From Keeping Time to Keeping Pace: The Swiss Watch Industry and the Future of the Jura Watch Region

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March 30, 1990

Developments in the international economy--technological change, global competition, corporate reorganization, and State-led development strategies--are increasingly important determinants of sub-national development. Given rapid technological advancements, theories of regional development based on comparative advantage and regional factor endowments are becoming obsolete. The experience of newly industrializing countries (NICs) illustrates that nations can **create** comparative advantage through state-led development planning. Many industrialized regions now directly compete with these newly industrializing countries where lower costs and relatively skilled labor combine to increase technological advances. And technological competition is leading to the development of homegrown technologies--a remarkable change from the past.

Sparsely populated regions of developed countries face peculiar problems during this period of rapid technological and regional competitive change. Historically, remote regions were disadvantaged relative to their urban counterparts. Rural communities have long been more susceptible to the effects of exogenous change due to the prevalence of mature manufacturing industries, the lack of population concentration, and insufficient economies. With the creation of indigenous industrial support complexes and the high skill requirements of even routine aspects of high technology industry, remote areas of developed countries are being overlooked as production sites in favor of newly industrializing countries (Henderson 1989; Glasmeier 1990).

Yet the Jura Arc of Switzerland disproves the rural-urban hierarchy concept. More than 200 years ago a precision industry, watch making, lodged in the region and resulted in the creation of a technological complex of unusual proportions. Since that time this mountain region's firms have dominated the world watch industry. Early process innovations also made significant technological contributions to the metal working industry. Unlike its sparsely populated counterparts, the Jura defied conventional wisdom. It was a technological leader among remote regions.

Beginning in the 1970s, when foreign competition hurdled technological paradigms from mechanical to electronic watch movements, the Jura's undisputed dominance ended. Massive job loss and outmigration followed as firms, unable or unwilling to adapt to new technologies, closed their doors. Today, while world leaders in watch export value, Swiss watch makers produce only a fraction of their pre-1970s output levels, and resources needed to invest in new product research and development are scarce.

Shifting Paradigms and Lost World Leadership

How did a remote mountain region gain world market leadership? The highly vertically disintegrated production structure promoted intense specialization, resulting in the formation of superior regional skills. In the early life of the industry this was a great advantage. The regional production complex was self-contained, and both watches and production equipment were manufactured locally. The early industry was further strengthened by industry-based organizations promoting technological innovation, market competition, and export development.

Beginning in the 1930s, a series of recessions led to protectionist measures that virtually hobbled the Swiss watch industry. At the time it was thought that cartelization--limiting exports of technology, parts, and know-how, and protecting independent assemblers--would preserve Swiss world market dominance. This rigid structure, which discouraged technological uptake by firms, survived until the 1970s. In the meantime, shifting technological paradigms--most notably the advent of quartz technology and economies of scale through vertical integration--led the Swiss watch industry to the brink of disaster. Japan, and more recently Hong Kong, took advantage of Swiss inertia to launch takeovers of traditionally Swiss-dominated market segments through aggressive marketing campaigns and emphasis on technological innovation.

In a span of less than 30 years, the world's dominant watch region yielded technological leadership (in watchmaking and micromechanics) to its Far Eastern rivals. What lessons can be learned about regional economic development and technological innovation from the experience of the watch region of Switzerland? Industrial restructuring of the past 20 years has left once dominant industrial regions such as America's industrial heartland and Germany's Ruhr valley debilitated. Thus reincorporating technological innovation within production systems of deindustrialized regions has become a major concern. Even technologically vibrant regions such as Route 128, Silicon Valley, and Emilia Romagna confront uncertain futures in the current period of intense technological development and international competition. They are also beginning to feel the wage-skill pressures of newly industrializing countries' flexible and technologically sophisticated production systems. Thus the problems of competitiveness in times of rapid technological change also extend to new centers of innovation.

If problems of structural transformation erode the foundation of urban regions, what does this say for more remote regions? How can a region remain innovative during a period of technological change? By examining the experience of the watch industry and the Swiss Jura we hope to tie together empirical experiences of researchers asking similar questions concerning the relationship between industrial structure, regional culture, technological change, the formation and maintenance of core skills, and state-led regional development in industrial hinterlands.

This paper summarizes both a large body of literature and firm and institutional interviews about the industrial evolution of precision machining in the Swiss Jura mountain region. The paper opens with an overview of the Swiss industry structure and reviews the Jura's economic experience over the last 20 years. Section two reviews the 20th century experience of the watch industry--focussing on how the pre-existing organizational structure hobbled the industry's response to a technological paradigm shift. The third section examines government policies established to counteract the effect of the watch industry's industrial restructuring. Part four of the paper draws on a broad body of research which identifies weaknesses of the region's industries and firms and relates industry structure, technological custom, skill formation, and technological change to the process of long run regional development. The final section of the paper considers a series of interventions proposed to counteract problems of rapid technological change and long term regional development.

Section I

Introduction

Switzerland's 6.5 million inhabitants enjoy one of the highest standards of living in the world. Prior to the industrial revolution, however, Switzerland was largely an agricultural country lacking a diversified economic base (Borner 1989). With few domestic employment alternatives, the country exported labor to surrounding countries to earn foreign currency. Through incremental advances in engineering skills and the manufacture of technologically sophisticated capital goods, however, Switzerland, a once poor and isolated agricultural economy, was transformed within a matter of one century into one of the richest nations in the world.

Historically, Switzerland's small economic size resulted in a dependence on export trade. Trade dependence has only accelerated in the 20th century. But this export orientation, coupled with an extremely open economy, leave the Swiss vulnerable to changes in the international market. Currency fluctuations, tariff barriers, new international competitors, and technological developments have seriously affected Swiss industry--causing industrialized regions to experience major dislocations.

Switzerland has undergone profound economic changes in recent years. In response to developments in international industry, there have been major managerial and organizational shifts. Industry has been forced to adopt global strategies to compete in the changing international market (Borner et al. 1985). Former practices such as labor peace, emphasis on existing technology, and reliance on the Swiss name for marketing have been replaced by increases in research and development spending, improvements

in productivity, growing multinationalization of firms, and sharpened market focus (International Marketing 1988). Emphasis has shifted from what is technically feasible to what is commercially profitable. This reorientation is most prominent among Switzerland's largest corporations.

Switzerland is a country of powerful multinational corporations and small, family-run firms. There appears to be no middle ground (Borner 1989). The nation's internationally competitive industries have excelled through specialization in certain fields--pharmaceuticals and chemicals (Ciba-Geigy, Roche, Sandoz and Shindler), engineering equipment and precision instruments (Von Roll, Asea-Brown-Boveri (ABB), Sulzer and SMH), consumables (Nestle), and of course, banking.

Swiss economic growth in the 1980s has remained remarkably stable despite industrial restructuring which has changed the nature of manufacturing worldwide. Economic growth peaked at 4.2 percent in 1985, while more modest growth of just over 2 percent was experienced in 1989 (Director 1988). Exports account for over one third of Switzerland's gross domestic product (not surprising considering its small domestic market). However, given the nation's international reputation as a global banking center, it is somewhat unexpected to find that manufacturing still accounts for one-third of gross domestic product and employment (although jobs in both the primary and secondary sectors are decreasing) (The Economist 1986). Nonetheless, the most important component of the Swiss economy is the service sector. Job loss in manufacturing and farming have been more than compensated for by growth in service industries such as banking and insurance (Elassar 1982).

Although several industries have undergone severe rationalization in the past decade--most notably the watch, engineering, and machine tool industries--unemployment rates have remained under 1 percent. At .6 percent, unemployment is at its lowest in 6 years. A record 16,000 job vacancies highlight labor constraints. Switzerland has likewise enjoyed one of the lowest inflation rates in Europe; late 1980s inflation is not likely to exceed 2-3 percent.

Two major reasons for this optimistic economic outlook are the high degree of multinationalization of Swiss firms and slow population growth. Much of Swiss production of pharmaceuticals, chemicals, and consumer goods has moved offshore to the NICs (Singapore, Taiwan, South Korea, Hong Kong), and other European and South American countries in search of markets, cheaper labor, and lower infrastructure costs. In 1985 75 percent (70 percent of Switzerland's residential industrial workforce) of the total personnel of the top 15 multinational companies worked outside of Switzerland. (Table 1 shows the employment breakdown of the top 15 Swiss multinationals).

Industrial restructuring has had a major impact on Switzerland's production sectors. Manufacturing has lost more than 180,000 jobs since 1965 (Elsasser 1982). In particular, trade-dependent sectors such as watches and machine tools have suffered massive declines in employment and establishments. The engineering sector alone has lost 50,000 jobs. And since 1970, watch making, the hallmark of Swiss manufacturing, has lost 57,000 jobs. In the late 1980s several of Switzerland's largest engineering firms continued to restructure. Mergers and bank-ordered reorganizations were required for firms such as Brown, Boveri and Sulzer.

Table 1

Employment in the Top 15 Swiss Multinationals Firms, 1985

	Switzerland	Total Abroad	Total Employment
Nestle	7,400	145,000	153,000
Ciba-Geigy	22,900	58,290	81,190
BBC	21,760	83,540	105,300
Alusuisse	8,650	36,430	45,080
Roche	9,610	34,040	43,650
Sandoz	9,830	25,630	35,460
Oerlikon-Buhrle	15,300	21,910	37,210
Sulzer	20,180	14,750	34,930
Holderbank	2,060	16,670	18,730
Georg Fischer	8,030	9,250	17,280
Schindler	6,010	15,650	21,660
SMH	12,830	2,740	15,570
Landis & Gyr	6,480	9,740	16,220
Von Roll	5,760	490	6,250
Hesta	3,840	8,610	12,450
Total	160,640	482,740	643,380

Source: Borner, Stuckey, Wehrle and Burgener. 1985. Global Structural Change and International Competition Among Industrial Firms: The Case of Switzerland, Kyklos. 38, Fasc. 1, pp. 77-103.

The Geographic Extent of Industrial Restructuring

The geographic impact of industrial restructuring has been highly spatially concentrated in Switzerland. Given the sectoral specificity of industrial decline over the last 30 years, a few cantons absorbed the majority of job loss. The country's mountainous regions experienced the most severe employment declines. In particular, half of all jobs lost in the country since 1965 were from the Jura (Elsasser 1982).

The Jura Region

The Jura arc, which lies in the northwestern part of Switzerland, consists of two sub-areas: the mountainous chain and the foothills of the Jura. The Jura straddles the Franco-Swiss border and includes the cantons (districts) of Jura, Neuchatel, Jura Bernois, and Nord Vaudois.

The area is characterized by a dispersed population clustered around a few cities, the largest being Neuchatel, La Chaux-de-Fonds, and Le Locle. The region's 400,000 inhabitants are primarily concentrated in the foothill cities. The mountainous portion of the region has only 127,000 residents.

The Jura Arc has been losing population since the 1970s. Massive declines in watches and machine tools resulted in an exodus of young people. Whereas in the 1970s Switzerland's total working population increased by 3.4 percent, the Jura arc's fell by more than 10 percent. And population shifts were followed by industrial shifts toward the region's more urbanized areas (Maillat 1984).

The industrial structure of the Jura Arc is characterized by a large number of small and medium-sized manufacturing enterprises (SME). More than half of the working age population is employed in manufacturing (a comparable figure for the nation is only 39 percent).

A second feature of the Jura's industrial structure is the predominance of family-run firms. While no recent census exists to buttress this statement, the history of the watch and machine tool industries includes a predominance of locally owned establishments. Further verifying this trend, recent studies show that self-financing is the major capitalization mechanism in the Jura (Maillat 1984).

The occupational structure of Jura firms differs significantly from the national average. Firm surveys reveal lower salaries and fewer employees with high levels of skill in the Jura than for the country as a whole. Subcontracting is a major revenue source for many watch and precision firms in the region.

According to some accounts, firms in the Jura retain antiquated production processes in lieu of adopting state-of-the-art manufacturing technology. Large segments of the business community are locked into established products and markets--demonstrating little ability to innovate. (Maillat 1984). For example, while the global machine tool industry gravitates toward multi-function machining centers, Jura machine tool firms manufacture single-purpose equipment employed in high volume mass production systems (Provo 1986). And while there are select establishments using robotics and laser technologies, there is still little technology transfer among regional firms. Thus although the Jura is presently considered the micromechanical and microelectronic epicenter of Switzerland, the historic industrial base still very much defines the structure of production and organization of the region's firms.

The antiquated production system signals the lost competitiveness of firms in the region. An early 1980s shift-share analysis of industrial employment indicated the region suffered from employment concentration in declining industries (Maillat 1984). The region's firms were also weaker relative to their counterparts in Switzerland's more urban areas.

The dominance of manufacturing in the region has not precipitated the formation of an equally strong service sector. Massive job loss in the 1970s decade was not matched with concomitant growth of service employment within the Jura. In fact, the effects of

industrial restructuring were particularly acute in the region because service job growth was far below the national average. Between 1965 and 1975 the Jura lost 3,000 jobs per year while gaining only an average of 600 jobs per year in the service sector (Elsasser 1982).

Compared with the national economy, the region's industrial structure has not promoted service sector job creation. In part this reflects the inward orientation of firms which still perform all functions in house. Because firms do not contract out for higher order services, the region's share of service firms is lower than the national average. This results in a self-fulfilling prophecy: low demand for business services means few firms provide them. And because there is a limited supply of business services, firms have difficulty accessing them. The federal government also provides many free business services which absorb a part of local demand. These "free" services may undercut a private firm's ability to provide services at profitable levels.

The lack of services has a profound effect on the competitiveness of firms in the Jura Arc. Contemporary research identifies the strong relationship between firm innovativeness and the use of high order business services such as management consulting and R&D services (Maillat 1984). Thus the Jura region is at a competitive disadvantage compared with more urban, service-rich regions.

Machine Tools and Watches: The Economic Base of the Region

Two of Switzerland's most important industries are concentrated in the Jura--precision tools and watchmaking. These two industries each export about 95 percent of their products abroad--making them particularly vulnerable to fluctuations in world

markets. SMH, the major watch holding company in Switzerland, is located in Neuchatel and manufactures key watch brands including Swatch, Longines, Rado, Tissot, and Omega. Additionally, the firm owns the major component firm, ASUAG, which produces the majority of Swiss watch movements. Small and medium-size machine tool companies such as Voormar and Dixie are also headquartered in the region.

Unlike other Swiss multinationals which shifted production to low-wage countries with growing markets, the watch and machine tool industries have remained entrenched in the Jura region. Table 1 shows that SMH, the largest watch manufacturer, employs fewer than 20 percent of its employees outside Switzerland.[1] Domestic employment concentration also characterizes machine tool firms such as Sulzer. Jura firms continue to automate routine production instead of outsourcing and will undoubtedly undergo further industry shrinkage. Automation and firm closures have resulted in massive job loss which has lead to a striking population decrease. Four of the major cities and sub-regions in the Jura (Val-de-Travers, Le Locle, Biel, and La Chaux-de-Fonds) were among the top ten Swiss cities that lost population between 1970 and 1980.

Industrial employment in the Jura fell by 41 percent from 1970 to 1980 (Maillat 1987). Most industries in the region underwent contraction, but none so dramatically as watch making. Nationally, watch industry employment plummeted from 89,450 in 1970 to 32,000 in 1985, an alarming decrease of 64 percent, as shown in Table 2 (Union Bank of Switzerland 1987). A similar level of job loss occurred in the Jura. Table 3 illustrates the striking employment losses in the watch, engineering, and metal industries between 1970 and 1984.

Table 2

Recent Changes in Companies and Jobs in the Watch Industry

	Number of Companies	Jobs	Jobs per Establishment
1970	1620	89,450	55
1973	1260	75,800	60
1976	1080	55,200	51
1979	870	46,700	54
1982	730	38,200	52
1985	600	32,000	53

Source: Annual Census of Employers Convention, as cited by Union Bank of Switzerland in The Swiss Watch Making Industry no. 100, March 1986.

Table 3

Industrial Employment in the Jura Region, 1970-1984

	Total	Metals	Machines	Watches	Others
1970	95,120	9,213	27,145	44,999	13,763
1975	72,148	6,995	21,697	32,243	11,213
1980	64,906	6,869	18,796	26,201	13,067
1981	64,435	6,971	21,569	25,040	10,855
1982	63,739	7,565	20,940	23,030	12,204
1983	60,964	8,194	18,623	20,492	13,655
1984	55,941	7,468	18,938	17,643	11,874

Source: Vasserot 1986, p. 3.

Employment statistics do not paint an entirely accurate picture of the Jura's population loss for two reasons. Foreign workers--who are the first to be let go in times of economic depression--are effectively not counted, and changes in the labor participation rate further reduce the base of individuals who might otherwise be considered unemployed. In 1986, 25 percent of the Swiss labor force consisted of foreign high and low skilled workers. From 1974 to 1977, the number of foreign workers in Neuchatel Canton alone dropped over 50 percent in response to crisis in the watch industry. In the Jura Arc, foreign worker numbers have never regained their pre-1974 levels.

Changes in labor force participation rates further masked the statistical impact of employment decline in the region's dominant industries. In 1980, almost 30 percent of Switzerland's population was over the age of 65. During the 1970s, the worst period of employment decline, many workers were at or near retirement age. These workers simply chose to retire rather than look for alternative work. Home work was essentially eliminated, and women left the factories but remained in the region with their families.

Not only have a large number of firms closed or left the Jura, but the existence of remaining firms is increasingly precarious. Despite published statements indicating the industry has "rounded the corner" and will soon stabilize, the machine tool and watch industries are still undergoing rationalization (Union Bank of Switzerland 1987). Remaining firms are less capable of financing new products and process techniques since market shares have been eroded by stepped-up international competition (Union Bank of Switzerland 1988/1989). The remaining internationally competitive firms are following other multinationals in deploying manufacturing to lower cost newly industrializing countries

where both markets and skilled labor can be found. This trend will only worsen employment prospects in the Jura.

Within the Jura Arc, job and establishment decline was unevenly distributed among cantons. Job loss was particularly severe in the outlying areas of Solothurn, Ticini, and Vaud. In and around Geneva, job loss was less severe. This uneven pattern relates to the geographic dispersion of firms specializing in watch market segments. Plants producing low cost watches were most severely affected by competition from low wage countries. Cantons where low cost watch manufacturing was concentrated experienced the greatest employment and establishment declines (Table 4).

Table 4

Reduction in Watch Industry Companies and Jobs by Canton 1984

Cantons	Companies	Workforce
Geneva	59	83
Vaud	59	31
Neuchatel	42	45
Basel-Country	41	48
Berne	35	33
Ticino	34	28
Solothurn	30	31
Other Cantons	46	39
Average	39	39

1970 index = 100

Source: The Union Bank of Switzerland 1986.

Conclusions

Once vibrant, the Jura region and the watch making industry have lost much of their luster. How can we understand the speed with which changes have occurred in the Jura Arc? What can regions and firms do to avoid such dramatic reversals? Are there strategic assets that a region has which can be redployed independent of a dominant sector? How can a region plan for a permanent state of change?

With this introduction we now turn to a detailed account of the twentieth century experience of the Swiss watch industry. The analysis departs from past treatments of the industry's post war experience by examining the rise of world competition through the lens of technological paradigm shifts. Previous treatments have largely relied on a model of ologopolistic competition to explain how the Swiss lost control of the world watch industry. We conclude, on the contrary, that the Swiss experience must be understood from the stand point of how technological paradigm shifts challenge previous ways of organizing an industry, culture, and society. Paradigm shifts present a series of strategic turning points that industrial leaders must navigate during a period of technological change. The Swiss were no exception. The industry's reaction to technological unknowns, given a fragmented production system, institutional inertia, and significant sunk costs in capital and equipment, were rather common responses of firms and industries undergoing radical technological change.

The magnitude of displacement required a state-led response. In section three we examine the policies designed to reclaim and nurture the lost technological superiority of the region. Section four reviews recent research on the Jura Arc which assesses the

region's success in adopting technological innovations and transitioning toward a new technological paradigm.

Section II

What Happened to Watches?

The history of the Swiss watch industry is instructive as countries and regions experiment with different production systems in attempts to maintain and augment their competitiveness in a global economy. On the eve of the electronics revolution, the Swiss watch production system was flexible, cost effective, and extremely profitable. The Swiss system offered enormous variety while maintaining quality and timeliness of delivery. "The multiplicity of enterprises, and the competition and emulation that characterized the industry, yielded a product of superior quality known the world over for high fashion, design, and precision" (Landes 1984).

This section reviews the 20th century history of the Swiss watch industry. Our purpose is to help explain why cultures and industrial production systems are adaptable to external change at different points in time. We attempt to show that an exclusive focus on "production" ignores other constraints that are powerful forces governing the reaction abilities of regions. This section then considers the historic evolution of the Swiss watch industry and shows its early adaptability to new production innovations within the dominant mechanical watch paradigm. The bulk of the remaining discussion traces the evolution of the industry--illustrating the difficulties experienced in the face of radical technological developments.

The Swiss watch industry provides an important case study of an industrial and cultural system that retained technological supremacy for two centuries and that still retains its dominant position within the earlier mechanical paradigm. The industry has,

however, yielded technological leadership to foreign competitors. The Swiss are now followers rather than leaders of industry trends.

The Early 20th Century and the American Challenge

Over the course of two centuries, the Swiss industry has shown surprising resilience in the face of change. During the early part of this century the industry was issued a major challenge by the U.S. watch production system. America's watch manufacturers developed machinery to produce watches at high volume with low cost, low skill, and relatively high levels of precision. Watch movements were drastically simplified and more economical to produce. While hand-adjustment was still required in final assembly, the overall skill content in American watches was drastically reduced.

Interchangeability of parts also significantly simplified the American production system and cut labor costs. Although true interchangeability in watch making was not achieved until the early 20th century, through a combination of low production costs, wartime scarcity, and closed markets, the Swiss share of the U.S. domestic market was cut by two-thirds.

The Swiss response to U.S. technological challenges was decisive. Over a period of 20 years the Swiss proved more than capable of making needed technical progress (Dosi 1984). Dosi defines this reaction as "natural trajectories of technical progress wherein a system, once established shows a momentum of its own which contributes to defining the directions toward which problem solving activity moves" (p.153). Within a paradigm well-known to the Swiss--mechanical watch manufacturing--the nation's production system generated a decisive response to a new technology.

While the Swiss lost considerable market shares in the U.S., the country's manufacturers did not yield control of global markets (Landes 1979). Over the course of two decades, the Swiss system adapted aspects of the American system that were cost effective. The Swiss system shifted from its reliance on small scale cottage production to an intermediate form that combined mechanization and partial vertical integration. Standard parts were mechanically manufactured at large scale in centralized factories while flexibility was maintained in dispersed design and assembly activities. Even the more complicated parts were eventually mechanized using "versatile machines which were susceptible of all manner of adjustment, hence required some skill to operate..." (Landes 1983). Thus within the existing mechanical paradigm, the industry achieved new levels of profitability and international renown.

Unlike the American system which strove to reduce its reliance on skilled labor by simplifying the product, the Swiss system of watch making maintained product complexity and high levels of precision. Skilled labor was shifted away from repetitive tasks easily performed by machines toward more complex and multifaceted functions aimed at increasing product quality, precision, and variety (Landes 1979). Thus while gaining certain economic benefits of vertical integration and mass production, the Swiss emphasized their core skill--precision machining--and allocated labor accordingly.

There is no doubt that by the 1910s Swiss mechanical watches dominated the world watch industry (Knickerbocker 1976). The Swiss controlled the micro-mechanical export industry by cost competitiveness, superior manufacturing competency, high levels of precision, and extraordinary attention to detail and style. The vertically integrated parts manufacturers' achieved economies of scale through volume production. This benefit was

passed on to assemblers in the form of low cost movements. In the most labor intensive aspects of the industry, the vertically disintegrated system of assembly and case manufacture kept overhead charges low.

International Economic Chaos and the Call for Regulation

The early 1920s was a period of instability in the watch industry. The First World War created severe disruptions in the world watch market. Russia, a major Swiss market, closed its borders to international trade, while other countries raised protectionist barriers in attempts to preserve domestic industries. Demand for Swiss watches declined precipitously between 1916 and 1921.

Disruptions in the watch market presented the Swiss with new and different problems (Knickerbocker 1976). By the 1920s the financial stakes were much higher. Significant sums of capital had been invested to meet the American manufacturing challenge. Firms were larger, and the industry represented a larger share of gross national product (Landes 1984). The severity of the crisis forced family businesses to take drastic steps simply to reduce inventory. Opportunism, price cutting, and increased export of movements and parts further destabilized the industry (Tissot 1990). This unprecedented threat resulted in a call for industry regulation, and a cartel was formed.[2]

During the 1920s various associations were created to represent the interests of industry members. The Swiss watch industry federation (FH) was organized to govern both firms assembling watches from component parts and those few firms with integrated manufacturing operations. The 17 manufacturers of ebauches (watch movements) were organized into a trust EBAUCHE S.A. Manufacturers of components other than ebauches

(balance wheels, assortments, hair springs) were organized into the Union des Branches Annexes de l'Horlogerie (UBAH). In the late 1920s members of the various associations agreed to set levels of output and prices, and explicit rules were designed to restrict exportation of parts (Knickerbocker 1976).

When this degree of collaboration proved insufficient to control opportunistic firms, the government intervened. In conjunction with industry and banking leaders, the federal government created the massive holding company ASUAG (which included EBAUCHE S.A. as well as other leading component producers). This final merger halted the exportation of parts and components to competitor countries (Knickerbocker 1976).

Statut Horlogerie and the Codification of the Swiss System

The Statut Horlogerie of the early 1930s established a regulatory system that governed Swiss watch manufacturing for more than 30 years. Through a combination of cartelization and government ownership, the Swiss industry was regulated to control vertical integration, foreign sourcing, and off-shore production. Swiss manufacturers could buy only from Swiss component producers, and component producers could sell only to Swiss firms. To further limit competition, government regulated the sale of machinery. The Statut Horlogerie regulated the volume of Swiss watch production by requiring permits for the construction and expansion of production facilities (Jaquet and Chapuis 1970).

The resulting industry structure consisted of the parts manufacturers who sold their output to assemblers, the assemblers, and the brand name manufacturers. ASUAG could sell only to firms recognized by the Swiss government under the Statut Horlogerie. It

could not export parts or technology. Manufacturers fabricated complete watches but were restricted from selling movements and other parts to assemblers--thus eliminating competition with parts suppliers. They were also restricted from setting up production in other countries. Assemblers were prohibited from establishing production outside of Switzerland, and they could buy parts from non-Swiss manufacturers only if prices were 20 percent below Swiss levels.

The Statut Horlogerie codified the 1930s industry structure and established rules to regulate the industry. And while there was some further vertical integration on the eve of the law's passage (particularly in the components-producing sector), as late as the early 1970s the industry still consisted of thousands of small firms (Landes 1979; Landes 1984; Jaquet and Chapuis 1970). The law's greatest effect was in regulating who was allowed to produce, what could be produced, and how much could be produced.

From 1933 to 1961 the Swiss watch industry experienced considerable stability matched by handsome growth. By requiring export and manufacturing permits, the government essentially held supply below world demand and ensured Swiss firms handsome profit levels. All industry sectors enjoyed the benefits of growth. And since growth in output capacity (hence market share) was regulated, profits were re-invested in process technology. The high profits made in this period allowed firms to develop a mechanical watch manufacturing system unparalleled in efficiency. And the two world wars effectively destroyed the productive capacities of the French, German, and English (Knickerbocker 1976; Tissot 1990).

Abandoning Industry Regulation; Instituting Industrial Change

In the early 1970s 30 years of stability once again gave way to uncertainty. Foreign competition ended the Swiss monopoly on mechanical watch production and the country's quasi-monopoly on the world watch industry. The slow erosion of Swiss world export market share met with cries from industry members to change the Statut Horlogerie that had regulated the industry for 30 years.

Reasons for industry discontent were straightforward. The more profitable and better run firms lobbied against the cartel arguing that it protected firms that were producing low quality watches (Tissot 1990; Landes 1984). The law was also criticized for fixing the level of Swiss production at a time when other countries were making substantial inroads in the Swiss world export market share. In 1961 the Federal Assembly of the Swiss Confederation ratified a new decree eliminating the regulation of output and encouraging rationalization of the industry. The new statute took effect in 1962.

The law also included a new provision designed to preserve the quality of the Swiss watch product. The government established a technical inspection of watches and movements (Jaquet and Chapuis 1970). This action was designed to counteract the production of low quality watches and parts and to create exclusivity.

In 1966 the government rescinded (effective 1971) all remaining regulations governing the manufacture of watches. Firms were free to export, merge, buy, and sell to foreign firms. The industry was finally free of almost 40 years of restrictions.

As expected, the watch industry underwent a series of unprecedented mergers. The healthier and larger establishments merged to match the sizes of their Far East Asian and American rivals. Within two years three firms were producing 32 percent of Swiss

exports. SSIH (formed in the 1930s with the merger of Tissot and Omega to become a leading vertically integrated manufacturer) became the third largest watch manufacturer in the world (behind Timex and Seiko). In 1971 the ASUAG created the General Watch Company, a holding organization of several brand names and component manufacturers (Knickerbocker 1976). This was the first in a series of steps taken to expand ASUAG's traditional role as component manufacturer. A third holding company, Societe des Garde-Temps (SGT), was created primarily to manufacture low-price and electronic watches. The SGT holding company also acquired two American watch companies, Waltham and Elgin.

In addition to the three holding companies, there were a number of important groups. Rolex, although privately held, had 1972 sales estimated at 200 million Swiss francs. There were also four middle-sized groups including two subsidiaries of U.S. companies, Zenith and Bulova, and the prestige brands, Piaget and Patek Philippe. The remainder of the industry was made up of hundreds of small companies assembling and selling watches.

Through rationalization, restructuring, mergers, and acquisitions, the Swiss reached price parity with the Japanese. The number of calibers (watch dimensions) was reduced along with the variety of watch types produced. Productivity increases were apparent as employment fell (by almost 15,000 jobs) while output increased by 15 percent. The Swiss met an organizational dilemma head-on and achieved great success relative to their competitors. Within the existing technological paradigm (mechanical watches), the Swiss again successfully responded to foreign competition.

Contested Terrain: The World Market for Watches

The early 1970s were a time of profound change in the world watch industry. Free of the Statut Horlogerie, Swiss manufacturers and assemblers set out to meet their major Japanese and American competitors head-on. But their production system was not easy to dismantle or rearrange. While the Swiss struggled to re-orient their factories, nimble competitors flooded the field. Japanese and American firms posed unique challenges to Swiss watch makers. This new and rising competition and the advent of a technological paradigm shift were both significant problems.

The Japanese industry was highly vertically integrated and therefore a low cost producer (Knickerbocker 1976; Maillat 1982). Firms followed a policy of market share expansion through attractive pricing. Japanese companies (Seiko and Citizen) made major inroads in the world watch market as both component and finished watch manufacturers. The Japanese made high quality low-priced movements that were sold to firms around the world.

Finished watch sales strategy skillfully positioned products between price segments (Tissot 1990). For example, Seiko priced its self-winding watch between the low priced manual and self-winding Swiss watch. Seiko's goal was market share. The company did not follow the Swiss lead of establishing a collection of watches. Instead Japanese firms went for high volume and low prices. This strategy worked particularly well in self-winding watches because of peculiarities associated with Swiss pricing strategy. EBAUCHE'S long standing policy was to equate new technology with higher prices. The self-winding watch was considered technically superior to the manual watch, thus Swiss self-winding watches

were priced higher. Recognizing this idiosyncracy, Seiko simply positioned its product in between the two market segments and increased market share (Tissot 1990).

With the rescission of the Statut Horlogerie, the Swiss continued to rationalize. Yet the Japanese were by no means standing still (Landes 1984; Knickerbocker 1976). By the early 1970s Japanese watch companies had succeeded in capturing 14 percent of the world watch market. Just over half was sold in export markets. With domestic markets almost saturated, the Japanese sought market outlets in Southeast Asia--once the exclusive domain of the Swiss (Knickerbocker 1976). In addition, Japan was selling large volumes of movements to the U.S. and Hong Kong. Although the Japanese produced models for every price range, they targeted the lucrative middle range--undercutting Swiss competitors.

The Japanese increased their share of world export markets through various means. They had lower labor costs and an undervalued currency. They were also vertically integrated and employed advanced automation. The Japanese developed the capacity to manufacture standardized movements and watch models. Dominant Japanese firms were not content to rely solely upon volume as their competitive edge. They sought competitive supremacy through innovation and manufacturing prowess. When domestic wages began to rise, the Japanese quickly shifted assembly to Hong Kong where wages were lower (creating a spatial division of labor to ensure low price and timely product delivery).

Unlike the Swiss, the Japanese also had the advantage of a large protected home market. Because other watch manufacturers were effectively locked out of their domestic market, Japanese producers enjoyed high domestic prices. As with other industry

segments, domestic prices for watches were kept artificially high to cover fixed costs. Thus in international markets watches could be sold close to or at marginal costs.

Japanese watch manufacturers also made great strides in manufacturing process, technology and design. Government assistance (R&D grants) accelerated Japanese penetration of the world watch industry. And unlike the Japanese system of production that had many levels of subcontracting, the Japanese watch industry also underwent rapid and profound vertical integration that streamlined operations and reduced inefficiencies. Watch manufacturing broke with the Japanese tradition of vertically-disintegrated production because the technical requirements of the product called for high levels of precision. The government also encouraged vertical integration to "minimize the proliferation of marginal watch producers and to minimize the drain on foreign reserves caused by the importation of watch machinery" (Knickerbocker 1976). In 1978 88 percent of Japanese production was attributable to two firms. Switzerland's leading manufacturer accounted for only 9 percent of total production (Business Month 1988).

The U.S. Market and American Watch Manufacturers

Japan was not the only significant challenge to the Swiss watch industry. The U.S. was both the world's largest and most competitive watch market. The vast majority of American demand was satisfied by domestic firms. America's two stellar watch manufacturers--Timex and Bulova--essentially controlled two-third's of the nation's market (Knickerbocker 1976; Landes 1979).

American watch making firms were dominant in the U.S. partly because of high tariffs implemented to protect the domestic industry. In response, Swiss production was

refashioned to minimize the effects of U.S. protectionism. As the tariff was based on the number of jewels in the movement, Swiss manufacturers redesigned the watch to include fewer jewels. Such actions were costly to Swiss manufacturers who were forced to adjust their product lines to minimize high tariffs (Retornaz 1989). A bad side effect of this strategy was most firms' inability to produce at volumes that would allow for productivity gains.

On the other hand, American firms enjoyed a loophole in trade policy which permitted off-shore watch assembly by low wage laborers. Because American firms could avoid paying duties, they could sell cheaper products.

The use of very cheap labor for assembly of watches was off-limits to the Swiss (Landes 1984; Knickerbocker 1976). Until the early 1970s the Statut Horlogerie prohibited them from following the American example. Thus while both Japanese and U.S. firms found low wage havens for assembly, the Swiss could only maintain price parity by rationalizing, mechanizing, and making production more efficient.

The two leading American firms, Timex and Bulova, presented significant problems for Japanese and Swiss manufacturers. Both corporations followed the American system of mass production. Employing a combination of sophisticated production technology and labor flexibility (through internationalization of production), Bulova produced a range of products spanning all price categories. The firm became the industry leader by scattering production around the world and trading off wage levels for labor skill. As part of this strategy, the company also subcontracted with Japanese component producers for low priced movements (Knickerbocker 1976; Landes 1983).

The medium price range was Bulova's strong suit--with literally hundreds of different styles manufactured in the company's Swiss factories. According to some estimates, at one point Bulova was the largest manufacturer in Switzerland. At the high end, with its aggressively marketed tuning fork technology, Bulova was by itself.

The company's international production system maximized site-specific advantages such as skill levels, technology, and markets. For example, Accutron was made in the U.S. where technology levels were high despite lesser manual labor skills. Medium- and low-priced mechanical watches were manufactured by high-skilled Swiss workers. The company's international orientation provided important opportunities to test-market new products. By having a strong brand policy and aggressively marketing products, Bulova moved into markets worldwide.

Alternatively, Timex sold a product that was cheap, simplified, and standardized. It was therefore easily mass produced. The company developed highly efficient, dedicated production equipment to produce huge volumes of standardized products. Timex introduced hundreds of different models based around the original 8-step process.

Timex also developed true interchangeability. Parts could be exchanged not only within but between plants (Landes 1984). Because the U.S. lacked skilled watch workers, Timex pursued a capital-intensive production strategy. Machines were automated to reduce human involvement to a minimum. The company designed a dramatically simplified but well-manufactured watch with a relatively long life. Given that their watch was cheap, Timex made no pretense of providing after sales service. When the watch stopped running, it was simply thrown away and a new one purchased.

The company also chose an unconventional means of marketing. Locked out of traditional watch sales outlets, Timex established a new standard by selling its watches (that were cheaper and could not be repaired) through drug stores and other high traffic outlets. Manufacturing and distribution strategies were supported by an aggressive marketing campaign that focused on the indestructible qualities of Timex watches.

The company did not confine itself to the low price market segment. By the early 1960s Timex had developed a low-priced higher quality jeweled watch line. In addition to its traditional and effective distribution channels, Timex introduced its watches into jewelry stores--more conventional watch sales outlets. Within 20 years the company had gone from bankruptcy to control of 45 percent of the U.S. market and 86 percent of U.S. domestic watch production.

Like Bulova, Timex established international market presence and production capacity. The company had 20 plants scattered around the globe. Each market was carefully analyzed, and sales strategies were adjusted according to local customers (Knickerbocker 1976).

Thus while the U.S. was Switzerland's largest volume export market, this was by no means achieved by exporting Swiss brands. Domestic manufacturers were highly successful in defining new market niches and developing new products that succeeded in limiting Swiss market share.

Technological Change and Industrial Instability

Prior to the 1970s, the world watch industry grew steadily, and production was shared among three countries, the U.S., Japan, and Switzerland.[3] Trade liberalization in

the 1950s, coupled with GATT and U.S. tariff reductions in the 1960s, set the stage for enormous expansion of markets in the 1970s. In a span of 10 years the market for watches doubled from 230 to 450 million watches (Union Bank of Switzerland 1987).

In the early 1970s world demand for watches was overwhelmingly for mechanical devices. Only 2 percent of export sales were electronic watches. But in a single decade, the structure of demand changed. By the late 1980s, electronic products comprised 76 percent of world consumption--approximately 60 percent digital, and the remainder analog watches.

The competitive terrain shifted from precision based on mechanical know-how to accuracy based on electronic engineering. While the Swiss were the first to develop electronic watch technology, competitors succeeded in commercializing it. And although the Swiss responded relatively rapidly (within two years) to this new competitive technological threat, volume market share was permanently lost to the Japanese, and more recently, to the Hong Kong watch industry.

The introduction of electronic watches in the early 1970s had a profound impact on the Swiss share of world markets (Table 5). In 1974 Swiss watches made up 40 percent of the world export market (by volume). Ten years later this figure had fallen to 10 percent. The loss occurred almost entirely in the high volume, low- and medium-price watch market segments.

Table 5

Export of Watch Movements and Completed Watches 1951-1980

(thousands of units)

	Japan	Switzerland
1951	31	33549
1955	19	33742
1960	145	40981
1965	4860	53164
1970	11399	71437
1975	17017	65798
1980*	68300	50986

*Includes movements. (Landes 1984)

Science Replaces Art in Watch Manufacturing

How was it that the Swiss share of world markets fell so precipitously? Following World War II, the Swiss dominated the world watch industry through excellent production capability and product quality--not radical technological innovation. As one Swiss source noted, "After the economic crisis of 1933-1937, the Swiss watch industry (until the early 1950s) showed unspectacular but steady industrial and technical advance unmarked by any revolutionary changes" (Jaquet and Chapuis 1970. p. 252). As output (therefore market share) was effectively fixed, firms were not encouraged to invest in research and

development toward major technological innovations. There was no guarantee that such efforts would lead to successful commercialization.

The watch cartel insulated Swiss manufacturers from the effects of inter-firm competition[4]. With (volume) control of the world market (based on mechanical devices), it was easy for firms to become myopic about external events and new technology introduced by distant competitors. Most watch-related R&D investments were made perfecting the existing mechanical technology. Major breakthroughs in metallurgy, materials, oils, and production equipment were on-going. Thus research and development focussed on problems within the existing technological paradigm rather than establishing the basis for radical innovations. Because ASUAG looked only to members of the Swiss Watch Industry Federation (FH) for market information, new developments outside Switzerland did not filter into existing information channels.

When pressured to incorporate radical technological innovations, the Swiss industry proved unprepared to commercialize on new ideas. Although inventions were very frequent, industry leaders were often skeptical about the viability of new proposals--particularly if they implied a radical reorientation of existing time keeping methods. As Morgan Thomas notes, "many firms attempt to screen basic science and technical knowledge relevant to the firm's mission" (Thomas 1986). This skeptical complacency proved costly when Hetzel, the Swiss inventor of tuning fork technology was ignored by Swiss watch manufacturers. After he successfully commercialized his new technology in the United States, the Swiss were forced into a remedial position just to gain control of the new technology.

Although they dramatically increased spending for R&D and attempted to develop their own tuning fork technology, the Swiss never quite exceeded patent restrictions. Consequently EBAUCHE was eventually forced to cross-license the technology from American Bulova (Landes 1984; Jaquet and Chapuis 1970; Knickerbocker 1976).

By 1970 the Swiss R&D revival had not only enabled them to catch up with foreign competitors in several areas of technology, but to pull ahead in others. However, investments were still predominantly for improvements on the mechanical watch. Failure to embrace new technology confronted the Swiss again when microelectronics applications were being developed for timekeeping. This time, however, while the Swiss developed the initial technology, they failed to commercialize upon it. The Swiss were not the first to suffer this fate. As Hoffman notes, this is common to many firms, and "an innovation may be a technical success but a commercial failure in the innovator firm but a commercial success in the imitator firm" (Hoffman 1976). While the Swiss could claim that they were the first to develop a quartz watch (1971), they had to buy the necessary accompanying semiconductor technology from the Americans. Increased investments in R&D could not overcome the Swiss lag in microelectronics technology.

It should be pointed out that Timex and Bulova were caught in the same predicament as the Swiss. After the introduction of the quartz watch, Bulova no longer had the exclusive claim to the world's most accurate watch. Quartz watches were accurate and increasingly inexpensive. Timex was also caught by the introduction of quartz. The company did not initially have quartz watch making capacity, and its eight-step production process was made largely obsolete by the commercialization of quartz.

Just as the Swiss industry recovered technological parity, another innovative threat--digital display technology--arose. This time the Swiss simply miscalculated digital watch appeal. Their original market forecasts downplayed the importance of digital watches. Market share estimates were finally revised in the mid 1970s when the Swiss admitted that in ten years digital watches would comprise one-half to two-thirds of the world export market. But the realization came too late; in the mid 1970s only 10 percent of the Swiss industry's output was electronic (Tissot 1990; Union Bank of Switzerland 1987; Knickerbocker 1976).

Lost technological and volume leadership proved devastating. Accustomed to volume-based dominance of world markets, the Swiss industry became lax about technological leadership. Rather than initiate market changes, the Swiss simply reacted as threats were posed. As ASUAG president Peter Renggli noted in 1978, "The mechanical watch was successful until the recession of the mid-1970s. There seemed no reason to switch over to electronic watch production while we could hardly fulfill our orders for mechanical watches. Why should we have chosen to compete against ourselves with electronic products?" (Katzenstein 1986 p. 220, sic.) Dosi describes the dilemma of technological complacency from the standpoint that "Technological paradigms have a powerful exclusion effect: the efforts and the technological imagination of engineers and of the organizations they are in are focused in rather precise directions while they are, so to speak, 'blind' with respect to other technological possibilities. At the same time technological paradigms define what constitutes progress." (Dosi 1982 p. 153). Thus for the Swiss, innovation was expected, planned for, and financed to improve mechanical watches. The quartz revolution was simply outside the mindset of Swiss

watch manufacturing and precluded the search for new products not part of the existing paradigm.

Technological Discontinuity: The Advent of Quartz[5]

Organizational limitations set forth by the 1930s decree inhibited ASUAG, the major movement producer, from moving into quartz. Because its market was literally hundreds of mechanical watch assemblers, no individual firm's demand was enough to persuade ASUAG to commit to one quartz movement design. But neither did any single manufacturer have an incentive to switch technologies. And even when ASUAG recognized the importance of quartz technology, the company lacked the marketing capability to successfully sell a quartz product to its primary market--Swiss assemblers (Tissot 1990). A captive producer (unable to sell movements outside Switzerland), the firm lacked the incentive and the necessity to develop the marketing skills to compete internationally. Simultaneously, key watch manufacturers such as SSIH were unable to decide upon a quartz model. They therefore invested in numerous efforts to develop a quartz movement.

By the time the Swiss developed a systematic response to quartz technology, they lagged two years behind the Japanese. The Swiss did not anticipate that the new technology would dominate the market in such a short time. But as integrated circuit prices fell precipitously, quartz watches became increasingly affordable. Because the Japanese had been vertically integrated since the 1960s, companies such as Seiko were poised to take full advantage of manufacturing developments occurring at various stages in the watch manufacturing process--further cementing their technological lead.

Simultaneously, they could cross-subsidize component manufacturing--reducing per unit prices while raising per unit performance. The Swiss, with only limited domestic production of integrated circuits in a free-standing enterprise, could not take advantage of information passing between component producers and watch manufacturers.

Unlike the Japanese watch manufacturers who saw semiconductor technology as an end in itself, the Swiss' eventual forays into microprocessor technology were oriented strictly toward watches. This end market focus did not facilitate synergies between semiconductor manufacturers and a wide range of users. Given the size of the watch industry's demand for chips, it was difficult to operate a production facility at optimal scale. It also made investments in R&D very costly per unit of expected demand for chips. Nonetheless, companies such as SSIH attempted to overcome their lack of technological capacity through a joint R&D project with Battelle. FH also initiated a joint R&D project to lessen Swiss dependence on U.S. semiconductor technology. Brown Boveri and Philips of the Netherlands formed FASEC, a laboratory to develop Swiss semiconductor production capacity. By the mid 1970s it was hard to judge the success of the venture because operations were never made public (Knickerbocker 1976; Tissot 1990).

Complicating matters further was the rapid development of digital display technology. The commercialization of digital watches occurred with lightening speed. Digital display technology led to further price declines. This time the competition included American semiconductor manufacturers producing their own brands. Price reductions were dramatic, and by 1975 Texas Instruments had introduced a digital watch in a plastic case for $19.95. Although problems with the battery momentarily resulted in high reject levels, and consumers really wanted watches with more visual appeal, it did not take long

to solve these problems. Battery longevity was vastly increased, watch designs improved aesthetically, and within an astonishingly short period of time, Digital took over a large share of the market.

The Swiss responded slowly to change in digital technology largely because when it was introduced, it was crude. Given what promised to be a reasonably long developmental period between the introduction of the innovation and its eventual market success, the Swiss were understandably skeptical. As Dosi characterizes this moment,

> Especially when a trajectory is very 'powerful,' it might be difficult to switch from one trajectory to an alterative one. Moreover, when some comparability is possible between the two (i.e., when they have some dimensions in common) the frontier on the alternative (new) trajectory might be far behind that on the old one with respect to some or all the common dimensions. In other words, whenever the technological paradigm changes, one has got to start (almost) from the beginning in the problem-solving activity. p. 154

The rapid development of quartz meant there were now many sets of tools needed to produce cases and dials. Uncertainty in both technology and consumer preference forced the Swiss watch companies to compete in three watch markets--digital, tuning fork, and quartz. The succession of innovations and new model development resulted in excess inventory. It seemed that just as a watch was developed, it became obsolete. During this period of rapid technological change, Swiss firms (and others) were forced to take back and in many cases write down inventory--a costly endeavor (Tissot 1990). The

problems of the industry did not become widely apparent, however, until hidden reserves were consumed, and firms were forced to reveal their weakened position.

The experience of the Swiss watch industry is indicative of the turmoil experienced when a new technological trajectory unfolds. The signals about which direction the technology will ultimately take are filtered through institutions which often have competing short term interests. In the case of the watch industry, firms had a vested interest in mechanical watch making. They were receiving positive signals about their existing product, and demand was strong. Therefore suggestions about a possible technological shift seemed misplaced. While the market provides a good focusing device after a decision is taken by industry participants, it is rarely helpful in deciding ex ante which direction the technology will ultimately take. As Dosi suggests,

> . . . the point we wish to stress, however, is the general weakness of market mechanisms in the ex ante selection of technological directions especially at the initial stage of the history of an industry. This is, incidentally, one of the reasons that militates for the existence of 'bridging institutions' between 'pure' science and applied R&D. Even when a significant 'institutional focussing' occurs, there are likely to be different technological possibilities, an uncertain process of search with different organizations, firms and individuals 'betting' on different technological solutions. With different competing technological paradigms, competition does not only occur between the 'new' technology and the 'old' one which it tends to substitute, but also among alternative 'new' technological approaches.

The introduction of the electronic watch resulted in unprecedented change in the organization of watch production. The differences between electronic and mechanical watches were dramatic. Whereas labor costs constituted as much as 70 percent of a mechanical watch, in electronic watches labor costs were expected to be very low (less than 10 percent). Another major difference was the control of technology. The Swiss effectively controlled mechanical watch technology (due to the Statut Horlogerie), and Bulova controlled the tuning fork. Electronics were fundamentally different. The technology was widely available--thus increasing the likelihood of new competitors with little or no prior watch making experience. Given the evolution of electronics it was almost a foregone conclusion that price declines would occur in tandem with increases in capability. Thus even the cheapest watch would be a good watch.

Foreign Investment[6]

Given stiff price competition from all sides, the Swiss industry did make efforts to relocate production abroad. But for various reasons Swiss transfers of manufacturing were unsuccessful. For example, Swiss Time Hong Kong (EST Hong Kong) began outsourcing boites and watch bracelets in 1969 through Economic Swiss Time Holding, a parent organization. In 1971 SSIH bought this company and regrouped it. By 1978 Economic Swiss Time Holding was regrouped into EST Mumpf in the canton of Argovie, EST New York, and EST Hong Kong. Rationalization ensued, and each part of the parent company was either sold to a private concern or dismantled.

Mondaine Watch was one of the major Swiss watch groups in the 1970s (5th in 1974 after ASUAG, SSIH, SGT, and Rolex). In 1974 it was transformed into the Asian

Swiss Industrial Company (ASICO). From the beginning this enterprise was assembly oriented. And in the late 1970s Mondaine Watch expanded assembly activities into Brazil. Changes in the low end of the watch industry in the early 1980s precipitated reorganization of the company, resulting in a much smaller workforce and a shift toward electronics.

There are additional examples of Swiss watch companies which tried outsourcing in other countries during the 1970s and 1980s. These include Baumgartner Freres SA (BFG), Ronda SA, and Beltime Watch Company of Switzerland (Hong Kong) Ltd. In fact, all of the major Swiss watch groups attempted foreign production or assembly at one time or another. However, in each case the decision to begin outsourcing was made on a piecemeal basis--without a joint Swiss industrial strategy. In response to difficulties with new technologies such as quartz and later to their lack of flexible response, each group attempted (alone) to transfer production abroad.

Organizational Rigidities Hamper Industry Response

Internal industry organizational and cultural impediments hampered a rapid response to the electronic watch. For example, the production planning time horizon for mechanical watches differed radically from electronics. The manufacturing cycle was organized according to the lead time needed to manufacture tools and dies for the fabrication of a new caliber, or watch dimension. Once committed to a design, tools and dies were crafted to cut the necessary metal parts. After parts were manufactured, movements were assembled and sold. Introducing a new watch model took up to two years. This two year time lag was built into every aspect of the watch industry. With

electronic watches there were fewer parts to be manufactured. Consequently the time needed to make a watch dropped dramatically. Thus when the Swiss were faced with the need to shift to a new technology, they were already two years behind--given the differences in the manufacturing cycles.

Ironically, product variety further hampered the industry. Few factories specialized in a single caliber. Therefore firms were unable to achieve economies of scale. And importantly, because most factories produced several calibers' parts, inventory overhead was costly. Parts were required for each caliber--resulting in huge volumes of work in process. And the manufacturing cycle had to be managed across a wide range of products from tool making to product assembly. Had the manufacturers been able to sell movements to assemblers, perhaps some degree of efficiency could have been achieved. But the 1930s cartelization policy prohibited manufacturers from selling movements and parts (Tissot 1990).

ASUAG--the big movement manufacturer--enjoyed a virtual monopoly on their sale and could achieve large economies of scale. However, because its pricing policy was public, ASUAG's customers were forced to sell their products virtually at cost. Assemblers were continually pressed by wholesalers for price cuts in watches. There were also no price discounts for volume production. Consequently large assemblers were unable to enjoy productivity gains due to large volume production. Thus they lacked funds to invest in marketing and brand name development.

Manufacturers had no other choice but to focus on quality to differentiate themselves from the assemblers. Moreover, marketing strategy dictated the need to produce a family of watches to preserve firm market share. Since manufacturers could

not sell movements, they could not achieve sufficient economies of scale to enjoy minimum efficiencies. Low volume of output led to high prices.

The advent of the electronic watch presented a severe problem for watch manufacturers. Given their emphasis on quality and precision, a foray into electronics had to carry with it the principles underlying any Swiss watch production. This led to investments in quartz technology of the highest frequency and highest price. A further problem arose in trying to select a single brand to be the Swiss electronic "flagship" watch. The delays that resulted put the Swiss further behind their foreign competition.

Distribution

The Swiss also had to contend with a centuries-old distribution system built around the watch as a piece of jewelry. Mechanical watches were traditionally distributed through jewelry stores, and jewelers made steady profits on repair. But quartz technology threatened to change all that.

Swiss distribution outlets initially balked at the quartz watch. Early rejection was partially attributable to awkward styling--electronic watches were bulky and unattractive (Knickerbocker 1976; Tissot 1990). But more importantly, watch distributors effectively stalled the introduction of Swiss quartz analog watches in defense of their own market for watch repair. Quartz watches were more accurate and relatively unbreakable compared with mechanical watches.

Unlike the Swiss, the Japanese did not have an age-old distribution system. Market channel conflicts did not confront Japanese quartz watch manufacturers. Indeed Japanese channel strategy selected outlets through which the benefits of quartz longevity

and error-free operation were maximized. The quartz watch was easier to sell, and it was more accurate. Timing was also important. The Japanese quest for large markets occurred simultaneously with the retail revolution. Mass marketing greatly expanded the number of outlets for watches. By the 1970s consumers were more likely to buy a watch in a variety store than a jewelry shop.

By the mid 1970s the Swiss were running just to catch up. Major Japanese competitors introduced increasingly cheap, long-lived, and refined watches. They pursued a strategy of short production runs; each time improving upon previous designs and climbing the learning curve more rapidly. Because the manufacturing cycle for the electronic watch was much shorter than for the mechanical watch, the Japanese could experiment within a relatively short time period.

The final blow came when the benefits of quartz converged to produce a cheaper, smaller, thinner, stylish, and accurate woman's watch. Before quartz women's watches had been less accurate and more costly than men's. Now accuracy no longer distinguished cheap from expensive watches. The entire basis of Swiss market hegemony--precision--had evaporated.

Reorganization and Rationalization

The mid-1970s recession had devastating effects on the Swiss watch industry. World demand declined. The Swiss were particularly hard hit because the franc appreciated dramatically relatively to the currencies of other watch producing countries (Retornaz 1989; Katzenstein 1982; Union Bank of Switzerland; Landes 1983).

Starting in the late 1970s, rapid decline in output and market share precipitated bank intervention to stabilize the Swiss industry. Hundreds of small family-run firms went out of business. Mergers occurred to gain greater access to markets. Family-run firms attempted to rationalize outdated organizational structures--creating further industry chaos.

By the early 1980s the Swiss industry was in disarray. The recession dealt the final blow to the Swiss watch industry's historic organization. Faced with operating losses and massive inventories, SSIH was eventually a victim of industry reorganization. The company could not solve the equation of low prices, wide assortment, small volume, rapid change, short delivery time, and big model series (Tissot 1990). Seiko, Japan's largest watch producer, was able to respond because it had the market volume to offer a wide assortment with economical series, low prices, and short delivery. A single statistic says it all, "on the average Japan produced, under each brandname, 6 million watches in the 1970s compared with fewer than 100,000 in Switzerland" (Katzenstein p. 221).

In the early 1980s SSIH and ASUAG were forced by the banks to merge. While the national significance of the Swiss watch industry could not be abandoned, neither could industry organization be allowed to continue as it had in the past. The merged SMH Group was taken over by powerful Swiss industrialists. One of the most dramatic changes arising from the merger was the introduction of a wholly new product, the "Swatch," propelling the Swiss back into the low-priced segment of the market (Business Month 1988). Swatch is a plastic watch manufactured at high volume using advanced automation and assembly-line methods. But the real innovation is in marketing the watch as a high fashion, mood-oriented product. Multiple ownership is stressed, and marketing is targeted toward specific age groups.

The Future

Although the Swiss share of world (volume) output continues to fall, the country remains the leading watch exporting country by value. With only 10 percent of world output, the Swiss command 45 percent of watch export sales value. The Japanese predominance in mid-priced watches is evident in the 1 to 1 ratio between volume and value of watches sold (35 percent of volume and 35 percent of world export sales). Hong Kong demonstrates the inverse of the Swiss experience with 50 percent of the world's output, but only 10 percent of watch industry value.

Leaders in the watch industry feel their industry is still fragile and vulnerable to changes in the world watch market. While low-priced (Swatch) and prestige brand manufacturers consider the future bright, medium-priced watch producers continue to experience intense competition from Japanese and Hong Kong producers. Hong Kong poses a significant threat. Assemblers have created low-priced jeweled watches to compete in the medium-price range, and manufacturers are increasing capital investment to improve overall product quality. And regardless of market segment, Hong Kong firms have a seemingly limitless supply of low cost labor.

The reorganization and merger of ASUAG and SSIH in the early 1980s was only a precursor to further rationalization. Recent interviews with watch companies indicated 1989 demand (including an unexpected revival of interest in mechanical watches) was strong. However, industry participants cautioned that a momentary upswing in demand should not lull producers into complacency. Indeed, Tihomil Radja, chief economist of the Swiss watch industry federation, indicated increased demand was occurring in only some

watch industry segments. FH's annual survey of firms indicated wide variation in firm opinion about the future of the industry. While strong growth was forecast for the low (primarily Swatch) and high ends of the industry, middle range watch producers expect heavy competition from Far Eastern rivals. As one watch maker put it, "we [producers] at the high end of the industry were largely unaffected by the 1982 recession. Because we face inelastic demand, our limited clientele continue to buy--regardless of economic circumstances. Those firms in the middle range, however, were severely affected. Now enjoying strong demand, some firms are once again becoming complacent. This could be dangerous because the market is so unpredictable."

Conclusions

Over the course of the last twenty years the Swiss lost both volume market leadership and technological supremacy. Given the industry's well-tuned production system, high level of profitability, and persistent success in its traditional line of business, what precipitated this historic reversal? Several inter-related issues were identified which exerted major influence over the trajectory of the industry. These factors included not only those which can be ascribed to the industry itself, but equally important, other contextual/institutional factors influencing the modern watch industry.

First and foremost, beginning in the late 1920s the industry organized as a cartel to reduce the opportunistic behavior of industry participants. The resulting structure, though highly efficient and profitable, outlived its usefulness. Unshackled from the Statut Horlogerie, the nation's industry structure attempted to reorganize in the face of international competition. But the changes demanded were massive, and the system

proved incapable of rapidly transitioning into a new technological trajectory. Several factors contributed to Swiss industry inertia.

The structure of production, while efficient and flexible, was also fragmented. Faced with the need to shift from a technology based on mechanics to one based on electronics, a time lag built into the fragmented system inhibited rapid information flow. Moreover, the fragmented system feedback loops which normally carry vital information between manufacturing and marketing functions were deficient due to the archaic structure of production codified in the 1930s. ASUAG sold only to firms in Switzerland. Hence it did not experience pressure to change when the technological paradigm outside shifted. And assemblers' information came strictly from ASUAG so there was no effective signal indicating the need for product change.

Shifting technological paradigms required that institutions and other critical components of the existing system be substantially modified. But this task proved difficult. The 200 year dominance of the previous paradigm constituted an "outlook which focused the eyes and efforts of technologists, engineers, and institutions in defined directions," (Dosi 1982 p. 158). Initially the region did not have the training capacity to provide electronics engineers. These skilled workers had to be imported from outside. In the case of Swiss watches, the decades old distribution system promoted Swiss watches based on their mechanical precision. When electronic products were introduced (and then quickly achieved and then exceeded mechanical precision at a lower cost), the pre-existing distribution channel was hard pressed to respond. Other organizations which represented the industry, such as the FH, were still predicting mechanical watch supremacy as late as the early 1970s. Educational and technical institutions--the core of

the region's production complex--took even longer to respond to the new technological regime.

Amid radical change, organizations could not form a single voice to respond. The watch industry's collective research efforts to pioneer new technology could not overcome organizational inertia and infighting that arose with the need to commercialize the new technology. Without detailed and prearranged specifications about how the benefits of research were to be distributed, institutional inertia slowed the process of change. Since no single firm could be the "first" to introduce the collectively developed innovation, each firm had to develop its own (Tissot 1990). When industrial reorganization eventually occurred, efforts were insufficient to address the structural crisis. Longstanding inefficiencies embedded in the production system led many firms into bankruptcy--resulting in bank ownership of some of the region's most famous and successful firms.

Finally, a shift between technological paradigms included intermediate technologies which were hard to predict or plan for. Shifts occurring among competing technologies necessitated multiple efforts to maintain control of market share. Such multiple research and development efforts were costly. During a period of heightened competition and profit squeeze, the need to deploy resources in multiple directions under great uncertainty placed firms at substantial risk. As the world industry leader, the Swiss had to respond to all new technological developments because it was never clear which technology would become the industry standard.

Section III

Regional Policy in the Jura

For almost 300 years watch making was a vital component of the Swiss economy. In 1970 more than 1,000 firms and over 80,000 people were involved in the watch manufacturing enterprise. Watch making accounted for almost 3 percent of Switzerland's gross national product and employed almost 8 percent of the nation's manufacturing work force. Watches were critical components of the nation's exports--making up 12 percent of 1970 shipments.

The rapid decline of the watch and machine tool industries left manufacturing-dependent regions like the Jura close to disaster. Although a large share of job loss was born by foreign workers forced to leave the country, the entire production system of the mountain region was nevertheless severely weakened. Massive outmigration and restructuring experienced by the Jura in the late 1970s and 1980s led to economic development policy at both the federal and cantonal level.

The two major programs at the federal level are the LIM to aid mountain regions and the Arrete Bonny to encourage innovation and diversification in threatened economic regions. Local initiatives in the Jura and Neuchatel cantons also encourage economic development. These programs have increased the number of semi and nonskilled positions in the region, but the number of jobs created are modest, and the subsidies per job are significant. As the following summary of economic development policy illustrates, Swiss programming shows little variation from standard practice in developed countries. Emphasis is placed on small and medium size business, yet there appears to be little

concern about the efficacy of such actions. The second part of this section reviews the strengths and limitations of such a focus.

Federal Institutions and Regional Economic Development Programming

While the federal government has traditionally acted as an advisor to private enterprise, it has normally been quite reticent about intervening in cantonal development.[7] Switzerland's 23 cantons have been largely responsible for local economic development. But devastation in recent decades of the precision machine tool and instruments industries has exceeded cantonal ability to cope. Political pressure from regional governments has resulted in federal intervention to stabilize economies and protect the remaining precision machining industry in the Jura.

Politique Industrielle Regionale (PIR)

Regional industrial policy (PIR or Politique Industrielle Regionale) is a relatively new phenomenon dating from the mid-1960s when rapid outmigration of rural peripheral populations and increasing concentration of population in the larger metropolitan areas sparked Swiss federal action. The earliest federal legislation addressing regional inequities was enacted in 1959 to create vertical and horizontal equity in federal funding provisions. However, parliamentary decisions to reduce the national debt during the same time period unexpectedly reduced federal aid across the board. This ruling most severely affected fiscally weak cantons such as the Jura.

Because of the structure and distribution of firms in the remote regions of the country, government policy favors small and medium-sized businesses. Emphasis is

placed on picking firms that already exhibit success rather than establishing a broad basis for local economic development. Such policy inadvertently supports maintenance of the status quo and is relatively risk averse.

La Loi sur l'Aide Aux Investissements dans les Regions de Montagne (LIM)

Two federal programs targeted the Jura specifically. One of these is La Loi sur l'Aide Aux Investissements dans Les Regions de montagne (LIM). LIM legislation was enacted in 1974 and modified in 1984. The thrust of this federal aid program is twofold:

1) to improve living conditions in the mountain regions;

2) to reduce emigration from mountain regions.

In particular, the program seeks to develop infrastructure. To qualify, a region must have a regional development program recognized by the federal government. Further, cantons must match federal funding and execute the program for which they receive funds. Aid consists of guaranteed loans with favorable conditions. In some instances the government will assume interest costs for infrastructure development in regions.

In 1984 LIM was modified to allow acquisition of industrial space and funding for a LIM director in each canton. To date 54 LIM regions have been created covering two-thirds of the nation.

But the LIM program has met with limited success. Since the program was implemented during a period of economic crisis, it is difficult to determine total benefits. In 1984 additional funds (500 million francs) were added to the LIM program. By 1985 2,125 projects had received funding, and aid totaled 592 million francs.

Arrete Bonny

Another large federal program is the Arrete Bonny--legislation for regions with endangered economies. Enacted in 1978 (and modified in 1984), the law promotes innovative projects with potential for diversification in regions undergoing difficulties. (Figure 4a shows the Swiss regions that are economically endangered).

In order to qualify, a region's economic base must be concentrated in a single industry which is experiencing severe employee reduction. Financial aid is distributed through investment credits for purchase of machines, equipment, licenses, buildings, and new construction. Assistance is also available to underwrite risky projects which have potential to increase employment in the region.

This program is financed largely by the cantons and participating banks. The federal government bestows loans initially, and the cantons must insure them. Banks provide market-rate loans to qualified companies. Individual firms are responsible for innovation and diversification. The Arrete Bonny was modified in 1984 to be more flexible and to target technology firms. Although originally intended as a stop-gap measure, the program was extended to 1994.

By June 1985 200 industrial projects were sponsored through the Arrete legislation. A total of 780 million francs were spent. Of this, 204 million francs were jointly provided by the federal government and the cantons. Small and Medium Enterprises (SME) benefitted most from the legislation. Of 200 projects funded, 132 were to companies with less than 50 employees and 64 were to companies with between 50 and 500 employees. The Jura region received the lion's share--173. Projects have been primarily in the fields of electronics, electrotechnique, and machine construction.

Arrete Bonny has had positive impacts on the Jura and Neuchatel regions. Nonetheless, the program has problems. One of the main criticisms is that grants are given only to projects sufficiently developed to present the least risk. Thus aid is not supporting the research and development activities of firms--a chief target of the program.

Federal Academic Programs

In July 1976 the Swiss government passed legislation to finance a National Research Program on the "Regional Problems in Switzerland." Between 1976 and 1984 approximately 100 individual research projects were funded totalling 11 million francs. Two other National Research Programs examined regional disparity in Switzerland: "Man and Biosphere" and "Economic Development." Many regional studies are still funded by the Swiss government.

The aim of "Regional Problems in Switzerland" and "Economic Development" was to determine the level of regional disparity in Switzerland and to identify negative effects of past government policy in order to outline the best policies for the future. A disproportionate number of research studies focussed on the Jura because it appeared that drastic changes in the watch industry had left the region's fragile economy most in need of restructuring.

In the early stages of the research program analysts identified the innovation process as the central factor in regional development. Entrepreneurship was deemed a necessary catalyst for regional welfare because there were doubts about the capacity of Swiss firms to manage structural changes occurring in the global market.

Cantonal Economic Development

In the late 1970s cantons began enacting legislation aimed at economic development. In 1977 cantons started to lay out economic development goals and to work with local banks to increase their competitive edge. Cantons have used the following instruments to promote economic development:

Financial Aid: Guarantees for investment credits, direct loans, direct participation in private firms' capital accumulation.

Land and Housing Policy: Purchase of industrial sites, aid for industrial equipment.

Fiscal Policy: Total or partial abatement of taxes for five to ten years, tax and utility reductions, privileges for holding companies.

Research and Development Support: Loans, interest rate reductions, contributions to sinking funds.

Labor Policy: Allocations for reintegration of the workforce, training courses for unemployed, travel permits for unemployed foreign workers within a region.

Neuchatel

Neuchatel has the most innovative economic development program in Switzerland. The "Neuchatel Way" targets entrepreneurs in both regional and foreign firms. Economic promotion is presented as a complete package of allowances and grants to prospective firms to move into Neuchatel.

In 1971 funding was approved for a full time economic development position for Neuchatel Canton. The economic development staff targets companies in the U.S., Germany, France, and Hong Kong. Firms in microtechnology, precision mechanics, robotics, and products with a high value-added component are given special attention. And development policies also favor SMEs with proven entrepreneurs.

The economic development staff assists clients with site selection, finds lodging for company executives, recruits personnel, and arranges for schooling of new workers' children. The staff also works with bankers and lawyers who are commissioned by the canton. These specialists initially help prospective firms with location problems, but after establishment they continue to serve as an information source.

Jura Canton

Enabling legislation in 1979 established economic development in the Jura canton. The SDEJ (Societe pour le Developpement de L'Economie Jurassien) was formed as a collaboration between the canton and local banks. This organization is charged with economic development financing. By the end of 1984 SDEJ had awarded 24 grants for a total of 9.5 million francs and over 1.6 million francs in interest rate abatements. By 1986 67 projects had received funding for a total investment of 150 million francs.

Small and Medium Size Enterprises and Regional Development

As indicated in the introduction of this section, Swiss regional policy targets small and medium size business. This orientation is a result of both historic and contemporary political and economic circumstances. Historically, the region's major business enterprises were small firms. Presumably these establishments experienced the worst effects of industrial restructuring and were therefore in greatest need of assistance. Furthermore, during this century watch and machine tool firms were responsible for a significant share of the nation's GNP, manufacturing employment, and exports. Watch assemblers and manufacturers were consequently an important political constituency that

could not be ignored. Although in recent times small and medium sized watch and machine tool firms have lost both political and economical power, these industries still represent an important component of Swiss national identity. Finally, from a pragmatic perspective, it can be argued that local government has little direct influence over national and multinational corporations. Therefore, if public policy is to have any affect, it must be targeted toward enterprises which are susceptible to regional influence.

Academic literature about the Jura also points out that policy has been influenced by the belief that small firms are a major source of innovation and job generation. This perspective arises from research begun in the U.S. in the 1970s that documented job creation by small firms.

The subject of small firms, innovation, and regional development has been the object of at least 17 studies in Switzerland (Brugger and Stuckey 1986). And although there appears to be some debate about the efficacy of small enterprise development and policy programming, this skepticism has not altered either academic or policy discourse. Because most policy and theoretical emphasis focuses on small business, we review recent research about small business job generation and small business' ability to create and implement new technological innovations.

In previous sections we have alluded to the problems of small firms and regional innovation. In later discussions it will be our contention that the organizational structure of firms in the region is in fact a serious impediment limiting the Jura's ability to adapt to changing international circumstances.

Small Business Myths

Much has been said about the job generation prospects of small firms, particularly in the U.S. This has led to a widely shared belief that small firms are a major source of local economic development. In spite of longstanding small firm limitations--lack of capital, know-how, and access to markets--most local economic development policy embraces a small firm component. Nevertheless, recent changes in the international division of labor, the creation of strategic alliances, and the continued importance of large firms in economic development has led researchers to question the efficacy of small firm development strategy (See Harrison 1990 for a recent critique).

The original empirical basis for small business enthusiasm has largely been discredited. The infatuation with small firms originated with mid-1970s research by David Birch in which he claimed that small firms created 80 percent of all new jobs.[8] First indications of problems with Birch's results arose when researchers attempted to reconstruct his original work. The Dun and Bradstreet Corporation concluded that Birch's work relied upon inflated figures. Acquisitions had been counted as new firm creations when they were in fact simply ownership changes.

It is now widely accepted that small businesses create jobs in proportions close to their share of all establishments in the business population. In an exhaustive review of literature on small firm job generation, Bennett Harrison indicates that U.S. and European researchers found small firm growth rates were modest at best and were at worst below average during the 1980s (see Storey 1986 for an empirical critique).

Are Small Firms Innovators?

Additional questions have been raised about small business' role in the innovation process. While examples exist where small high tech firms have grown into multinational behemoths, the weight of evidence indicates that small firms are not inordinately innovative. There is growing evidence suggesting that small firms are technological laggards, falling significantly behind large firms in the application of new technologies to manufacturing processes. Research on investment behavior further indicates that small firms are less sensitive to business cycle upswings than large firms. Unable to respond quickly to opportunities, they can not participate fully in the benefits of periods of economic expansion in an industry (Storey 1986). Contemporary work by Harrison comparing business research in the US., Japan, and Europe also finds that rates of innovation are consistently lower in small firms than large firms (1990).

Another overstated quality of small business is their presumed adaptability to exogenous change. Much recent scholarly writing about production complexes in Central Italy, for example, focuses on small firms' adaptability to business cycle fluctuations due to membership in regional production networks. While there is some evidence to support the claim about Central Italy, recent research indicates that considerable consolidation is taking place. While production currently remains fragmented, reconcentration is occurring in strategic functions such as design and marketing (Martinelli and Schoenberger 1990). There are also historic counter examples such as the Northern Ireland linen industry of the early 20th century. The industry erupted into chaos when both material inputs and markets unexpectedly changed. Only the firms which were able to vertically integrate and gain some control over their markets survived (Steed 1974).

The literature on small firm production complexes emphasizes small firms' flexibility to shift products in response to market signals. This literature implies that flexibility is the exclusive domain of small firms. However, recent literature contends that large and small firms both exhibit flexibility (albeit in different forms). For example, Martinelli and Schoenberger argue that small firms achieve flexibility primarily by operating at the margins, while large firms achieve flexibility through more established means (1990). Thus while small firms achieve labor market flexibility through creation of secondary labor markets, large firms achieve similar flexibility through creation of spatial divisions of labor.

Small firms have also been associated with high adoption rates of new flexible production technology. Some authors argue that increased unit variability made possible by new computerized manufacturing equipment allows small firms to operate efficienttly at low volumes. But evidence suggests that within the U.S. machine tool industry, small firms do not exhibit greater rates of technology adoption (Kelly and Brooks 1988). Additional research shows that while small firms do use computer numerically controlled machines, more advanced technologies such as robotics and integrated machining centers are too costly (Acs, Audretsch, Carlsson 1988). Consequently while today's stand-alone conventional computer-aided machine tools are being applied by small firms, cutting edge computer-aided technology is not.

While surprising, these results should not be wholly unexpected. Small firms rarely have the funds to invest in new technology. And even if they are able to create new innovations, small firms lack the resources to bring new products successfully to market (Friedling 1982). The rise in strategic alliances among small and large firms in countries worldwide attests to small firms' problems with bringing new products to fruition.

In sum, the weight of recent evidence indicates that small firms do not have a corner on flexibility, innovation, or job generation. In fact, numerous authors criticize past research for focussing on single units of analysis while ignoring "the social institutions associated with distinctive kinds of industrialization (Storper and Walker 1989)." "In other words, the absence of studies of the context of industrialization has tended to lead to reductionist explanations of uneven development based either upon selective firm or sector studies (Sayer p. 691)." As Sayer goes on to note, what these studies do not explain is why:

> in certain historical periods particular countries tend to do exceptionally well in export performance not just in one or two industrial sectors, but in many simultaneously, indeed sometimes in almost all of those sectors which are dominated by natural resource availability or long-term traditional fashion-based factors (Freeman, 1987:96).

"The answers to this puzzle are to be found in matters such as education, the social and institutional form of capital and state-capital relations, and moving beyond the bounds of 'national innovation systems,' in labor market characteristics, employment relations and culture (Sayer 1989)."

Since the early 1980s scholars have been fixated with the notion of small firm production complexes. The resulting literature has romanticized the viability, flexibility, and longevity of this form of industrial organization. In large part this literature was intended as an antidote to large firm dominance in much scholarly work regional and international development. With greater reflection, scholars are now beginning to question the efficacy of small firm production complexes. They are recognizing that their existence is both

time- and sector-dependent and therefore an improbable model of future regional development.

Industrial Recruitment

An alternative to small business development is industrial recruitment. A recent primary means of affecting economic development in the Jura has been through branch plant attraction. New jobs have been created through relocation of firms headquartered throughout Europe. On average these facilities are more technologically innovative and tend to use more sophisticated production technology than locally owned firms (Brugger and Stuckey 1986). However, rather than revealing an unusually high level of technology in foreign-owned establishments, this finding may simply reflect the lack of technological sophistication in locally owned firms.

It is important to note the extent that these new branch plants are pioneering a new industrial structure by determining the types of jobs created by foreign and regional firms. Foreign companies relocating to the Jura employ high proportions of semi and unskilled labor. Again, this is not surprising given the region's admitted shortage of skilled labor and abundance of semiskilled and unskilled workers.

Similar to local firms, foreign affiliates have to import technically trained workers. The watch region's proximity to Switzerland's border with France encourages branch plants to locate in the Jura mountains where French citizens commute in and fill vacant low-wage positions in the factories.

Mature Product Branch Plants

Branch plants bring mixed blessings worldwide. From a corporate perspective, branch plants maximize inter-regional cost differentials for land and labor. Early literature on the new international division of labor characterized these plants as manufacturing mature products for which labor costs were a significant component of total cost. Firms decentralized production to less developed areas to take advantage of pools of low paid, docile labor (see Glasmeier 1986 for an elaboration of this perspective).

From the community's perspective, branch plant attraction has been a welcome source of employment for countries and regions with inferior technologies and limited production structures. Communities actively recruit branch plants because they provide a large source of employment. Given the time it takes to "grow your own" establishments, political leaders see hosting branch plants as a expeditious means of creating jobs. Thus while the cost of attracting branch plants is often high, the short term payoff can be significant.

Industrial development in the post-war U.S. is a vivid example of this strategy. Starting in the 1950s, state government officials in the nation's traditionally underdeveloped region--the South--spent enormous sums of money to attract plants from the Northeast and Midwest. Firms were attracted to the South because of low wages and union-free environments. Many southern rural communities were industrialized in this manner.

In general these establishments employed relatively standard technology with only minimal need of process-based engineering. The occupational profile of these branch plants was heavily weighted toward production employment. As the plants were members

of multilocational firms, little support staff was needed; services were provided by parent organizations. Because of this strong link back to a parent corporation, branch plants traditionally bought few goods and services locally, depressing the local employment multiplier and precluding the formation of supplier firms. Hence a major complaint of scholars studying branch plants was that communities received little indirect benefits. And because plants were in cost competitive industries, they were prone to close during periods of economic recession.

Technical Branch Plants

Technologically sophisticated firms also create branch plants. These establishments are not manufacturing standardized products at the end of a product cycle (Glasmeier 1988, 1990). In many cases they are manufacturing products which still have strong market appeal and incorporate state-of-the-art-technology. Location of these branch plants is predicated by a supply of technical labor. Yet the plants also employ significant levels of direct labor in manufacturing and assembly operations. Given that low cost labor is relatively immobile in high wage countries, firms must locate technical branch plants in areas with this bimodal labor pool. These branch plants present different opportunities for community economic development.

In high wage regions of developed countries branch plant creation consists of facilities with significant levels of process and product technology. Firms create remote facilities when they must decentralize technical production to places with lower labor costs and stable sources of labor supply. But while labor costs are significant, these firms' need

to attract technical labor may be more pressing. Compared with more mature product branch plants, these establishments enhance the local skill level.

In the U.S. technical branch plants were created as the firms concentrated in original centers of innovation such as Route 128 and Silicon Valley faced rising production costs and found it increasingly difficult to attract engineers to operate production plants. Branch plants of these firms could not move just anywhere. They sought less costly metropolitan areas where appropriate skills, institutions, and less costly direct production labor were available.

In summary, not all branch plants are created equal. Some have the ability to improve aggregate skill levels of a region. But this does not mean that technical branch plants avoid the pitfalls traditionally associated with non-local establishments. Indeed, they are characterized by many of the same deficiencies of their mature product counterparts. For example, they still tend to remain isolated in a local environment. In the past this problem largely focused on firms' failures to establish local linkages with the service sector and other secondary industries. Today, however, the problem revolves more around gaining access to the technology and know-how embedded in technical branch plants which may be more technologically sophisticated than locally owned establishments (Frielding 1982). The Swiss programs do not appear tailored to encourage technology transfer among technical branch plants and local firms.

Regardless of the type of branch plant, communities spend considerable sums to attract these facilities. Most studies of branch plant incentives indicate that many firms that garnered large incentive packages would have made the same location decision with much smaller inducements. When communities in the U.S. are competing against each

other, relocating firms consider incentives only as "tie breakers" for making final selections. In Switzerland it appears that incentive programs are so lucrative that firms take advantage of them even when they do not plan to remain in the region after tax holidays and other program benefits have been exhausted.

The Implications of Regional Economic Development Policy

Quantitative information documenting the effect of Jura economic development policy is scarce (See Corat 1985 for a francophone treatment of the issue). Although some data exists about numbers of jobs, levels of incentives, etc., the results are difficult to interpret. In part this lack of information stems from the relative newness of many of the programs. Yet given the large sums of money spent on economic development programs and research, it seems vital that there be some evaluation of program output to determine future policy orientation.

The Swiss system of local, cantonal, and federal economic development programs mirrors that found in other developed countries. Tax holidays, worker training, wage subsidies, infrastructure etc. have also all been implemented in other countries. In fact, because the U.S. pioneered many of these local economic development programs, their experience may be illustrative of the efficacy of these local economic development programs.

Most evaluation research about local economic development in the U.S. indicates that incentives are indeterminate influences on firm location behavior. Other factors such as access to markets, skilled labor, and other competitors, dominate firm location decisions. Aggregate statistical research shows that at a regional level, tax incentives are

essentially give aways. There is some evidence, however, that within a region, tax rates have some effect on firm location decisions. Nonetheless, firms comment that incentives do not ultimately determine their location decisions. However, given that incentives are now wide spread, it is virtually impossible for a community to compete for industry without them.

Successful economic development programs are those that provide training and infrastructure. Firms readily admit these two programs are important determinants of their location decisions. Firms are therefore often willing to share the burden of their provision. As with tax incentives, communities must increasingly offer these programs just to remain on par with their competitors. Yet these programs improve the overall condition of the community.

Within the U.S., incentives for R&D have shown little effect on local economic development. This may reflect the overall low level of investment made in such programs. Furthermore because communities copy each other, any uniqueness that might arise from R&D incentives is diminished. Imitation tends to homogenize local offerings--thus screening out the potential for true program innovation.

Whereas local governments apply few standards in the awarding of incentives to targets of industrial recruitment, small business programs often err in the opposite direction. They are so discriminating that many establishments which need help can't qualify. Small business' problems differ from those of branch plants. Small businesses need access to information and new technology. They also need easy access to working capital and managerial assistance. But small business' own cynical attitude toward assistance can be self-defeating. Even when programs exist, businesses often don't

apply because they anticipate long bureaucratic delays. Local economic development programs rarely have the patience or perseverance to really help small firms.

Conclusions

Previous discussion suggests that regional fortunes are increasingly intertwined with global events that are largely beyond a single community's control. External economic forces influence the trajectory of a region's development through their effects on locally established firms. Relationship between regions and industry are therefore reciprocal. As an industrial culture comes to define a place, it structures future opportunities for innovation. Given that job creation tends to mirror a region's skill base, and supply constraints govern the availability of mobile technically trained labor, policy has only modest effect on reestablishing regional innovation.

The long tradition of watch making and precision machining is the technological base for the region, yet this history is also responsible for many limitations to development. The intent of this second section is to illuminate the barriers to future regional innovation. Our purpose in the next section is to step back from questions about watch manufacturing per se, and focus on the regional context using empirical studies of the Jura region as our information base. In this section we emphasize the institutional context in which industrial production occurs. Our intent is discover the extent to which regional institutions and cultural outlook are evolving in response to technological change.

Section IV

Empirical Research on the Role of Industrial Innovation and Regional Development in the Jura[9]

It was evident from previous discussion that institutions play a key role in the evolution and transformation of a regional production system. This section examines how these institutions are evolving during a period of heightened international competition and technical change.

The Jurassien Arc has been the subject of bountiful research over the past 10 years. We review this material to answer implicit questions raised in previous sections about how change is unfolding in the region. The section begins by reviewing research at the firm level. Firms are the basic building block of a regional production system, therefore we review literature that examines the innovative experience of this sector of the region's economy. An equally important component of the region's economic foundation is its institutions. Based on written reports and personal interviews with key informants, the second part of this section reviews the strengths and weaknesses of public and private institutions in the Jura. The third part examines how Jura firms are integrating into the new international division of labor.

Innovation in the Context of Reindustrialization

Over the last ten years, scholars of the Jura have developed a large body of research about innovation and regional development. While much of this research has been intentionally abstract and theoretical (see Loertscher 1982 for a summary and critique; see Brugger and Stuckey for a summary of the literature 1986), a number of

important empirical studies about firms in the region provide insight into the role of innovation and the process of industrial transformation currently underway. To discern the significance of this research, we will first establish its context and then contrast the observed with other innovative regions.

Research on the Jura has been conducted largely from the perspective of a prior center of innovation undergoing industrial restructuring and regional decline. For two centuries the Jura represented an anomaly in the otherwise urban-dominated hierarchy of innovation centers. In contrast, U.S. research on technological change and regional development focuses on a few new and highly successful regions in the country. Much of this new industrialization has occurred in previously non-manufacturing regions. The evolution of these new complexes must be understood in conjunction with overall population and industry movements underway in the U.S. since before the Second World War. And importantly, the knowledge base underlying these phenomena has identified the fundamental importance of post-war government spending on defense-related research and development.

Despite these radically divergent experiences, the factors attributed to innovative regional development (labor, venture capital, access to universities) read like a prescription for the next Silicon Valley. And while we do not claim here that these factors are unimportant, we point out that supply factors cannot be viewed in isolation. They are not the ingredients of an elixir which, when mixed in the right quantities, will produce regional innovation. While in the age of microelectronics it is appropriate to emphasize the importance of human capital (firms in associated industries require technically trained labor forces), a singular focus on place-based characteristics overlooks and therefore

underestimates contextual weaknesses of a region. Place-based studies of innovative regions generally under-emphasize historic conditions and cultural norms. In these studies there is also a tendency to overstate the significance of new technology applications, such as microelectronics, to traditional industries (Maillat 1982, 1986; Friedling 1982). As McArther (1988) notes:

> the vast majority of recent research on the role of regional innovation tends to equate the application of new technology with the ability to grow and change when it can do many things depending upon how it is applied; whether it is an input or output, intermediate or final product. Whereas the level of adoption, the kind of uses, and the kinds of effects are all distinguishing features--features which cannot be left unstated nor read off surrogate measures of innovation (pg. 30).

Most research on innovative regions consists of cross-sectional studies examining regional conditions at a single point in time. Furthermore, there is an absence of control groups which would allow reasonable assessment of the evolutionary condition of the region's production and institutional structure. Without controls it is impossible to determine what a condition of non-innovation (null hypothesis) is. Claims of regional revitalization must be made on the basis of historical regional analysis which identifies changing trends over time. Aspects of the earlier research on the Jura suffer from some of these methodological shortcomings. In recent years researchers have attempted to rectify problems of comparability.

The Industrial Structure of the Jura Arc: Shifting Paradigms?

The bulk of empirical work on Jurassien firms attempts to discern whether the region's establishments (and therefore production system) are transitioning from a dominant mechanical technology paradigm toward a multi-sector economy based around information technology. Indeed, early research describes the Jura watch making region as largely mono-industrial, dominated by mechanical watch manufacturing (Maillat 1982; Boulianne 1982; Boulianne and Maillat 1984). With the exception of the machine tool industry, which largely grew out of watch making, no other industries established a significant presence in the region. And as one scholar noted, "the dominating position of watchmaking . . . had a dampening effect on business enterprises in other sectors." Swiss industry maintained its geographic dominance until foreign competition eroded the absolute comparative advantage derived from the decentralized production structure. "Whereas the [foreign competition] was vertically integrated, the organization of Swiss watch manufacture relied on a very slow transition from horizontal to vertical activities, starting upstream and thus neglecting the highly vulnerable downstream structure" (Landes 1984).

Speculation exists about whether application of microelectronics to industries in the region constitutes a successful transition from a mechanical to an electronic paradigm. Divergent views exist. Maillat (1982) suggests "the electronic watch forced the gates of the region open." Whereas another view suggests the two paradigms appear to coexist, "Although the [traditional] production system . . . has been partly dismembered, it must be recognized, nevertheless, that two new partial "industrial substructures" have emerged (Hainard 1988). This implies that this new technology has not really changed the existing

institutional context. Indeed, with the exception of the largest firms, production technology remains the same. Few radically new innovations are created by the region's firms.

Surveys of Innovation Diffusion

A substantial effort has been made to determine the degree of technology diffusion in Jura firms. This research also gauges the significance of the innovation process itself and the degree that local firms are innovative. These studies identify the way new technology enters the region and how differences in regional supply factors affect firms' ability to innovate.

In one study, Maillat and Boulianne (1982) found that slightly more than 1/3 of firms interviewed had introduced either a new product or process. Further probing indicated these adopting establishments were larger, more mature (between 30 and 70 years old) and more capital-intensive on average, and were not primarily from the watch industry (p. 49). These establishments were neither the fastest growing nor the largest job generators in the region. Rather they emphasized depth in specific technology areas and redefined positions rather than adding new jobs as technology changed. Furthermore, they were not located in the more remote areas of the mountain region.

The studies noted that acquisition of advanced technology occurred as new employees were hired from outside. These same organizations followed strategic plans when undertaking new product development (Boulianne and Maillat 1983 p. 60; Brugger and Stuckey 1986). They found that information transfer occurred through pre-established channels of communication. In the diffusion process, information carriers were technical personnel and new machines purchased from other firms. Dynamic firms with high rates

of innovation adoption employed large numbers of workers in tertiary tasks. They also purchased sophisticated business services outside the firm.

For both early and late adopters an important factor in the rate of innovation diffusion was entrepreneurial assessment of the regional economic climate. A large number of firms in the Jura were risk averse and adhered firmly to past practices. This attitude limited their adoption of new technologies.

Few Firms Innovate

The bulk of research on innovation adoption and development in Jurassien firms suggests that firms are engaged in incremental industrial innovation in the spirit of what Dosi calls "natural technical progress within an existing paradigm" (1982 p. 154). Most new developments are modifications to existing products and processes. Firms rarely planned to pursue new innovations. Rather innovations occurred as firms reacted to market conditions. While there was some suggestion that firms were taking up wholely new innovations, the majority of change in traditional industries took place at a slow, methodological rate.

In a large 1985 survey project Maillat and Vasserot identified firm characteristics associated with new product and process innovations (Maillat 1986; Vasserot 1986). Of 320 firms interviewed, 79 percent introduced some type of innovation. For the non-innovators, market stability and lack of financing were most important in explaining their reluctance. Of the innovating firms, the majority introduced innovations which represented minor modifications discovered by chance rather than through strategy. In other words,

firms did not set out purposefully to develop new innovation. They stumbled upon them in the course of daily affairs.

Only a fraction of all firms (less than 12 percent) originated radical innovations. Firms introducing truly new products were primarily in machine tools, clothing, and plastics industries. Superficially it appears that very small firms are highly innovative. Careful examination of the evidence indicates, however, that small firms innovate at expected levels given their representation in the study data.

The study confirmed that firms lacked strategy when implementing new innovations. Most answered that new products were developed in alignment with business cycles and to stave off competition. One-third indicated that they followed a planned strategy for new product development (p. 18).

The introduction of new process innovations followed similar lines. The most widely introduced technology was numerical control equipment. Given that computer numerical control has been in use for 20 years, this result is somewhat ironic (Kelly and Brooks 1989). Very few firms used robots, process control systems, or lasers--three new technologies used in machining operations. While the application of general automation was reported by a fair number of firms, this is not a new process innovation per se. Automating devices can be very basic and used primarily to decrease labor input. No surveyed firms created wholely unique process technology. Process innovators were sub-contractors in the metal trades industries and ranged in size from very small to medium sized. Very few of these firms followed a preconceived plan when adopting new technology.[10]

Firms that introduced both process and product innovations were larger on average and engaged in strategic planning for new developments. However, these firms did not boast a technologically sophisticated labor force (Maillat 1986, p. 18).

The Absence of Complementary Service Functions

The studies on innovation diffusion and regional transformation identify the lack of business services in the Jura as a critical weakness in the region's industrial base (Boulianne 1982; Maillat 1982, 1984, 1986). Almost every study highlighted the relative under-representation of service functions in the region. This finding is related to regional firms' minimal use of services and their tendency to perform service functions in house. Even innovative firms that successfully diversified into new products employed few workers in tertiary activities. Thus there was relative under-representation of service functions in the region. The studies further indicated that business enterprises created between 1978 and 1983 converged on the region from outside in response to industrial recruitment efforts. As the previous discussion suggests, these foreign-owned establishments appear to reside in the region to take advantage of semi-skilled, lower wage workers and lucrative incentives (Corat 1985). Branch plants are noted for low levels of service demands. Presumably the parent firms provide the majority of service inputs.

Key Components of Technology Diffusion: Labor Markets

Another study discussed the influence of firm-level internal labor markets on a region's ability to maintain its skilled labor force. In 1984 Maillat reported the degree of

job mobility and prospects for employment loss in the Neuchatel region. His research examined 13 types of establishments started between 1970 and 1979. The study reported that during recessionary periods firms experiencing job losses were those with the least skill-intensive operations. The more sophisticated its internal labor market, the more likely a firm survived the recession without massive job loss. Obviously firms with significant investments in their employees retained them even during industry downturns.

Summary

In order to evaluate the significance of these findings, further study is needed. For example, to assess the extent that firms in the complex are changing established behavior requires a measurement of the introduction and diffusion of innovations over time. To assess the Jura's position in the global production system, it is necessary to make comparisons of innovation adoption among similar places with similar vintage technology. On the basis of existing empirical evidence, it is impossible to determine the extent that the complex has made the transition to a new technological paradigm. Of major significance, no research indicated that firms had introduced a world class technologically sophisticated product within the contemporary microelectronic technological paradigm.

The Role of the Milieu

In a summary report of several GREMI-sponsored studies, Maillat (1989) discusses research on firm level innovation and regional complex structure. Drawing upon studies of Central Italy, Silicon Valley, and the Jura, Maillat suggests that the key to innovative firms is their degree of extroversion and secondarily, their integration into a local "milieu." With

milieu, Maillat identifies "a coherent area organized around its physical structures (territorial production system) and around its non-material structures (technical culture). This definition is very close to "industrial district" as used by Scott (1988), Sabel (1988) and others.

The multi-country study suggests that "the more a milieu is characterized by a strong degree of openness, the more a strong local interdependence and integration between firms are necessary," Maillat 1989, p. 12).[11] Of particular importance is the extent that firms innovate without strong ties to the surrounding milieu. Indeed, many firms interviewed were wholely independent of their local complex. This implies that the notion of vertical disintegration as the raison d'etre for innovation and complex expansion is perhaps misplaced. The studies cited suggest that "the degree of integration of innovative firms in a milieu varies and that firms may very well innovate without using the milieu's resources." Thus we can only conclude that the role of the regional production complex in the formation of new industrial innovations is indirect if not ambiguous.

Regional Institutional Weaknesses

The production system, consisting of firms in the dominant sectors as well as support services, can be viewed as a member of a larger institutional context. This context (milieu, industrial district, or industrial complex, etc.) is the reservoir in which a region's amalgam forms. Thus now we turn to a discussion of the level of institution and an examination of the weaknesses of the region's social reproduction system.

A recent synthesis by Crevoisier, Fragomichelakis, Hainard and Maillat merges many insights from previous work into a useful summary of the region's institutional and

cultural weaknesses (1989). The authors emphasize the weakness of the mountain region training system. While firms exhibit empirical know how--the practical relationship to the production process--they noted an absence of "analytical know-how: the additional existence of an ability to carry-out a relatively-thorough scientific analysis of the factors involved in that process" (p. 3-4).

Other scholars contend that the Jura has primarily been a site of high precision assembly. While historically residents of the region made significant contributions to watch manufacturing technology, the knowledge base was relatively small and controlled by a few individuals. Francois Hainard argues that the Jurassien style is associated with docility, dexterity, and skill at working on small pieces. This ability is more pronounced in the Jura than in other Swiss regions or in neighboring countries. He argues that few members of the region--entrepreneurs or just a few elites--ever had the ability to conceptualize new products and create new technologies. In contrast with conceptual knowledge, Hainard feels that the "ability to do" (savoir-faire) is not synonymous with dynamism and innovation. On the contrary, it can lead to complacency, recalcitrance, and production delays. In essence the Jura's critical competitive advantage was precision assembly. The region generally lacks the intellectual capacity to innovate autonomously. He suggests the region's problem is perceptual, arising from longstanding dependence on a single industry.

Comments about the Swiss machine tool industry by Professor Provo parallel Hainard's conclusions. Swiss industries, particularly small and medium-sized businesses, are locked in a technological paradigm which emphasizes precision. Interviews with machine tool firms indicated that the firms viewed their key competitive advantage as

precision metal machining and assembly. But while this is an useful core skill, it is by no means unique to the Swiss. Anecdotal evidence supports the contention that in lieu of competing at the cutting edge of technology, firms hide behind this label. As Provo noted, Swiss machine toolers receive orders from Japanese firms because Japanese machine tool companies have stopped making single purpose equipment. Thus while Jura-based machine tools are still being made and sold, they are not at the cutting edge of technology, and their design is driven by customer request rather than direction from Swiss machine tool companies themselves. Over the long run, retreat to niche marketing implies that machine tool makers cannot compete on a high volume basis.

Regional Institutions Promote Technical Change

The Jura region boasts a number of institutions providing technical information and advanced production acumen. These include high tech research centers such as the Centre Suisse D'Electronique et de Microtechnique (CSEM). But in general, research organizations have difficulty filtering scientific knowledge to firms in the immediate vicinity. In part this is because firms receive technical information through different channels than those created by the scientific laboratories. More fundamentally, this type of basic knowledge is most readily absorbed by large firms that have research and development departments capable of using theoretical breakthroughs in technology.

While there is electronic component capacity in the region, some observers believe these producers operate at sub-optimal levels and lack the ability to create significant technological developments with potential for down stream commercialization. Moreover, because the intended market for these electronic products is the watch industry, the

technology is based on the characteristics of the end user. This makes it doubtful whether the region can develop an independent microelectronic base which is separate of watch making.

Institutional Inadequacies and Labor Force Limitations

While the Jura enjoys a number of training institutes and technical research facilities, the region still has an acute shortage of technically qualified personnel. In spite of the presence of such technical centers as CSEM, most educational facilities in the region are still oriented toward the vocational skills formerly tied to watch manufacturing. And in watch making and machine tooling in particular, the educational emphasis has traditionally been on apprenticeships or on-the-job-training (as opposed to research-oriented education).

Recruitment of skilled labor is a critical problem for firms in the region. Branch plants have had to hire skilled workers from outside the region to operate their factories. Local manufacturers are also increasingly turning to foreign workers trained in other countries to provide technical skills.

Two reasons for this lack of qualified personnel are demographics and education. The Jura's population is aging, and many young workers have migrated out of the region in search of employment elsewhere. The loss of young workers is an especially acute problem during periods of technological change. While older workers are sometimes difficult to retrain (particularly in technical fields), young workers just entering the labor force (many still in school), can more easily grasp new skills. With this segment of the population declining in numbers, there is a reduced pool to draw from.

Furthermore, Switzerland's smaller population vis a vis other industrialized countries means fewer Swiss researchers and fewer skilled workers. There are lower numbers of engineers and scientists per capita in Switzerland than in other industrialized nations. As a result, many of the top engineers and researchers are from West Germany, France, and Japan.

While the region boasts a national university, few business respondents indicated they had benefitted from any university-industry collaboration. Respondents were divided about the ease of such transactions and the extent that collaboration led to necessary changes in curriculum. On the one hand, one firm's owner suggested that university-industry collaboration was not enough, and that major changes were needed in school curricula. The owner firm indicated that discussions about school curriculum reform would take 10 years to implement. In the meantime, technology would move ahead, and the region's educational institutions would fall further behind. On the other hand, another firm interviewed found it relatively easy to work with a local professor on electronic problems. The manager indicated the professor was eager to work with his company because it had up-to-date technology and modern equipment.

Another education-related problem is the overabundance of unskilled workers. In the past, machine tools and watch making were lucrative and respected fields. Today young people are attracted to other fields with a more stable future such as international business and finance.

Regional firms are experimenting with programs to resolve skilled labor shortages. Several machine tool firms joined together to develop a firm-certified curriculum. Enrollment in the program leads to an industry-approved certificate. Upon completion, a

graduate is considered equally qualified to work in all participating firms. Workers can move between firms in search of a satisfying working environment.

Watch industry officials are also concerned about the problem of skill shortages. One official indicated that the industry needed to reinvigorate the profession through a publicity campaign to attract young people back to the field and the region (Retornaz 1989).

Globalization of Production and the Changing Jura Production System

At the end of the 1980s, the Jura Arc finds itself increasingly influenced by international economic events. While historically the region's production system was internally integrated and relatively autonomous, today regional structural change is occurring within the new international division of labor. The question then becomes how a region's firms choose to participate in the global system of production and consumption.

The following discussion suggests that Jura firms are selecting short term paths of integration. To remain price-competitive with lower cost countries, Jura firms are increasingly relying on subcontracting, automation, and de-skilling to reduce costs. Yet ironically this strategy that allows for immediate regional industry survival may preclude longterm autonomy and innovative ability. Like firms in other regions of industrialized nations, firms in the Jura must address the problem of how they can compete on the basis of both cost **and** skill--a situation never before confronted. The following discussion highlights recent developments in the Jura and raises questions about the need for a strategy which emphasizes a region's longstanding core skills during a period of rapid competitive and technological change.

Subcontracting

Switzerland is a high wage country. Thus to counter high labor costs, firms increasingly subcontract out various aspects of tool making and metal fabrication. Some of these subcontracted components are highly labor-intensive and are manufactured with menial skills. But other components are very specialized and technologically sophisticated. This latter subcontracting activity may erode the region's ability to innovate over time.

In the machine tool industry there is an intimate link between new product development and "learning by doing." Firms gain knowledge about future innovations through solving immediate problems. When the problem solving context is diminished through subcontracting, firms eliminate the context in which this learning by doing takes place and ultimately lose the ability to "learn by doing." And compounding the problem, developments or lack of developments in one technology might foster or prevent developments in other technologies. Over the long run, subcontracting may erode Jura firms' ability to make sophisticated advances in new product development. As Dosi notes: "there are complementarities among trajectories (i.e. there are strong complementarities between different forms of knowledge, experience, skills, etc.)."

An example from the American semiconductor industry may be instructive here. U.S. semiconductor firms increasingly yielded the development of manufacturing technology to the Japanese and concentrated on new innovations and the design and manufacture of technologically complex products. Over time U.S firms were unable to manufacture the newest generation of high volume semiconductors because they had

given up on developing the aspects of production technology needed to move to the next level of miniaturization. While still competitive in customized products, U.S. firms have essentially backed away from the profitable high volume market (Stowsky 1988).

There is ongoing debate about the significance of this development. U.S. semiconductor merchant firms and the U.S. Department of Defense established a research consortium--SEMATECH--to regain America's ability to manufacture high volume semiconductors. A major goal of the project is to strengthen America's supplier firms that manufacture semiconductor production equipment. According to some industry leaders, without the capacity to supply the industry with new technology, American firms will lose their ability to be the world leader in electronics.[12] Analogously, the Swiss machine tool industry may subcontract out parts fabrication that incorporates key technologies. Over time, the Swiss industry may lose its ability to conceptualize key components of products and processes. More immediately, while companies interviewed indicated their competitive edge was "precision," they no longer have a corner the leading edge on this skill. For example, Toshiba's shipment to the Soviet Union of a metal lathe capable of producing super-quiet submarine rotors indicates that Japan also has precision capability. Therefore, the market for "precision" is no longer the exclusive purview of the Swiss.

The Internationalization of Watch Manufacturing

Multinational corporate solutions to the Jura's competitive problem are precipitating dramatic regional change. In February, 1988, ETA, the largest Swiss watch conglomerate closed several factories in the Jura in an effort to compete more efficiently in the world market. Under pressure from the Swiss Watch Federation, the local government in Saint

Imier made demands to ETA to substitute a production unit equal to the one that was closing. While past public dissension had little effect on the rate of plant closures, the latest wave of closures has met with stiff resistance from local residents who complain that such closures are further eroding the industry's prominence in the region.

An example of labor's growing voice in regional policy concerns shift-work in factories. Although the Jura has long been the site of assembly operations, there have never been widespread 24-hour factory shifts. Swatch's success can be attributed, in part, to labor intensification. Under pressure from the labor unions, the Swiss government initially declared this practice unconstitutional. And although shift-work has been legitimized, Swatch's comparatively lower wages and longer working hours are still under fire by employees.

Clearly a low-wage competitive strategy does not sit well with the majority of the Jura's workers. Jura firms cannot practically expect to compete with Asian rivals on a cost basis alone. Multinational firms recognize they are competing with countries where wages are not only lower, but workers are better trained. Regions like the Jura must re-orient away from cost minimizing to profit and skill maximizing strategies (Blanc 1989).

Researchers point out differing paths for regional economic recovery. Vasserot calls for a stronger network of SMEs and more significant inter-firm collaborations and research-enterprise links. Maillat emphasizes closer linkages between manufacturing and tertiary activities. He finds the "traditional divisions between the secondary and tertiary sectors have been replaced by new structures in which scientific knowledge and production processes are combined at the strategy-development level and the manufacturing level itself." Maillat advocates a regional production system based around

a "production file," comprising SMEs supplemented by upstream tertiary activities (data collection, feasibility studies, design and development of products), downstream activities (market surveys, subcontracting, advertising), and horizontal management support services.

Finally, recent research by Maillat and others focuses on production strategies and the application of flexible technology to niche products. It is our contention that to focus on production strategies draws the discussion boundaries too narrowly. Flexibility is only useful in conjunction with a set of core skills that can be successfully deployed and redeployed in the face of market uncertainty.

Report Conclusions

The purpose of this project has been to ascertain the current state of understanding about regional change and industrial innovation. We began from the perspective that there are certain unique qualities of regions which set them apart. These unique attributes are known as core skills, and they are the basis upon which a region competes in the world.

Section I set the context for the discussion of regional circumstances of Switzerland. The country rapidly became the world's most prosperous nation through know-how and shrewd business acumen. At the end of the 19th century Switzerland was largely an agricultural backwater; its 20th century success stemmed from hard work and extraordinary emphasis on education and innovation.

The contemporary period poses unique problems for Switzerland's regions. The country has a typically bifurcated capitalist structure with both multinational and national

firms. While Swiss multinational firms are some of the world's most successful, regional and local firms still rest upon the nation's historic preeminence in precision machining to define their present position in the world economy.

Section II developed a theoretical perspective about the relationship between regions, institutions and industrial innovation. In this section we reviewed the literature on radical industrial innovation. We argued that within the existing technological paradigm, the Swiss responded with reasonable speed, but when a radical shift occurred, the regional culture was unable to respond rapidly. We used the Swiss watch industry as an illustration of the difficulties a society in the faces in times of rapid technological change.

Section III reviewed policies designed to counteract the worst affects of industrial change. Most development programs mirrored those found in other developed countries. A lack of systematic evaluation makes it difficult to ascertain the efficacy of such programs. We reviewed recent research on small firms, noting that their contribution to innovation and job growth has been overstated. Small firms are often technological laggards lacking access to capital, markets, and the latest vintage technology. We also discussed the role of branch plants. These agents have been a major source of employment growth in the region. While these organizations add needed jobs, their technological wealth remains largely inaccessible to the region. It is our contention that new programs should be developed to tap this valuable resource. Such programs might include seminars, personnel exchanges, and product sales.

The fourth section took a broader view of industrial development and focused on the wealth of studies about the Jura region completed since the late 1970s. In general, few firms were identified as true innovators. Although firms applied new technology, they

were passive rather than active contributors to wholly new innovation. The lack of business services in the region further inhibited firms' ability to innovate. And the larger industrial culture and regional institutions were also found to be slow to change. Several studies reported a need to make regional institutions more flexible and sensitive to worldwide events. During periods of rapid technological change there is often the need for "bridging institutions" responsible for translating basic research and prototype results into marketable innovations (Dosi 1982). Finally, recent research suggests that successful innovative firms were outward in orientation and not dependent on the region for information, markets, or skills. The more successful firms were part of an elaborate information network which provided knowledge about new technologies and market opportunities around the world.

Switzerland is still the world leader in mechanical watch making. Much of this manufacturing capacity is concentrated in the Swiss Jura although industrial restructuring of the last 20 years has weakened the region's industries and eroded its core skills. In the final section of this project we will examine the issue of core skills within the Jura Arc. This final analysis will build upon work carried out in the U.S., Switzerland, Japan, and Hong Kong.

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Notes

1. As part of the reorganization agreement, SMH shareholders were required to maintain employment in Switzerland and were prohibited from either selling the firm before 1992 or from selling it to foreign interests.

2. It was the larger firms that had made the capital investments in equipment that requested injecting order into the historically anarchistic industry. To recoup capital investments, the more advanced firms had to control the small firms that easily sprang up and produced cheap watches (Jaquet and Chapuis 1970).

3. We do not include Eastern Block country production in these figures. A considerable volume of watches is produced in the Soviet Union, East Germany, and other Eastern Block nations (Knickerbocker 1976).

4. Sayer and Morgan make a similar point about government protectionist policies over high technology industry in Britain (1987).

5. It is interesting to note that the advent of new technological paradigms is usually championed by new firms. This logic obviously pertains to a wholly new technology and not type three as characterized by Freeman. In the case of watches and quartz the dominant firms were the major pioneers in the application of the new technology.

6. This section was drawn from M. Blanc's book on the Swiss watch industry.

7. Banks have become increasingly responsible for regional financial aid.

8. Birch's study was based on U.S. establishment credit data developed by the Dun and Bradstreet Corporation.

9. At the outset it is important to indicate that much of the English language literature on the Jura region does establish baseline characteristics of empirical studies. In many of the analyses it was impossible to determine, for example, whether the studies reflected a statistically representative view of the region's firms. Most empirical reports do not adequately describe the sample interviewed relative to the overall industrial distribution in the region. Nor is there information about the response rates or characteristics of non-respondents. Therefore this analysis should not be viewed as definitive but rather suggestive of possible firm level characteristics and development potential.

10. The study results do not allow unequivocal determination of the role of firm size and the introduction of product and process innovations. Tables in the 1986 report (particularly #10) do not indicate clearly the share of <u>all</u> firms in the different size categories regardless of innovative activity. To determine the innovativeness of small firms, it is necessary to control for non-innovators. Our conclusions may therefore differ from the authors' original assessment.

11. While these components are important, from the most recent research it is not clear either what combination of factors or what type of production system and technical culture are needed to produce regional innovation and development. Moreover, the discussion is static. It does not account for problems which arise during periods of intense technological change.

12. While European joint ventures are not primarily concerned with their inability to manufacture new production technology, large firms are engaged in joint venture research to develop a continental alternative to Japanese semiconductor dominance.