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**Responses to the Crisis:
Constraints to a Rapid Trade Adjustment
in East Asia's Electronics Industry**

Dieter Ernst
March 1999

**RESPONSES TO THE CRISIS:
CONSTRAINTS TO A RAPID TRADE ADJUSTMENT IN EAST ASIA'S
ELECTRONICS INDUSTRY**

by

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ABSTRACT

It has been argued that "... trade adjustment in East Asia...will be rapid and sizable, lifting aggregate growth in these economies even as the domestic non-tradable sectors continue to suffer a decline (as in Mexico)" (World Bank, 1998, p.5). Much hope has been pinned on the electronics industry to come through with rapid growth through expanding exports. Two arguments appear to bolster such an expectation: the severity of the region's currency depreciations has lowered the cost of much of its electronics supply base relative to its competitors; and the electronics industry's proven track record as an engine of export-led growth shows that it can be quickly started and accelerated in response to changes in the market.

However, no export boom in electronics has (as yet) materialized. The paper analyzes what explains this puzzle. We first introduce a *taxonomy of East Asia's electronics firms and market segments* to distinguish *different capacities to ride out the crisis*. We then discuss three barriers to an East Asian export boom in electronics: i) *supply-side constraints* that result from limited access to trade finance, and from the cost-increasing impact of local currency depreciations in highly import-dependent countries; ii) *demand-related constraints*, resulting from deteriorating growth perspectives in East Asia's electronics export markets; and iii) *deflationary pricing pressures*, resulting from a *narrow specialization in high-tech commodities* that are characterized by *periodic surplus capacity* and *price wars*. Combined, these barriers have produced a vicious circle: once exports increase, net volume gains are likely to be offset by pricing losses.

Key words

Crisis; industrial dynamics; specialization; deflation; Asia; electronics industry

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INTRODUCTION

We now understand well the initial triggers of the Asian crisis that result from an exposure to global financial markets: research highlights *endogenous* failures of international capital markets¹ and domestic policy failures, especially for financial regulation². It is time to move on to an analysis of possible responses. Elsewhere, I have analyzed how the crisis reshapes the region's longer-term industrial upgrading options (Ernst, 1998b and 1999c). In this paper, I focus on *short-term* responses and discuss a *puzzle* related to rapid trade adjustment³.

A PUZZLE

Both Japan and important East Asian countries are currently in the grip of debt deflation. In a debt deflation, companies devote income to trying to reduce excessive debt rather than spending it on consumption or investment. But what makes sense for individual companies does not make sense for economies. In an economy gripped by private sector debt deflation, activity can be sustained only by expanding fiscal deficits, improved external balances, or both. Most Asian countries do not have the first option, as it is excluded by IMF agreements. They are thus forced to rely on the second option, which indicates how dramatic are pressures to export one's way out of the crisis.

It has been argued that "... trade adjustment in East Asia...will be rapid and sizable, lifting aggregate growth in these economies even as the domestic non-tradable sectors continue to suffer a decline (as in Mexico)" (World Bank, 1998, p.5)⁴. Much hope has been pinned on the electronics industry to come through with rapid growth through expanding exports.

Two arguments appear to bolster such an expectation: the severity of the region's currency depreciations has lowered the cost of much of its electronics supply base relative to its competitors; and the electronics industry's proven track record as an engine of export-led growth shows that it can be quickly started and accelerated in response to changes in the

¹ Stiglitz, 1997; Sachs, 1997; Jomo, 1998; Wade and Veneroso, 1998; and Palma, 1998

² Chang et al, 1998; Garnaut and McLead, 1998; and World Bank, 1998 b and c.

³ If not mentioned otherwise, data on East Asia's electronics industry are based on interviews (March and September 1998, and from: Ernst, 1998b. See also Ernst, 1998 a (for Korea); and Ernst 1999 b (for Taiwan).

⁴ "Given their deep exchange rate depreciations, EA5 (= Korea, Malaysia, Indonesia, Thailand and the Philippines) exports are expected to rebound by 18% in 1998 and 12 percent in 1999. Sharply lower GDP

market⁵. Since July 1997, the countries worst affected have seen the value of their currencies fall by between 35% and 70% against the US dollar⁶ - which in principle should feed into a substantial reduction of export prices. And rapid export expansion in line with shifting comparative advantages has been one of the great achievements of the region's electronics industry.

However, no export boom in electronics has (as yet) materialized. For instance, Korea's electronics exports during the first half of 1998, on a year-to-year basis, declined by more than five per cent in US dollar terms (courtesy of the Electronics Industry Association of Korea); and Singapore's disk drive exports during the first quarter of 1998 declined by almost five percent (again in US-\$ terms, courtesy of the Trade Development Board, Singapore).

What explains this puzzle? We first introduce a *taxonomy of East Asia's electronics firms and market segments* to distinguish *different capacities to ride out the crisis*. We then discuss three barriers to an East Asian export boom in electronics: i) *supply-side constraints* that result from limited access to trade finance, and from the cost-increasing impact of local currency depreciations in highly import-dependent countries; ii) *demand-related constraints*, resulting from deteriorating growth perspectives in East Asia's electronics export markets; and iii) *deflationary pricing pressures*, resulting from a *narrow specialization in high-tech commodities* that are characterized by *periodic surplus capacity* and *price wars*. Combined, these barriers have produced a vicious circle: once exports increase, net volume gains are likely to be offset by pricing losses.

A TAXONOMY OF FIRMS AND MARKET SEGMENTS

A stylised *taxonomy* of East Asia's electronics firms and market segments highlights a strictly *hierarchical* industry structure: *global brand-name multinationals dominate and shape the development of all the other layers of East Asia's electronics industry*. Clearly, some firms are "more equal than others", to paraphrase George Orwell, in terms of their

growth and real exchange rate depreciations are simultaneously expected to cut EA5 import growth to a negative 2 percent in 1998 and to 6 percent in 1999." (World Bank, 1998a, p.6)

⁵ For case studies, see various contributions in Ernst, Ganiatsos and Mytelka, 1998

⁶ Real effective exchange rates, courtesy of Morgan Guarantee Trust Company, Economic Research. Historical effective exchange rate indices are available through the Internet at: www.jpmmorgan.com

capacity to ride out the crisis. We will see that multinationals have little difficulties to adjust, and that it is local firms, primarily low-end suppliers to global production networks⁷, that are most likely negatively affected.

Five *layers* can be distinguished:

- On top, the industry is dominated by foreign MNCs which control *global brands and architectural design standards* (Henderson and Clark, 1990) for computer, communications and consumer applications⁸.
- A second layer consists of large firms (mostly foreign MNCs) that dominate the production of *key sub-assemblies and components* like hard disk drives (HDD), picture tubes or displays, and semiconductors (especially DRAM)⁹.
- A third layer consists of small group of *local original-brand-manufacturers (OBM)*, such as Samsung and LG in Korea, Acer in Taiwan and Creative Technology in Singapore.
- A fourth layer comprises *contract manufacturers* which can be foreign firms like Solectron and SCI, or Asian firms like for instance Venture Manufacturing, Flextronics, in Singapore, and many others¹⁰.
- Finally, a fifth group of actors consists of many *small-and-medium-sized suppliers of a great variety of components and support activities*, located all over the region. This includes for instance plastic moulding, metal stamping, tool and die making, precision parts and components, electroplating and finishing, mold making, jigs and fixtures,

⁷ The concept of an global production network (GPN) is an attempt to capture the spread of broader and more systemic forms of international production that cut across different stages of the value chain and that may or may not involve equity ownership. Such networks constitute an important organizational innovation that enable multinational corporations to cope with the conflicting requirements of specialization and coordination. The concept allows us to analyze the globalization strategies of a particular firm with regard to the following four questions: 1) Where does a firm locate which stages of the value chain? 2) To what degree does a firm rely on outsourcing? What is the importance of inter-firm production networks relative to the firm's internal production network? 3) To what degree is the control over these transactions exercised in a centralized or in a decentralized manner? And 4) how do these different elements of the IPN hang together? This concept has been developed in studies prepared for the OECD (Ernst, 1994b), the Sloan Foundation (Ernst, 1997b); and the Brookings Institution 1997 (Ernst, 1997a). See also Ernst, 1999a.

⁸ Main actors include a handful of global players like Microsoft, Intel, Cisco, Compaq, HP, Dell, IBM, Sony, Fujitsu, Toshiba, Ericsson, Motorola, Siemens, Philips, Matsushita, Sharp and Canon.

⁹ For DRAM for instance, this includes foreign multinationals (like Texas Instruments, NEC, Toshiba and Hitachi); Asian companies such as Samsung Electronics (the world industry leader), and LG (from Korea), Acer Semiconductor Manufacturing (ASMI), Nanya Plastic and others (from Taiwan); as well as alliances between multinationals and state-owned enterprises, such Singapore's Chartered Semiconductor Manufacturing, Tech-Semiconductor and Tri-Tech.

¹⁰ While traditionally these firms have focused primarily on printed circuit board assembly, they have recently expanded into the final assembly and shipment of PCs and digital consumer and communication devices (= "complete-box-build-and-ship").

casting and industrial automation equipment. Apart from a number of Japanese suppliers, many of these suppliers are small, local companies with very limited capital resources.

This stylised taxonomy can help to improve and fine-tune the findings of macro-economic analysis: it enables us to highlight some fundamental differences in terms of size-related economies of scale and scope, financial clout, technological capabilities and market access that only emerge once the analysis has been pushed down to a sufficiently disaggregated level. The firms in the top layer obviously have much *greater opportunities to cope with the impact of the crisis than firms on the respective lower layers*.

SUPPLY-SIDE CONSTRAINTS TO AN EXPORT EXPANSION

A very fundamental constraint is that Asian exporters now have trouble finding containers to ship their goods, because so few are arriving carrying imports¹¹. In addition, two of the most pressing obstacles are: i) a shortage of credit that results from the devastation of the financial sector - Asian exporters face very serious constraints in their access to trade finance; and ii) the negative impact of devaluation on the cost of imported materials and machinery.

Access to trade finance

Access to trade finance is no problem for MNC affiliates, especially if they are located in a country that has an open capital account. In Singapore for instance, foreign affiliates can bring in US-Dollars and transfer them abroad at their discretion. There are no foreign exchange regulations. Furthermore, MNC affiliates have no problems of obtaining letters of credit. Under pressure from the IMF, most countries in the region have moved in a similar direction and have opened up the capital account.

Especially in the EA-5 countries, the IMF's prescriptions, such as tight monetary policies and the restructuring of the financial systems, have severely hit exports: local electronics firms are squeezed by high interest rates, and they have great difficulties to find a bank willing to provide trade credit. Such pressures are severe for the highly leveraged Korean

¹¹ Maersk, the Danish shipping company, for instance currently ships its containers empty to Singapore and then fills them up with exports from the region. This is extremely costly and may not be sustainable for long (Interview at Danish Industry Association).

chaebol: they all actively court foreign multinationals for M&A arrangements, in order to reduce their horrendous debt. An additional financial constraint to exports is the difficulty of securing letters of credit through local banks, none of which now is regarded internationally as creditworthy. This has caused a dramatic decline in Korea's input imports: "Importing capital goods has become very difficult for most South Korean companies...No signs of recovery in imports can be seen..." (Yoshiaki Usami, director of the Seoul branch of JETRO, as quoted in Nikkei Weekly, February 9, 1998).

Access to trade finance is clearly a major problem for Asian contract manufacturers and subcontractors. In general, the lower a firm is positioned along a particular product's supply chain, the more it has been negatively affected by restricted access to trade finance. This increasing inequality also applies in geographic terms: suppliers that are located in Malaysia and Thailand are much more affected by these credit constraints than Singapore-based suppliers. This has two important negative implications for the long-term upgrading potential of East Asia's electronics industries: For each individual country, it strengthens an industry structure that is characterized by an *inverted production pyramid*: the pyramid's top, i.e. final assembly, keeps expanding, *despite* the weakness of the pyramid's base, i.e. an immature set of support industries. In other words, *capacity expansion proceeds without industrial deepening*. Second, and more general, this reduces the role that smaller firms can play as engines of export growth. Overall, the crisis is likely to have a negative cascading effect that increases inequality and that may block further industrial upgrading. In order to counter such negative trends, corrective policy instruments have been discussed in various forums, but so far very little has been achieved.

Devaluation and import prices

East Asia's electronics industries heavily depend on imports of key components, subassemblies and production equipment. While import content ratios are not available¹², it is possible to construct proxy indicators. Table 1 documents the critical role played by electronic components, and especially semiconductors (SC) both for electronics imports and

¹² Import content ratios differ from product to product, and even for a given product, they differ from company to company. This obviously poses severe methodological problems for the collection of such data. An important objective for future research is to conduct a questionnaire survey to collect a representative set of product-specific import content ratios and to document how these ratios have developed over time.

merchandise imports. In the extreme cases of Malaysia and Thailand, electronic components account for almost 30% respectively almost 25% of merchandise imports. And among the four leading East Asian electronics producers (Korea, Taiwan, Singapore and Malaysia), components on an average account for three quarters of their electronics imports.

Table 1: Share of components in electronics imports and merchandise imports, 1996 (%)

| Country/share | Electronics imports | Merchandise imports |
|-------------------|---------------------|---------------------|
| Korea | Components:74.3 | Comp: 10.1 |
| | -- SC: 49.2 | -- SC: 6.7 |
| Taiwan | Comp: 81.3 | Comp: 16.9 |
| | -- SC: 53.1 | -- SC: 11.0 |
| Singapore (1997) | Comp: 61.0 | Comp: 24.2 |
| | -- SC: 37.5 | -- SC: 15.0 |
| Malaysia | Comp: 82.7 | Comp: 29.6 |
| | -- SC: 53.5 | -- SC: 19.1 |

| | | |
|------------------|-------------|-------------|
| Thailand (1995) | Comp: 69.4 | Comp: 12.5 |
| | -- SC: 33.3 | --- SC: 6.5 |
| Philippines | Comp: 74.2 | Comp: 20.3 |
| | -- SC: 55.5 | -- SC: 15.2 |
| Indonesia | Comp: 65.2 | Comp: 3.2 |
| | -- SC: 5.0 | -- SC: 0,2 |
| Hong Kong (1997) | Comp: 51.6 | Comp: 13.3 |
| | -- SC: 24.3 | -- SC: 6.3 |
| China | Comp: 67 | Comp: 7.6 |
| | -- SC: 23.3 | -- SC: 2.6 |

Source: Ernst, D., 1998, Destroying or upgrading the engine of growth ? The reshaping of the electronics industry in East Asia after the crisis, study prepared for the World Bank report East Asia - The Road to Recovery, The World Bank, Washington, D.C. , September

The tenacity of the region's import dependence in electronics becomes clear when we look at the two most prominent success stories: Korea's semiconductor industry and Taiwan's PC industry. Despite all their impressive achievements, both industries remain heavily dependent on input imports. Korea's semiconductor industry is based on an extremely weak foundation, in terms of the materials and production equipment required. Korea's current annual consumption of semiconductors materials is approximately \$600 million, with 70% of total consumption being imported (40% from Japan and 20% from the United States). As for the production equipment, 90% have to be imported, with 50% originating from Japan. In Taiwan's PC industry, a rapid expansion of production capacity and international market share has not been matched by industrial deepening. For most of the key components that determine the price and the performance features of its major export products, Taiwan continues to rely heavily on imports, primarily from Japan. Picture tubes for computer monitors provide an example: nearly two thirds have to be imported, either from Japan or from Japanese affiliates in Southeast Asia. The situation is equally severe for display panels, a key component for Taiwan's thriving portable PC industry. Taiwan has to import virtually all of the high-end flat panel displays that are used in its portable PCs, and the supply of these devices is controlled by a tightly knit oligopoly consisting of Sharp, a Toshiba-IBM joint venture and NEC, with Hitachi and Matsushita being important second-tier producers¹³.

A high import dependence constitutes an important barrier to export expansion. It implies that local currency depreciations will lead to substantial price increases in key components and machinery required for Asia's electronics production. For both products, import prices are normally quoted in US-dollars¹⁴. As a result, the massive devaluation imposed by the Asian crisis has led to an equally massive increase of import prices, at least for Asian companies that rely on open market purchases (Author's interviews, September 1998). This is likely to be very different for Asia-based MNC affiliates. Many of their transactions take place as intra-firm trade, where sophisticated *transfer pricing* techniques can shield these

¹³ This heavy dependence on component imports from Japan has been the root cause for Taiwan's exploding electronics trade deficit with Japan: Taiwan's trade deficit in components is currently responsible for around 70 percent of its total electronics trade deficit with Japan (Ernst and Guerrieri, 1998)

¹⁴ There are now some discussions in Japan whether a shift to Yen-denominated prices would enable Japanese suppliers of materials and machinery to preserve their important markets in Asia. It is unclear however what will be the outcome of these discussions.

affiliates from an increase in import prices¹⁵. To the degree that they buy from independent sources, they engage in global sourcing: large orders usually enable them to request substantial price discounts. This is an option which does not exist for most Asian electronics firms, with the exception of some chaebol and some large Taiwanese business groups¹⁶.

DEMAND-RELATED CONSTRAINTS

The scope for trade adjustment depends to a very large degree on *demand-related* factors. This raises two questions: Where are the main export markets for East Asia's electronics industry? And can these markets absorb a substantial increase in the region's electronics exports?

A basic dilemma

The outbreak of the Asian crisis has brought back into the limelight a basic *dilemma* that has accompanied the development of the region's electronics industry almost from its beginning: How to balance different markets for its products? Should the focus primarily be on the US and Europe, or should there be a shift toward *intra-regional* trade?

Initially, a heavy reliance on exports to the US and Europe has helped to compensate for insufficient domestic market size and lack of sophisticated demand; it also helped to insulate individual Asian economies from economic turmoil within the region. Until well into the second half of the 1980s, the lion's share of these exports went to the US and Europe: in 1987 for instance both markets together accounted for 84.4% of the exports of the four leading Asian NIEs; for ASEAN countries, this share was even higher, at 93.2%¹⁷. The US market alone accounted for more than 58 % for NIE exports, and 67% for those originating from ASEAN countries - only Mexico, unsurprisingly, displayed a higher degree of US market dependence. Both the Japanese market and the East Asian markets accounted for a very small share of East Asia's electronics exports.

¹⁵ The role of transfer-pricing for inter-firm trade poses serious methodological problems for attempts to conduct a reliable quantitative analysis of price effects resulting from currency devaluations.

¹⁶ Kim Youngsoo, 1998, provides a fascinating case of the difficulties faced by Samsung Electronics in its attempt to develop a global sourcing network.

¹⁷ Ernst and O'Connor, 1992, chapter III, table 13. *NIEs* here include Korea, Taiwan, Singapore and Hong Kong, while *ASEAN* countries exclude Singapore.

The flipside of this strategy however has been a heavy exposure to the highly volatile business cycles of a handful of electronics exportables. The response to this dilemma has been a rapid growth of intra-regional trade which, especially since the early 1990s, has become one of the hallmarks of the “Asian Miracle”¹⁸. Two years ago, in 1996, the main concern was a demand glut for DRAM and consumer electronics which had caused a dramatic crash in the region’s exports. Trade regionalization was considered to be a powerful countervailing force that could help to mitigate this fundamental weakness. The result has been a significant increase in intra-regional exports, including exports to Japan.

Intra-regional trade

Over the last few years before the crisis, East Asia has become a strategic growth market for its electronics industry. Table 2 documents that an increasing share of the region’s electronics exports is now staying within the region (exclusive of Japan)

Table 2: An Increasing Share of Intra-regional Electronics Exports, 1991-1996 (%)

| Country/year | 1991 | 1996 |
|--------------|------|------|
| Korea | 21.5 | 31 |
| Taiwan | 20.5 | 27.9 |
| Singapore | 26.2 | 37.6 |
| Malaysia | 39.5 | 41.6 |

= share of a country’s electronics exports to East Asia (exclusive of Japan) out of its total electronics exports (%)

Source: Ernst, D., 1998, Destroying or upgrading the engine of growth ? The reshaping of the electronics industry in East Asia after the crisis, study prepared for the World Bank report East Asia - The Road to Recovery, The World Bank, Washington, D.C. , September

¹⁸ Over the last decade, intra-regional trade has made an increasing contribution to growth: in 1996, its share in East Asia’s total exports accounted for about 40%, up from 32% in 1990. If Japan is included, the share of intra-regional trade rises to 50% (World Bank, 1998b). Trade theorists argue that this reflects the region’s increasing specialization, based on shifting comparative advantages (Balassa, 1977). The most prominent version of this argument has been the *flying geese* theory (based on Akamatsu, 1962). Recent research however has shown that the expansion of intra-Asian trade is due primarily to the spread of increasingly complex global production networks (GPN) (Ernst and Guerrieri, 1998)

Similarly, East Asia has become an important source of Japanese electronics imports¹⁹. Until the outbreak of the crisis in 1997, Japan's imports of electronics products have been growing very rapidly, and Asia has become the most important source of these imports. Asia's share in Japan's total electronics imports has surged from less than 31% in 1988 to almost 58% in 1996 (Ernst, 1998 WB)²⁰.

Table 3 documents these dramatic changes for Korea's electronics exports: between 1991 and 1996, the combined share of North America's and Europe's markets decreased from almost 51% to slightly more than 41%, leading to a massive increase in the share of East Asia and other emerging markets.

Table 3: Korea - Direction of Electronics Exports, 1991-1996(%)

| Share/year | 1991 | 1996 |
|-------------------|------|------|
| North America(NA) | 32.5 | 27.5 |
| NA & EU-15 | 50.5 | 41.2 |
| Japan | 10.1 | 10.8 |
| NA&EU&Japan | 60.6 | 52.0 |
| East Asia | 21.5 | 31.0 |
| East Asia & RoW | 39.4 | 48.1 |

Source: Ernst, D., 1998, Destroying or upgrading the engine of growth ? The reshaping of the electronics industry in East Asia after the crisis, study prepared for the World Bank report East Asia - The Road to Recovery, The World Bank, Washington, D.C. , September

The result is that almost 60% of Korea's electronics exports are destined for markets where demand is now either stagnating or declining. This includes Japan, with 10.8 %, and a

¹⁹ Despite its close proximity, East Asia has surprisingly played a much less prominent role as a source of Japanese electronics imports than it did for the US (Ernst and Guerrieri, 1998). Until 1990, Japanese electronics imports overwhelmingly originated from the US, and even in 1993, East Asia's share was significantly lower than that of the US.

²⁰ In absolute terms, Japanese electronics imports continue to be substantially smaller than those of the US: in 1996, Japan's total electronics imports were \$47.439 billion, less than one third of the US total of \$ 151.5 billion. This however is a substantial improvement relative to 1991, when Japan's total electronics imports were worth only 20% of the US worldwide electronics imports. The most rapid increase has occurred for electronic components, where the import ratio shot up from 16% in 1985 to more than 35% in 1993. While in 1988, the US was the only source of imported ICs and computers, Japan now imports roughly the same amount of ICs and computers from Asia and from the US.

48.1% share for emerging markets in East Asia²¹, Latin America, Eastern Europe, Russia and the rest of Asia, up from 39.4% in 1991. These figures indicate a disturbing dependence on markets that are highly vulnerable to contagion from the Asian crisis; demand is falling in most of these markets. In addition, a high dependence on emerging markets has three substantial disadvantages: i) there is less pressures to upgrade product performance and quality; ii) there is less exposure to sophisticated customers; and iii) it gives rise to an extreme vulnerability to exchange rate fluctuations. Given Korea's sticky pattern of specialization, it is no longer possible to claim that Korean firms "make products that sell in the most demanding markets - if the exchange rate is right." (Wade and Veneroso, 1998, p.1)

The impact of the crisis: East Asia's shrinking markets

The outbreak of the crisis has again reversed the agenda. Paradoxically, *intra-regional trade* has now become a liability because it provides a perfect *channel* for the *contagion* to spread swiftly through East Asia. The primary concern now is to reduce the industry's vulnerability to economic turmoil within the region: debates centre on the role that the electronics industry could play in sheltering the region against crisis contagion.

Has there been a shift of East Asia's electronics exports away from Japan and East Asia, throwing the region back into a heavy reliance on exports to the US and Europe? We still lack systematic trade data for the electronics industry, covering the period since July 1997. Proxy indicators however clearly indicate a dramatic downward trend in East Asia's electronics markets. During 1998, the computer market in Asia (including Japan) has declined by 7% on a yearly basis. It is thus safe to assume that electronics exports to the rest of the region will fall drastically, as all of these countries are now struggling with a severe decline in domestic demand, and as most of them lack the financial resources for new investment and imports.

Exports of consumer electronics and of related components are most vulnerable to the impact of the financial crisis, for two reasons: i) East Asia has already substantial surplus production capacities; and ii) demand for these products in EA-5 countries has dropped sharply by about 70 to 80% on a year-to-year basis during 1998. But demand in most of

²¹ East Asia itself accounts for almost one third of Korea's electronics exports, up from 21.5% in 1991.

these economies is also likely to decline for computers and telecommunications equipment, given the massive decline projected for capital expenditures in the region.

As Japan is in the throes of a severe recession, its imports from Asia have collapsed: while overall, Japan's imports fell by 15% (during the first half of 1998), imports from every Asian country were down, with Malaysia, Vietnam and Indonesia suffering the biggest falls, down respectively 22 percent, 23 per cent and 30 percent. Taiwan's exports to Japan, its third largest export market, fell by almost 24% during the first quarter of 1998.

In short, the *coexistence of the Asian financial crisis and Japan's deflationary downward spiral* has created an explosive mixture of forces that could play havoc with the region's established trade patterns: in response to a drastic fall of their intra-regional exports, most Asian countries, including China, are now under tremendous *pressure to shift their exports away from Asia as well as Japan, to the U.S. and Europe*. The question of course is whether they will succeed in implementing such a shift in their export markets.

It is a scary thought that the US trade deficit is at its highest level in nine years, even though the full impact of the Asian crisis has yet to be felt. In 1997, the US trade deficit in manufactured goods rose by 4.1% to a record \$172.6bn. Most of the increase was accounted for by rising deficits with China and Japan: in December 1997, the U.S. trade deficit with China has increased by 45% on a year-to-year basis (Nikkei Weekly, March 16, 1998); and Japan's trade surplus with the US rose 66% from a year earlier to Y493.85bn (Financial Times, February 20, 1998, p.22, citing Japan's Ministry of Trade and Industry trade figures). This, no doubt, is an unfortunate starting-point for the US to absorb an expected export boom from Asia. Since then, the combined effect of the declining demand in Asia and a surging US dollar has produced a further sharp deterioration in the US trade position. Sooner or later, this may well invite a protectionist response.

In short, Asian economies should not expect too much from devaluation-induced export expansion: there are very little chances that exporting one's way out of the crisis will produce the expected results. One reason is the familiar *trade restriction trap*: once a substantial increase in Asian exports would deteriorate the US current account, this may lead to vigorous trade restrictions. A second reason could be a *worsening of East Asia's terms of trade*: whatever expansion will occur in its export volume, these gains are likely be more

than compensated by substantial price declines. We will now turn to an analysis of such effects.

CONSTRAINTS RESULTING FROM DEFLATIONARY PRICING PRESSURES

Deflationary pricing pressures dominate many if not most sectors of the electronics industry that are of relevance to East Asia. This has given rise to a further set of constraints to a devaluation-induced export expansion: even if East Asian electronics industries succeed to expand their export volumes, negative pricing effects may erase such gains.

It is important to emphasize that local Asian firms are likely to be more vulnerable to such negative pricing effects than MNC affiliates. Established market leaders with a strong global brand image can cope with these pressures: they can charge premium prices, and they can shift the burden of cost reduction onto other shoulders, primarily their Asian suppliers. For the latter companies, this magnifies the pressure to reduce their prices. At the same time, they are under tremendous pressure to broaden their capability base and to increase their investment outlays, simply to sustain their link with their main global customers. There is a substantial risk that, once devaluation is reversed, Asian suppliers will find themselves being caught in a higher-cost production structure than before the crisis. But then they will be unable to back away from the price reductions which they have granted in response to the currency depreciation.

Asian producers of final electronics products are caught in the middle: they must increase hard currency export revenues at almost any cost, in order to service their mounting debt; at the same time, they have to bear the full brunt of this ruthless cost reduction pressure, as they do not have someone else to whom they could pass it on. The root cause of this vulnerability is a *narrow specialization in high-tech commodities* that are characterized by *periodic surplus capacity* and *price wars*²². This leaves Asian electronics firms very little room for price increases; there is a constant squeeze on their profit margins, with the result that the funds required for continuous upgrading may dry up even further.

²² This argument has been first developed in Ernst, 1994a. For a similar, independently developed argument, see the excellent paper by Kaplinsky (1998).

Deflationary pricing pressures on Asian suppliers

How does devaluation affect the prices paid by MNC affiliates to their Asian suppliers? In order to understand this important issue, let us look at the impact of devaluation on the production cost of a Malaysian supplier to a global OEM customer based in Singapore (Author's interviews in Singapore, March 1998). Most of the materials need to be purchased in US-dollars, due to the very high import content ratios of production; non-material costs (like labor and overheads) on the other hand are overwhelmingly in local currency. This implies that depreciation should lead to a reduction in the share of non-material costs (both labor costs and overheads).

The Singapore-based OEM customer requests that this reduction in non-material costs be translated in proportional price reductions. The supplier does not have much choice but to give in to such pressure. Its main concern is to sustain the link with its OEM customer, at almost any cost. Lower-end suppliers, in particular those located outside of Singapore, have been pushed to the limit in granting such price reductions. This reflects the intense price wars in most sectors of the electronics industry (see next section).

This is a very problematic development: it deprives lower-end suppliers of the means that they need urgently for upgrading their product and technology portfolio. Such upgrading requirements are now much more demanding: the dominant global PC manufacturers have drastically reduced the duration of contracts for printed circuit board assembly (PCBA): typically, PCBA suppliers can now be dropped within a week. PC manufacturers have also off-loaded so-called *back-end* activities (related to logistics and global supply chain management) to contract manufacturers, in order to concentrate on their core competencies. This has forced Asian contract manufacturers to move beyond PCBA to the final assembly of PCs (so-called "box-build" contracts). The main concern is to stabilize the link with their main customers: the duration of box-build contracts typically is around six months. This however requires substantial investments which may no longer be possible.

Even more problematic is a somewhat longer-term effect: once local currencies will start to appreciate again, this will leave lower-end suppliers in a very vulnerable position where they will be stuck with a higher-cost production structure that cannot sustain the currently granted price reductions. It is unlikely that they will be able to back away from these price

reductions which they have granted in response to the currency crisis. In other words, there is a real danger that current price reductions may force many of these suppliers out of the market.

In short, price pressures which were already intense before the financial crisis, have now become even more severe. At the same time however, Asian suppliers are under tremendous pressure to recapitalize: in order to survive, they need to upgrade their product mix and their efficiency; they also need to proceed with a regionalization of their production base. This dual pressure has resulted in severe cash-flow problems, especially for smaller local suppliers. Asian contract manufacturers are now saddled with a higher-cost production structure than before the crisis, and thus are potentially more vulnerable to its impact.

A narrow and sticky specialization in high-tech commodities

Specialization is an important indicator of the degree of industrial upgrading that a country has achieved. Industrial economists distinguish specialization patterns that reflect differences in the *product mix* (*homogeneous* versus *differentiated* products²³), and in the types of *production process* (*mass* production versus *flexible* production). A fundamental problem of East Asia's electronics industries is a *narrow and sticky specialization* on a few *high-tech* commodities (Ernst, 1997 b) that are prone to periodic *surplus capacity* and *price wars*. With few exceptions, the region has failed to upgrade into higher-end and rapidly growing market segments for differentiated products that provide sufficient scope for premium pricing (Ernst, 1999 c).

Take Korea (Ernst, 1994a , chapters I and II, and Ernst,1998a). Almost without exception, the chaebol have targeted those segments of the electronics industry that require huge investment outlays and sophisticated *mass* production techniques for fairly *homogeneous* products like microwave ovens, TV sets, VCRs, computer monitors, picture tubes, displays,

²³ *Homogeneous* (standard) products are distinguished from differentiated (unique) products, in terms of the complexity of their technology and the demand patterns they are facing. Homogeneous products are based on widely accessible and mature technology and are thus easy to replicate. Changes in demand patterns are fairly predictable and interactions with customers plays a role only at the margin. *Differentiated* products, on the other hand, are based on new technology whose design features are still fluid and are thus difficult to replicate. This is due to the high entry barriers that result from the high R&D outlays required. Close interaction with customers is a critical prerequisite for success. It is argued that different market structures will result from these different product features: for *differentiated* products, firms can charge *premium* prices, while for *homogeneous* products, *price competition* is the over-riding concern. See, for instance, Baumol, Panzer and Willig (1982) and Nilsson (1996).

and computer memories, especially DRAM. Overwhelmingly, the focus has been on consumer electronics and components, with only limited inroads into industrial electronics. Burdened with unimpressive “me too” products, the chaebol have all failed to establish themselves as credible competitors in the more design-intensive sectors of the computer industry.

A particularly disturbing feature of Korea’s specialization pattern is that it typically combines *high investment thresholds* and *highly volatile income streams*. This poses a considerable risk. For instance, the minimum efficient scale for producing DRAM devices is now more than \$1 billion of annual sales. This implies that only firms that have reached the critical threshold of 5% of world production can compete successfully²⁴. Competition in DRAM centers on the capacity to invest in huge mega-plants churning out a limited variety of standard products and on the capacity to improve as quickly as possible yields and productivity.

The very high entry barriers typical for DRAM and other high-tech commodities are due less to their R&D intensity than to an explosive combination of high capital-intensity, very high economies of scale and an extremely volatile nature of demand for these devices. High-tech commodities are prone to periodic boom-and-bust cycles and hence do not generate a steady flow of profits. For companies with a high debt-equity ratio, this is obviously not an optimal choice²⁵.

Probably the most important weakness of Korea’s semiconductor industry is a very *narrow* product range. The three leading Korean semiconductor producers are all heavily dependent on computer memories: 80% of Samsung’s semiconductor revenues come from memories, and in the case of LG and Hyundai, this share is even higher, i.e., 87% and 90%²⁶. Korea’s competitive position in semiconductors thus remains highly fragile.

²⁴For a detailed analysis of entry barriers in different sectors of the electronics industry, see Ernst and O’Connor [1992].

²⁵Until the outbreak of the financial crisis, this was not much of a problem. The chaebol had guaranteed access to “patient capital” and ample opportunities for internal “cross-subsidization” and thus were among the few firms world-wide that could cope with the demanding financial requirements of high-tech commodities. The chaebol could also built on sophisticated production and investment capabilities, both in typical mass production industries like cars and consumer durables and in resource-intensive process industries like the steel industry. After the financial crisis hit, this pattern is no longer sustainable.

²⁶In the case of the largest Japanese semiconductor producer, NEC, for example, only 35% of its semiconductor revenues were generated by MOS (metal oxide on silicon) memories.

The narrow focus on memory products has very negative implications for the overall structure of the electronics industry. Korea keeps exporting more than 90% of its total semiconductor output, while at the same time importing more than 87% of its domestic demand. Such an *extreme imbalance between supply and demand* makes it very difficult to broaden and deepen forward and backward linkages within the electronics industry and to place it onto a more viable basis²⁷.

Surplus capacity and price wars

A narrow specialization on a few *high-tech commodities* has produced a *paradoxical* result: these products are more sensitive to price declines and negative terms of trade effects than labor-intensive ones. Between 1990 and 1997, world prices of high-tech products (based on US import prices) have sharply declined, while those of labor-intensive products were unstable, but did not experience such a sharp decline (World Bank 1998b, chapter 2). And while the average unit price index of Korean exports during the first quarter of 1998 declined by 19.4% from the corresponding period of 1997, much higher unit price reductions are reported for electronics (-38.6%) and semiconductors (-48.6%)²⁸.

It can be argued that *deflationary price pressures* result from persistent surplus capacity²⁹: a persistent tendency for production capacity to overshoot demand characterizes especially high-tech commodities that are the strength of East Asia. I illustrate this argument for two product groups that are of critical importance for East Asia's electronics industry: PCs and DRAM. Both product groups are less vulnerable to shrinking demand in Asia than for

²⁷ It is probably fair to say that Korea's semiconductor industry represents a modern version of the *classical mono-product export enclave*, characterized by a minimum of linkages with the domestic economy. There is, however, one important difference: the cost for entering the semiconductor industry is horrendously high, and certainly exceeds that of entering the plantation industry (Ernst, 1994, chapter 2).

²⁸ Bank of Korea figures, quoted in Hak K. Pyo, 1998

²⁹ There is no guarantee that demand growth will keep pace with supply - Say's law only applies under very restrictive conditions that are unlikely to occur in the real world. Krugman's claim to the contrary is not convincing. Neo-classical economists claim that *general* overproduction is impossible: "...all of the increased production in the world has as a necessary counterpart increased income -every dollar of sales must also represent a dollar of wages or profits to somebody. And there are only two things you can do with income: save it or spend it." (Krugman, 1998, p.1). The conclusion drawn is that, short of a global excess of savings compared to investment opportunities, global oversupply is logically impossible. Such a conclusion is consistent with the basic assumptions of the *maximization-and-equilibrium* paradigm. Yet, it fails to address the existence of persistent overproduction in specific industries and markets, which, as George B. Richardson (1998) has convincingly demonstrated, explains why *concurrent coordination* is the basic rationale for the existence of the firm.

instance consumer electronics; they critically depend on market developments in the US, and to a lesser degree in Europe.

Pricing trends in PC markets

Since the beginning of 1997, the pace of price reduction has substantially accelerated: during 1997, the average selling price of a home PC dropped 30% to \$1169; by Christmas 1998, these prices are expected to fall even faster, by almost 49% to below \$600. Price wars have now also spilled over into the corporate computer market: during 1998, prices for computer hardware (from PC servers to notebooks) sold to private business have fallen by around 20%.

Such drastic price reductions have led to a scissors effect between growth of sales volume and sales revenue: during 1998, it is estimated that worldwide unit sales of PC producers have increased by around 16%, yet US-Dollar denominated sales revenues have increased by only 6.4% (Dataquest figures).

This has far-reaching implications for East Asia's export perspectives for computer-related products. Export markets are likely to continue their rapid growth, especially in the US and Europe. As the crisis-induced currency depreciation has dramatically improved the price competitiveness of Asian suppliers, much of these new export sales will originate from Asia, provided that supply-related barriers to an export expansion can be removed, and provided of course that there will be no protectionist backlash. Yet, net volume gains will be offset by substantial pricing losses.

At the same time, we witness a drastic change in the rules of competition: cost reduction now needs to be combined with speed-to-market. The result is that Asian suppliers will have to assume most of the inventory risk and the time-to-market pressure by adopting just-in-time delivery schedules and by providing one-stop solution packages for global supply chain management. This requires a significant increase of upgrading investments at a time when pervasive price wars result in razor-thin profit margins, and when debt deflation has dried up investible resources.

DRAM price wars and their limits

Korean firms are among the leaders in this important market segment of the semiconductor industry³⁰. In response to the demand glut for DRAM since late 1995, Korean producers have shared a common interest with Japanese producers in supply regulation and in the re-establishment of a stable oligopoly. The main objective was to fend off attacks from new entrants in Taiwan and Singapore, and to frustrate attempts by Micron Technology Inc, one of the few remaining US manufacturers, and Siemens, to recapture market share.

These attempts are now in shambles. Since 1996, prices for DRAM have plunged due to accumulated world-wide over-capacity³¹: while the price for a staple 16-megabit DRAM chip in late 1995 was \$60, it has crashed to \$3 in late 1997, and has slightly increased since then to \$3.50. This price is at or below the manufacturing costs of all but the most efficient manufacturers in the industry.

All major DRAM producers DRAM producer are now desperate to generate foreign exchange through increasing exports at almost any cost. There is however reason to doubt that drastic price slashing will be sustainable: the threat of dumping procedures is very real; and worsening terms of trade will make it more difficult to purchase essential input imports. A major draw-back is that intensifying price wars will decrease export revenues, despite a possible substantial increase in export volumes, which is bound to further intensify the already severe profit squeeze³².

An additional reason why price-slashing strategies are unlikely to last results from drastic changes in the competitive dynamics of this industry. Until recently, the established business model was to *increase market share through aggressive forward price reductions based on incessant capacity expansion*. This model was pioneered in the 1980s by Toshiba and NEC, and later successfully emulated by Samsung, LG and Hyundai. It apparently has reached its

³⁰ DRAM (= Dynamic Random Access Memories) constitute the largest market segment for computer memories and make up roughly 24% of the world's total semiconductor demand (Dataquest, 1996). Intel and other American firms like Texas Instruments and Motorola had originally created the DRAM market. However by around 1986, five major Japanese firms (NEC, Toshiba, Hitachi, Fujitsu, and Mitsubishi) had taken over and had established a tight oligopoly that controlled roughly two third of the world market for DRAM. Their share has now fallen to below 48%, and this is primarily due to the successful market penetration by Korean firms. By 1997, Korea firms controlled roughly one third of the global market for DRAM, well ahead of the 20% market share of American companies.

³¹ The following DRAM price figures are courtesy of Dataquest, San José, CA

³² For instance, Korean chip makers are estimated to have lost a combined \$2.7bn in 1997. In response to such dramatic losses, they have announced to cut capital spending by around 40% in 1998. (These figures are

limits: aggressive price slashing has turned the DRAM business into the “bleeding-edge” of the semiconductor industry, with all leading players now experiencing huge losses.

This has provoked two types of responses: Within DRAM, an alternative business model is now emerging that focuses on *productivity improvements* and that tries to slow down the pace of capacity expansion³³. The main emphasis is to squeeze the remaining profits out of a product at the end of its life cycle, and by doing so, to avoid getting trapped into endless capacity expansion wars. A related response, chosen in particular by second-tier DRAM producers, is to retreat from the general-purpose DRAM market and to *diversify into higher value-added, less volatile market segments* for specialized memories, ASIC and logic devices³⁴.

East Asian countries are weak on both accounts. This is true even for Korea where much talk of radical change, and in particular diversification, has been followed by little action (Ernst, 1994 Book and 1998 APJM): Korea’s semiconductor industry is still stuck with a very narrow product range centered on DRAM. There are a few exceptions of successful diversification into higher value-added products. One example are synchronous DRAM³⁵, for which prices are about 30% higher than for standard DRAM, where Samsung competes on equal terms with NEC and Fujitsu. But this does not change the overall picture: despite their earlier impressive achievements in rapid capacity and international market share expansion, the Korean chaebol “... are too far behind and too focused on memory products to challenge the overall lead of companies in the US and Japan” (DRI, 1996, p.12).

CONCLUSIONS

This paper has shown that the electronics industry, East Asia’s traditional engine of export-

courtesy of VLSI Research Inc, a market researcher in San José, California that specializes on the market for semiconductor production equipment, and hence is a reliable source for investment and capacity planning).

³³ The new model for DRAM manufacturing has been pioneered by Micron Technology from the US that had earlier greatly suffered from the success of the Toshiba-NEC-Samsung model. Rather than spending billions of dollars to be the first supplier to the market of an accelerating succession of DRAM generations (64 Mb, 256 MB, and 1-gigabit), Micron has optimized its manufacturing process to wring more money from 16 Mb devices.

³⁴ Diversification beyond the DRAM market has been on the agenda already since the last demand glut of 1992/93. Since then, Japanese firms have drastically reduced their reliance on DRAM, and have developed strong positions for instance in specialized memories and ASIC.

³⁵ Recent microprocessor generations for PCs, specifically Intel’s new Pentium II chip, require a faster and more customized 64Mb chip, called Synchronous DRAM.

led growth, is unlikely to act as a carrier of rapid trade adjustment to the crisis. Three inter-related constraints are responsible for its *declining capacity to generate the hard currency revenues with which to pay the accumulated debt*: i) *supply-side constraints* that result from limited access to trade finance, and from the cost-increasing impact of local currency depreciations in highly import-dependent countries; ii) *demand-related constraints*, resulting from deteriorating growth perspectives in East Asia's electronics export markets; and iii) *deflationary pricing pressures*, resulting from a *narrow specialization in high-tech commodities* that are characterized by *periodic surplus capacity* and *price wars*. Together, these barriers have produced a *vicious circle*: once exports increase, net volume gains are likely to be offset by pricing losses.

The expectations of a rapid trade adjustment in East Asia were based on the unrealistic assumption that the experience of Mexico's 1995 peso crisis could be repeated. Yet, history never repeats itself. Then, after a deep devaluation of the peso, unit prices did not decline significantly during Mexico's phase of rapid export volume growth. This was possible for three reasons: a) the dollar value of world trade was rapidly expanding in 1995, unlike now; b) much of the Mexican rapid export growth was intra-firm exports to the US from export platform factories which contrasts with a much more complex pattern in East Asia (Ernst and Guerrieri, 1998); and c) there was no severe generalized regional crisis, as in East Asia today.

East Asia's experience has been very different: There has been some export volume growth, less so however than one could have expected³⁶. What really matters however is that net volume gains have been offset by substantial pricing losses. This paper has identified some *fundamental structural weaknesses of East Asia's electronics industries* that are responsible for this puzzling outcome.

There are however also important *external* constraints to a rapid trade adjustment that reflect a *substantially more hostile international environment* for what only a short time ago used to be called "emerging markets". The first such external constraint is the *global trade crash*: the fall in world export growth from its cyclical peak in 1995 was the largest in the past 15 years - from about 20% to about 4% in US dollars in just one year. The sharp depreciation of

³⁶ Based on earlier studies (Das Gupta, Hulu and Das Gupta, 1995), a 40% depreciation should have increased export volume in the crisis countries by 20 to 30 % based on typical elasticities. Only Korean exports matched this expectation.

the yen in 1995 compounded the negative impact of the slowdown in world exports on many East Asian countries³⁷.

Add to this the *crisis of international capital markets*, where panic and the Russian default have produced a flight into safe havens (US bonds), with the result of a drastic fall in international investment, especially to emerging markets. Furthermore, extremely volatile international currency markets obstruct potential advantages of local currency depreciations and have created a much more hostile international environment to exports and inward FDI. This has dramatically intensified the competition among exporters, not only from East Asia, but from all emerging markets. “This implies that if all East Asian countries lowered their export prices simultaneously, no one country would increase market share or export growth and the main effect would be lower export prices.”(World Bank, 1998b, p.29) This is precisely what happened in the electronics industry.

East Asia’s response to the crisis should not count too much on a rapid trade adjustment. *Reinstating the electronics industry as an engine of growth necessitates industrial upgrading*: the focus should be on improving profit margins on existing sales through productivity improvements and differentiation rather than sharply increasing export volumes. The crisis poses a fundamental dilemma: it has dramatically increased the need for industrial upgrading, while at the same time reducing its chances of success. This *precludes* a return to the *status quo ante* - fundamental changes are required in the different Asian development models, and these changes are very different from the ones proposed by the “Washington Consensus”, with its focus on orthodox fiscal and monetary policies. While drastic changes in the financial system are important, they need to be supplemented with changes in the real economy: a new round of policy and institutional innovations is required that can help to remove the barriers to industrial upgrading (Ernst, 1999c).

³⁷ This is especially so for Korea whose export structure is similar to Japan’s: in 1996, Japan’s imports from Korea fell by 8.5%. Throughout the period 1990 to 1997, Korea’s real export growth mirrors changes in the yen-dollar exchange rate, rising with an appreciation of the yen, and falling with its depreciation (World Bank, 1998b, figure 2.2., p.21)

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Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- *The firm as a learning organisation*
- *Competence building and inter-firm dynamics*
- *The learning economy and the competitiveness of systems of innovation*

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the resource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human resources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as

'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
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Each year DRUID welcomes a limited number of foreign Ph.D.-students who want to work on subjects and projects close to the core of the DRUID-research programme.

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