311	337	372	554	564	565	567
Italy	43	116	223	271	390	416	424	446	523	528
Mexico	19	30	36	46	57	113	148	219	270	272
Japan	73	---	335	359	539	579	611	684	683	686
Taiwan	3	---	24	55	55	---	---	---	---	---
S.Korea	0.3	1.6	19	71	165	189	210	334	336	348
Malaysia	0	6	12	37	87	115	148	164	170	172
China	0.02	---	0.8	1.3	9.0	65	130	205	319	321
India	0	0	0.1	0.8	4.4	13	32	51	61	65

Note: --- not available.
Source: Same as for Table 2.

Table 4 provides data for TV receiver prices in the main producing and consuming countries. Initially, a B&W TV receiver in USA was very expensive ($500 in mid-1930s) with the price decreasing constantly as the product matured and standardised. However, the average nominal price of colour TV sets in USA has been relatively stable over the last three decades. Considering the rapid improvement in quality (such as changes from small to large and high density screens and remote control) and increases of income, the effects of inflation, the real price of colour sets has actually decreased considerably. Data for various countries for 1994 shows the sale price differences. Japan had the most expensive colour TV sets, double that of the USA and the EU countries. Other Asian NICs colour sets were much cheaper than those of OECD countries, while China had the cheapest sets of both B&W and colour. According to some surveys (Ernst 1992, Jin 1997), TV products in all countries have experienced a real price decrease in recent times. With accelerated globalisation of production and technology transfer, competition has intensified.

Table 4

A average price of TV sets in selected countries (US$ per set)

Year		1936	1951	1957	1963	1973	1983	1994
U.S.A	(Colour)				345	308	350	341
	(B&W)	500	156	122	115	98	…	…
Japan	(Colour)				…	…	…	763
France	(Colour)				…	…	…	311
U.K	(Colour)				…	…	…	331
Germany	(Colour)				…	…	…	464
Italy	(Colour)				…	…	…	295
	(B&W)				…	…	…	51
Hong Kong	(Colour)				…	…	…	153
	(B&W)				…	…	…	61
Singapore	(Colour)				…	…	…	161
	(B&W)				…	…	…	51
China	(Colour)				…	…	…	123
	(B&W)				…	…	…	31

Note: The average price was calculated as total TV product value/total TV sets.
--- Not available.
Source: USA data is from TV Digest. Vol.32. No. 21 1993. Other data from Jin Pei (1997, pp.255-256).

Table V

Per capita income in US dollars for selected countries and years (1961-2000)

	1961	1967	1972	1975	1980	1985	1990	1996	2000
USA	2817	4036	4984	6324	10094	16844	21857	27420	---
U.K.	1357	1970	2503	3697	8222	---	16939	19847	---
France	1336	2346	3403	5735	10824	---	21077	26374	---
Germany	1300	2075	3769	6035	11759	---	24485	28728	---
Italy	701	1331	1984	3071	6244	7429	19184	21219	---
Mexico	334	528	684	1191	1537	2441	2932	3554	---
Japan	462	1214	2446	3862	7672	11116	24042	36658	---
Taiwan	153	268	505	970	2348	3243	7918	12732	---
S.Korea	153	152	281	527	1355	2277	5917	10698	---
Malaysia	278	315	602	714	---	1990	2394	4824	---
China	---	180	220	240	300	290	341	671	846
India	74	79	130	139	226	277	360	373	---

Note: --- not available.
Source: World Bank World Table, Statistics Yearbook of Republic of China, China Statistics Yearbook 2000 data from People's Daily 5-17, 3, 2001.

Table V indicates changing per capita income patterns among countries. After the end of World War II, the major European countries were preoccupied with post-war reconstruction, but during the 1950s to 1960s their per capita income rose towards income levels in the USA. Income levels in these EU countries (U.K., France and Germany) and in Japan was 5-10 years behind the USA before the mid-1970s and their TV set ownership ratio also lagged behind the USA by about 10 years (see Tables III and IV). Asian NICs income levels were 20 (Taiwan and S. Korea) to 30 (Malaysia) years behind that of the USA, and the relevant TV ownership gap was similar.

One of the most important changes of global ownership of TV sets occurred in China in the post-1980s period. China's demand for TV sets expanded rapidly in this period. In 1975, there were just 1.185 million TV sets in use, less than half the number in Mexico, but by 1997, the figure had reached 400 million, equivalent to the combined number of TV sets in the USA, the four major EU TV producing countries and Japan (Table 2). Ownership of sets per thousand persons in China was only 1.3 in 1975, much lower than in developed countries and the first tier Asian NICs. The figure rapidly rose to 321 in 1997. This latter ratio is much higher than that of most similar middle-low income countries, but is similar to that of some middle-income countries such as Mexico, Brazil, Chile and some middle-high income countries like Greece and S. Korea.

Several factors explain China's low ownership ratio in the pre-1980 period but an important one is its relatively low level of income in this period. Incomes were insufficient in China to provide a reasonable civilian market for sale of TV sets. After 1978, China started to recover from a series of political and economic crises and has since experienced about 20 years of economic growth. However, Chinese per capita income, calculated in U.S. dollar values only showed a limited increase from late 1970s to 1992, despite its two-digit annual economic growth rate. This is largely due to the continuous depreciation of the Yuan. Per capita income in China reached approximately US$959 in 2001 which is still far behind that of developed economies and the first tier Asian NICs.

The relatively high uptake of television sets in China in its present stage of development can be explained by two factors. First, China's real income is greater than its nominal income. Largely due to its socialist orientation: housing, transport and necessities are priced below real market values. According to an International Monetary Fund (IMF) survey, China's per capita income measured by price of Purchasing Power Parity (PPP) was $3,330 in 1996

(World Bank 1998). The same survey found the gaps between nominal and real income in developing countries, especially in previously centralised economies were quite large. Secondly, due to the unbalanced economic development in China, per capita income in the coastal regions and urban areas is much higher than in the inland and rural areas. The average income in the former is double or triple that of the other areas. For example, nominal per capita incomes in Beijing, Shanghai and Guangzhou were $3,000, $4,500 and $ 4,586 respectively in 2001 (*People's Daily* Jan 30, 2002) and these cities have a combined population of 31.3 million (CSY 2001). So there is a higher demand in the urban and coastal areas for electronic consumer durables such as TV sets despite the fact that the country's overall average income is still relatively low (Table V).

On the other hand, India has a low ratio of TV ownership. This can be attributed directly to its lower average level of per capita nominal income ($320 in 1994). Also its per capita real income level was $1,280 (measured by PPP) and, therefore, is at least half that of China. Another factor that assisted market penetration of television in China was local manufacture following the rapid development of localisation using cheap labour, parts and components. This was further assisted by economies of scale. Hence, the cost of China's TV production was reduced considerably and, in turn, this helped stimulate effective demand.

Therefore, demand for TV products and their pattern of diffusion of TV receivers have been broadly consistent with variations in income levels over the last three decades. When incomes rise, sales of TV sets rise. Differences in demand for TV sets are generally related to differences in income levels (i.e. real incomes). When the product enters the mature, standardised stage, demand increases, initially in high, middle-high income countries and then in low-income developing countries. This is consistent with product cycle theory.

5. The Television Production Cycle and Changing Global Location of Production

The product cycle has several implications for changes in the international location of production. According to the product cycle theory, demand in imitating countries will first be served by exports from the innovator. However, when that demand is large enough, producers in the innovating countries will invest in facilities in the imitator country. Those facilities may eventually produce for a third market, and even the home market of the innovator, depending on labour and transport costs.

The theory also considers the production process itself. As the product's specifications become standardised, reducing the need for on-going feedback from consumers, the techniques of production also become standardised. Mass production techniques become feasible, and the need for "external economies" is reduced. At this point, production costs become a key factor in the choice of location. As labour is a significant component of these costs and is the expense showing the greatest variation worldwide, low labour cost countries become prime influences on the location of production, and it becomes increasingly feasible to separate countries of production and consumption.

Table VI presents data on international production of TV sets and Table VII specifies the same data in percentage terms, Table VIII gives B&W production figures, while Table 9 lists colour production figures. Table VI looks at the absolute scale of TV production. In the early years (mid-1940 to late-1950) of B&W, the USA and U.K. were the major producers. Later (from mid-1950s) other European countries and Japan joined in. In colour, USA was the innovator, with Japan and EU countries following. In the late 1960s, Japan took the lead from USA and became the largest colour producer and then kept its lead for almost two decades. During the period 1960/70, production commenced in Taiwan, S. Korea, Mexico, Italy and Malaysia, all relatively low-income countries at that time (see Table 4). However, from the early 1980s onwards, another low-income imitator, China, dramatically increased its TV production and has been the largest single producer globally since 1987 (Table VI).

Table VI

Total production of TV receivers in selected countries and years (1000 units)

	1948	**1952**	**1955**	**1961**	**1966**	**1975**	**1978**	**1987**	**1995**	**1998**	**2000**
U.S.A.	975	5747	7678	6012	11673	7524	9309	12871	12131	11495	11493
U.K.	91	812	1771	1256	1394	2124	2417	3022	4429	---	---
France	1	28	186	808	1350	1606	1854	2184	3205	---	---
Germany		4	316	1728	2276	3356	4105	3537	3309	---	---
Italy			---	855	1238	1595	2031	2233	2780	---	---
Mexico			65	110	299	569	847	609	181	---	---
Japan			312	4609	5652	12625	13577	14777	9023	6608	4912
Taiwan					66	2999	6698	6443	2131	1166	1221
S.Korea					8	1225	5867	10714	18722	12735	14411
Malaysia						102	154	1703	9461	8035	20278
China						178	1319	19344	34962	42760	---
India								972	1540	8900	9481

Note: --- not available.

Source: UN Statistical Yearbook 1953-97; Statistical Yearbook of the Republic of China China Electronics Industry Yearbook and World Electronics Data.

Table VII shows the distribution of production of TV sets from 1948 to 1995 in percentage terms. The innovators and early producers of TV, USA and U.K., produced 91 per cent and 8 per cent of sets respectively in 1948. In 1953 USA still produced 76 per cent and U.K. 13 per cent. Thereafter these figures declined significantly to around 28 per cent (USA) and 11 per cent (U.K.) in the early 1960s and then to 14 per cent and 3 per cent respectively in the 1980s. Early imitators such as France, West Germany, Italy and Japan all experienced an early increase and then a decline in production. Japan's share rose dramatically in the 1960s to mid-1970s but dropped to 7 per cent by 1995. Much of the lost market was captured by other Asian NICs: Taiwan, Korea, Malaysia and later China.

Table VII

Purchases of TV sets as a percentage of total TV set production in selected countries for particular years (%)

	1948	**1953**	**1957**	**1960**	**1965**	**1970**	**1975**	**1979**	**1981**	**1985**	**1990**	**1995**
U.S.A.	91	76	52	28	33	18	15	15	14	14	11	9
U.K.	8	13	15	11	5	5	4	4	3	3	3	3
France		1	3	3	4	3	3	3	2	2	2	2
Germany			6	11	9	6	7	6	4	3	3	3
Italy				1	3	4	3	3	2	2	2	2
Mexico			1	---	1	1	1	1	1	---	---	---
Japan			5	18	14	30	26	21	20	19	12	7
Taiwan						3	6	10	9	3	3	---
S.Korea							2	9	10	10	3	14
Malaysia								---	---	1	17	7
China								2	7	15	21	27
India								---	---	1	---	2

Note: --- not available.

Source: The percentages were calculated using data from UN Statistical Yearbook, Statistical Yearbook of the Republic of China, China Electronics Industry Yearbook and World Electronics Data.

In the late 1940s to early 1960s, the US had by far the largest market penetration of B&W sets (Table VIII). B&W market penetration increased in all the high-income countries, and then declined when colour was introduced. In the UK, USA, Europe and Japan, B&W TV took varying periods to reach the mature and standardised stage after which their output started to decline. Taiwan, Singapore and S. Korea and other imitators such as Malaysia and China took shorter periods to reach the relevant stages.

Table VIII

Production of B&W TV sets in selected countries and for particular years (1000 units)

	1948	1955	1960	1967	1970	1975	1978	1981	1986	1990	1994	1998	2000
U.S.A.	975	7757	5708	4738	3734	1828	1015	57	---	---			
U.K.	91	1771	2141	1240	1743	552	604	171	---	25			
France	1	186	655	1279	1302	1020	196	196	12	9	5		
Germany		316	2164	1820	2064	1124	---	---	---	---			
Italy				1125	1989	1568	---	---	410	450	447		
Mexico		65	80	333	393	489	---	---	---	---			
Japan		137	3578	5756	7383	4980	5378	4330	904				
Taiwan				112	1226	2599	5040	5273	2228	1299	796	77	59
S.Korea				28	114	2300	---	---	6928	3568	229	5	3
Malaysia					44	102	150	159	17	69	300	80	68
China				5	1	98	279	2447	10444	15632	12762	6330	---
India						---	---	80	850	1150	5200	5500	5212

Note: --- not available.
Source: UN Statistical Yearbook; UN Statistics Yearbook for Asia and the Pacific; Japan Statistics Yearbook, Statistics Yearbook of Republic of China; Korea Statistics Yearbook; some of EU countries and Asian NICs data from World Electronics Yearbook Data and China data from China Electronics Industry Yearbook.

Table 9

Production of colour TV sets in selected countries and for particular years (1000 units)

	1956	1964	1967	1970	1974	1981	1986	1990	1994	1998	2000
U.S.A.	59	1340	4963	4564	6930	10025	12277	14500	14848	11495	8931
U.K.			32	471	1874	---	2755	2790	4002	---	
France			21	209	674	---	1742	2500	3043	---	
Germany			97	872	2363	---	3895	3226	3037	---	
Italy					311	---	1490	2115	2229	---	
Mexico			8	30	58	---	1742	2500	---	---	
Japan		57	1282	6399	7323	11630	13809	13243	11192	6567	4912
Taiwan				28	418	1650	3988	2403	1482	1066	1162
S. Korea					36	---	6996	12893	16999	10598	14408
Malaysia							884	2900	10700	13000	20211
China					2	150	4146	10229	16371	36430	38000[2]
India							850	1150	1330	3400	4269

Note: --- not available.
Source: Same as Table VIII. China data in 2000 is 2001 data, from *People's Daily*, September 3, 2002.

Colour TV was introduced in the late 1950s and colour receivers immediately began replacing B&W sets (Table 9). Production of colour sets spread via foreign direct investments (FDI). For example, the USA invested in Mexico and Taiwan, Japan invested in

Taiwan and S. Korea and Germany invested in Italy. In these cases, multinationals played an important role in the initial production of TV sets by host nations. MNCs dominated

production. The host country, especially if a small LDC often merely assembled the sets or just produced a few components. Expansion of production in host countries was led partly by local demand but mostly by exports. This is indicated by the high ratios of production/consumption in those countries (Table VII). These results are consistent with Vernon's theory.

6. China's Rise as a Global Producer of TV sets

Now consider further the evolution of China's production of TV sets. In the early 1980s, there was only limited production of B&W TVs and little colour TV production in China. However, during the 1980s, more than a hundred production lines were imported by China, 60 per cent of which were from Japan. The introduction, mastery and operation of these imported technologies and facilities rapidly increased the China's capacity to produce both B&W and colour sets.

Following the rise of China's TV production, the global pattern of production changed significantly with China replacing Japan in quantitative terms as the single largest producer of TV sets in the mid-1980s. Its output accounted for 27 per cent of world TV production in 1995. In 1989, its production reached 16.77 million sets. This amounted to about 48.7 per cent of the world's total output (Jin 1997). Even though the volume of China's B&W production fell sharply afterwards, China still accounted for about 51 per cent of world gross output in volume terms of B&W sets in 1998. By the end of 1994, China had become an important world producer of colour TV sets and its colour set output continued to grow and reached 38 million sets (Table 9) or 23 per cent of world output in 2001.

Vernon (1979) assumes that the transfer of standardised products to low-income countries is via MNCs because the host country's technological and productive capability would be inadequate initially. He envisages multinational companies more developed nations as prime movers in international technology transfer relocation of production of new products. Contrary to this as a LDC, China successfully developed and produced many TV products by itself and played an active role in acquiring TV technology and expanding its production of TV sets. There are several reasons for this.

1) A large local market in China allowed for massive levels of production and encouraged local competition and cost reduction. 2) An appropriate pattern of technology transfer was adopted. China was technically backward and production commenced by adopting embodied technology such as turnkey capital goods as a quick start to increasing production and substituting for imports. This also produced an industrial and technological base to narrow its technological gap with advanced industrial countries. 3) Economies of scale were developed by policy intervention. In the 1980s, most TV enterprises in China were small and the government adopted measures to promote the development of large companies in order to increase their competitiveness. In 1998, the top ten electronic manufacturers produced 80 per cent of all local produced colour sets in China. The Chang Hong Company alone made 23 per cent of all sets. In B&W, the concentration ratio was even greater, with the top five producers making 80 per cent and the top two enterprises accounting for 63 per cent of all output. 4) Effective industrial promotion was undertaken. China implemented a series of financial, institutional, trade and technological measures to overcome funding and technical bottlenecks experienced in industry and upgrade its industrial structure. Technical transfer and diffusion accelerated and improved technical competence in China.

In the development of the TV industry, China followed a strategy of combining assimilation and innovation in order to achieve overall technological upgrading as well as to promote the localisation of TV manufacturing and the utilisation of local resources.

The industry's technological capability improved and by the mid-1980s, forty-eight colour TV models had been developed, including models using dual circuit boards, dual screens and dual language systems. The technological level of production generally reached or exceeded international standards in the early 1980s, with reliability and consistency indicators raised significantly to an average of 15,000 hours (average international standard) of effective operation for TV sets (Feinstein 1997) and some brands even reached 30000-40000 hours of operation. By mid-1990s, China produced almost the whole range of TV models available in the world market. The quality of sets reached high standards.

This improvement also reflected changes in technology transfer mechanisms. By 1993, although imported embodied technology remained the main mechanism, none-the-less, some 20 per cent of imports took the form of licensee purchases. Advanced technology, such as CAD/CAM (computer-added design/computer-added manufacturing), was applied to production and new models and functions at the forefront of international trends were being

developed. By the late 1990s, the Chinese industry had been transformed from an assembler of imported SKD/CKD kits to one capable of using CAD/CAM technology in product and process development and of turning out products with more than 95 per cent local content. Colour picture tube (CPT) production reached 32.7 million units (13 per cent of world output) and satisfied 90 per cent of local demand. Integrated circuits were the least developed of TV components in China. However, production of these quickly developed to a stage where the locally made units met a quarter of local demand in 1998 with annual growth thereafter of about 25-30 per cent. China's target of localisation on television production was thus basically achieved.

7. Conclusion

This case study of TV development supports two hypotheses of the product cycle theory: The first is that product diffusion basically followed demand in this case. Variations in demand are for TV sets mainly caused by differences in income levels, measured by per capita income, when tastes are similar. When measuring the income level, the real income level needs to be considered, especially for transitional economies and LDCs. Following rising incomes in the EU, Japan and other Asian NICs (including China), TV production in those countries increased significantly. Evidence from the TV industry provides continuing support for the existence of an international product cycle in TV set production. In the new product stage, innovating firms enjoyed a temporary monopoly. The existence of lower wages in other countries acted as an incentive to transfer the technology to imitating countries where production costs were reduced. Production migrated from innovators to early high and middle-high income imitators when the product matured. Then, following the spread of industrial development and to take advantage of lower labour costs, it again moved to relatively low-income late imitators when the product becomes standardised.

The development of the TV industry confirms that in the era of globalisation, product life cycle still exists and that the relevant phases can be identified even though they are shortened. The majority of television products such as B&W, colour and digital TV were innovated in a handful of developed countries (U.K., USA and later in Western Europe and Japan). This review reveals that the movement of the location in innovation is much slower than movement of the location of TV production due to the relatively low technological capabilities and low levels of R&D expenditure of developing countries. This suggests that Vernon's hypothesis that innovation is normally carried out in high-income countries still

applies. However, low-income countries may eventually become higher income ones, as Japan did, and as China may do. They then can become industrial leaders.

When early and later imitators begin manufacturing mature and standardised products, innovators develop new products and upgrade their industrial structure in order to maintain competitiveness. While the international product cycle continues to be driven in many cases by the economic interests of multinationals in the manner traditionally claimed, patterns of international production and technology transfer are now more complex and varied in practice. Receiving nations are not necessarily passive, as China's position reveals. A dynamic two-way movement occurs. China's TV development suggests that technology transfer and changing of production location is not only led by overseas investment by MNCs but actively results from the desire of some developing countries to catch up to higher income nations. This is evident from Northeast Asian experience; first of Japan, then more recent NICs and now China. This development is largely beyond Vernon's prediction and has not been covered by recent industrial economic literature. In other words, government directed catching-up effort by relatively backward countries can be a significant driving force for changing production location of standardised/mature products. However, the relevant literature usually assumes that the multinationals located in higher income countries are the dominant driving force for industrial relocation with recipients being relatively passive in their acceptance of production transfers. Industrial policies pursued in China (and more generally in Northeast Asia) require this perception to be modified.

While this article finds that changes in global location of production in the television industry accord with many aspects of the international product cycle, production transfer has not been driven entirely by multinational companies in high-income Western countries. Particularly in Northeast Asia, governments of recipient countries have been important players. First they have, through their industrial policies, facilitated technological catch up with Western and high income countries. Subsequently, as in the case of China's TV industry, they have moved to reduce their technological dependence on high-income countries. A further step in many cases has been to use their own multinational companies to invest in higher income countries and reverse or almost reverse the dominance of these nations in TV production. Japan and Korea have followed this strategy, and China may be embarked on a similar course, judging from the development of its TV industry.

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