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Buss, Klaus-Peter

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A New Mode of Qualification Supply. The Realization of a High Road Strategy in the U.S. Semiconductor Industry

Klaus-Peter Buss

I. Introduction

Recent studies like »Working in America« (Osterman et al. 2001) have shed some light on problems and processes of change in the American labour market, that are often unnoticed from the German point of view. Contrary to common German perceptions of the U.S. American economic success as based on a labour market, that is quite deregulated and more or less market driven these studies are showing how only recent economic developments have resulted in a growing mismatch between a distinct institutional structure of the U.S. labour market and the reality of today's world of work.

In the following I will focus on vocational education and training as another central field of the U.S. labour market, that is not only deeply affected by the same socio-economic processes as well but that is marked by far-reaching processes of institutional change. Taking the example of the U.S. semiconductor industry[1] I will show, that – despite the erosion of institutional foundations of traditional work relations – it's not just the logic of the market that now reigns. Instead there seem to evolve new institutional arrangements on the regional level. I will describe how the semiconductor industry has reorganized its qualification supply strategy with regard to shop floor qualifications. This evolving mode of qualification supply may shape work and labour relations in a new way and therefore represent kind of the other side of the coin.

I will develop the argument in three steps: First I will outline the old mode of qualification supply as it was based on the traditional model of work relations and the established structure of the U.S. labour market. In a second step I will describe, how changing work organization strategies in the semiconductor industry resulted in problems in the supply with shop floor qualifications. Finally I will discuss the

1 When speaking about the semiconductor industry I refer mainly to the SOFI research project »Organisation von Innovationsprozessen in der Halbleiterfertigung« that was carried out by Dr. Volker Wittke and me in the second half of the 1990s (e.g., Buss 2001; Buss/Wittke 1999, 2000).

evolving new mode of qualification supply in semiconductor manufacturing and its implications for the regional commitment of the companies and for the local labour market.

II. The traditional U.S. mode of qualification supply

The U.S. are often seen as a purely market driven society. The market is the one coordinating mechanism between organizations and organizations as well as between organizations and individuals. In this context the supply with vocational qualifications is often described as a case of market failure: Vocational qualifications are »traded« in the highly flexible labour market. Companies that are looking for qualified labour will try to recruit suitable qualifications from the labour market. Poaching qualified people from other companies is a common recruitment practice. On the other hand the poaching risk threatens every corporate investment in education and training. As long as qualifications are transferable to other companies, companies are always reluctant to train. At the same time individuals will always try to get transferable qualifications. The more general and therefore transferable qualifications are the better are the individual labour market opportunities. In this context public vocational education and training programs will never be very specific. In short, there seem to be many external constraints to the production of transferable, industry-specific vocational qualifications, as they form the basis for qualification-intensive production strategies.

But at the same time this market driven allocation of qualifications corresponds with specific structures within the companies, that help to produce the required qualifications internally: On the one hand, the organization of work is marked by a high division of labour with narrow job profiles, that keep the demand for skilled workers and for training down. Especially on the shopfloor, there is only a very job-specific demand for vocational qualifications. Usually workers are recruited as unskilled or semiskilled workers and are trained on the job. However, on the other hand, that training on the job may sometimes be a quite extensive and time-consuming process. The better the workers are trained, the better are the chances for good production yields. So, the workplace or production experience these workers gain by the time is a valuable vocational qualification to the companies. To keep these experienced or qualified workers, companies have developed specific workplace policies with varying social provisions. Especially seniority rules help to keep the most experienced workers within the company. It is this »invisible handshake« (Okun), that traditionally forms the basis of the internal production and maintenance of vocational qualifications.

So U.S. companies have developed a specific mode of qualification supply that utilizes the flexibility of the external labour market on the one hand, and ensures the internal production of company specific qualifications on the other. But this mode ensures the provision of qualifications only in a certain way: it depends on a specific mixture of general and specific knowledge, on a certain division of labour, on the recruitment of unskilled or semiskilled workers and on the existence of an internal labour market, that helps to accumulate work experience. It stands for a certain path of industrial development that is marked by a low demand for transferable vocational qualifications. Therefore, as some researchers conclude, the adaptability of American firms seems to be restricted. Given a raising demand for qualified workers companies are threatened by a mismatch.

III. Changing work organization – raising qualificational demand

Regarding this traditional mode of qualification supply the case of shop floor qualifications in the U.S. semiconductor industry gives some evidence for such a mismatch. In the 1990s the global semiconductor industry went through a boom phase with never seen growth rates. The resurgence of this industry was based on a far reaching organizational and strategic change since the second half of the 1980s, which in turn deeply affected the work organization and the use of qualifications within the companies.

For several reasons manufacturing facilities were forced to drastically improve their cost reduction and optimization capabilities. And they had to become much more flexible to deal with an increasing pace of product and process innovations. Now, both, the process improvement capabilities as well as the innovation capabilities of manufacturing facilities depend very much on the understanding and the control of the very complicated production processes and production equipment.

But traditionally the understanding of the semiconductor manufacturing process was very bad. That in turn was traditionally reflected by a strict division of labour that could be found not only in American manufacturing facilities. Work organization is characterized by three distinct groups of workers: All improvement competences within the factories are strictly assigned to the engineers, who usually are not in the production cleanroom, but analyze the process results afterwards. Most technicians, as the ones, who maintain the production equipment, are specialized on single pieces of equipment and don't know much about its role in the production process. Operators, as the ones, who repetitively carry out single process steps, neither have the knowledge to recognize developing process problems nor do they have the competence to stop the production process, when something went wrong.

Today process control capabilities have been improved drastically. Problems shall be recognized as early as possible. To be able to do so companies needed at least some process knowledge within the manufacturing department. And at that point most semiconductor companies started to recognize the importance of shop floor qualifications. The traditional division of labour with its specialized workplace qualifications and its strict allocation of responsibilities became a problem. In improving their process control and innovation capabilities companies now often called the strict traditional division of labour into question. Subsequently during the 1990s almost all leading U.S. semiconductor companies have developed new approaches in factory and work organization, that especially assign new competences and responsibilities to shop floor workers. The approaches range from just shifting tasks from engineers to technicians and from technicians to operators to the introduction of high performance work practices up to a complete merger of technicians' and operators' job profiles in some factories.

What is important to note, is, that with these new approaches in work organization – regardless of the extent of changes in the single case – the character of vocational qualifications changes. As outlined above traditionally vocational qualifications at the shop floor are very workplace-specific. Now, shop floor qualifications become less workplace- or company-specific and more industry-specific and general. Workers shall take responsibility for certain process steps and pieces of equipment. At least at a low level they shall be able to make decisions that not just concern their own work place. Therefore, they have to learn about the principles of the process, they have to learn to think analytically, and they have to learn how to communicate problems and how to set up problem solving activities. So, companies do need a new mixture of qualifications at the shop floor, that can't be just trained.

The more the companies change their work organization strategies in this direction, the less does the established mode of qualification supply meet their demand for vocational qualifications: With regard to the merged operator-technician, one industry study summarizes:

»Few employees or new graduates are schooled and skilled in all dimensions of the new, more complex job: Graduates of good existing electronics or manufacturing programs typically lack the chemistry and physics we want and have no factory experience. Experienced workers have rich ›tribal‹ knowledge of the local factory, but most lack formal education to make process and equipment decisions or communicate ideas for proposals and problem solving. Workers transferring from the military or other industries often have key technical expertise, but without a flexible formal education they fit only in a narrow profile.« (SEMATECH 1995: 12)

This mismatch problem was even tightened by the success of the semiconductor industry, since in the 1990s the industry faced a period of unprecedented growth that – at least at that point of time – everyone expected to continue. The companies

expected to be less and less able to satisfy their demand for vocational qualifications within the established mode – neither with regard to the quality of required vocational qualifications nor to the number of workers needed. The established mode of qualification supply threatened to become a major obstacle to future growth.

IV. Preconditions of the new vocationalism

In reaction to this mismatch the semiconductor companies started to externalize vocational education and training. At the centre of the industry's strategy stands a new two-year-long community college education in Semiconductor Manufacturing Technology, that was introduced in 1995 and that is aiming at educating and training new technicians and in a »reduced« certificate version operators. That new SMT education was developed centrally by a joint working group of the main semiconductor companies. That group developed a first common curriculum that was further refined and put into teaching materials by a centre for advanced technology education financed by the National Science Foundation. The new college education in semiconductor technology shall replace the old internal training on the job and therefore lay the foundations for a new mode of qualification supply. It is often embedded in local career pathways that allow workers both to qualify for a certain level of the job hierarchy by acquiring colleges certificates and to collect credits for continuing their education later. Today more than 100 community colleges all over the U.S. are offering or developing such SMT programs, although these programs differ very much regionally.

The SMT programs seem to be but only one example of numerous new regional vocational education and training arrangements that evolved during the last decade in various industries. At the centre of these new regional vocational education and training arrangements stands the community college as an institution of the American higher education system, that increasingly is involved in vocational education and training. Although community colleges always have been engaged in occupational education, vocational programs are facing a growing importance since the 1990s. In search of new funds colleges are expanding their institutional role beyond the academic education of young high school graduates offering specialized vocational programs for local industries and setting up customized company specific training programs that are often established by contract. Although the expansion of vocational programs is often criticized as undermining their academic mission, such programs are an integral part of today's community colleges. During the last decade the industry increasingly made use of these regional education and training facilities. On behalf of local companies colleges are carrying out programs ranging from

traditional college courses to specialized company specific courses. Often these programs are located at the company's site.

But although community colleges are eager to set up such programs, the example of the semiconductor industry points out, that companies can't just outsource education and training. Certainly the ongoing reconfiguration of work relations and of the mode of qualification supply is in parts accompanied by the erosion of central institutions of the American labour market. But to successfully establish and utilize the new education program the companies have to meet a couple of requirements:

First: The semiconductor companies had to learn to cooperate on the industry level: Although community colleges do have some tradition in vocational education, they certainly don't have any experience in semiconductor manufacturing. So colleges need the industry's help. First, they need help to develop a curriculum. This was organized mainly on the industry level. Since especially the large semiconductor companies have several manufacturing sites all over the U.S., the industry established an own industry-wide task force. Although the existence of the research consortium SEMATECH as the host of the task force made it easier to cooperate, companies had to learn to cooperate in a subject area that formerly more or less was treated confidentially. But even more important for the success of such vocational programs is that local companies cooperate to help the local college to adjust the program to their common needs.

Second: the semiconductor companies have to invest in common training resources: Due to the character of the U.S. education system the SMT education had to be established locally. But local community colleges often lack the necessary resources. So, local companies help to develop local curricula, start to train college teachers or even sent their own engineers to teach semiconductor specific courses. But primarily colleges need help to set up a practically oriented vocational training. To train unskilled workers and to bring up »work-ready graduates« (SEMATECH) students especially need some hands on training that colleges usually do not provide on such a high technological level. So, companies help to set up training facilities. In some cases they even build new semiconductor laboratories and training cleanrooms. Some companies do invest large sums in the new education programs.

Third: the semiconductor companies have to coordinate their activities locally: Especially in the regional clusters of semiconductor manufacturing, different companies send their workers to the same college programs and college graduates are hired by different companies. Therefore, in setting up and supporting the new education companies have to find new, not market-driven ways to coordinate their local qualification demand and their activities and to keep the free-rider problem

down. So, in Austin/Texas, the Silicon Valley, Portland/Oregon, or Phoenix/Arizona new regional alliances emerge that are sometimes really formalized with contracts, cooperation agreements and membership fees. These alliances conceptualize the local SMT-programs and in parts try to embed them into a local educational chain from high school to university.

So, in short, the semiconductor companies are actively involved in building up new regional vocational education and training programs. Without the active participation and involvement of the local companies none of the new programs probably would have come into being.

V. Elements of an evolving occupational labour market?

At first sight, that seems to be contradictory given the erosion of the traditional social function of the company. But the erosion of job security and the evolving new mode of qualification supply also may be seen as just different sides of the same coin. After all the change from workplace-specific qualifications produced in the internal labour market to a common qualification supply strategy has to be reflected in work and labour market relations.

With regard to the internal labour market the new qualification on the one hand stands for a changing work organization strategy. Internally it becomes a culmination point of unsolved conflicts and problems resulting from the change. This concerns especially unskilled and semi-skilled operators who represent the old work organization and who don't manage to keep up with the pace of change. Often companies are taking the loss of experienced workers into account. On the other hand the new qualification also stands for the erosion of the old internal labour market. New hirings are preferentially college graduates with a certificate or degree at least in a semiconductor-related field. They not only come in at a higher level of the internal labour market and therefore are leapfrogging older, experienced employees. Although there certainly will arise new internal career pathways, these probably won't offer the same employment security.

That became evident in 2001 and 2002 at the latest. At that time the semiconductor industry went through its worst bust cycle ever with a high job loss. Just the Austin Area had to face a loss of approximately 10.000 jobs in semiconductors and related industries. But – although the semiconductor education originally was focussed on qualifying new workers – especially in the regional clusters of the industry the college programs were not abandoned. Instead companies and colleges have shifted the focus to further education.

With regard to the external labour market the transferability of vocational qualifications seems to become more important. Not only do students need to be guaranteed at least a certain transferability of a college qualification, since they are expected to finance at least parts of the education themselves. The transferability of vocational college qualifications also seems to be an important incentive in internal staff development. In addition to internal training on the job workers are often supported by their employer to visit the college to acquire additional qualifications. In parts, colleges are promoting career pathways in semiconductor manufacturing, that are coordinated with the local industry. So just in the sense of lifelong learning workers can move from manufacturing to college to manufacturing to college and upgrade their vocational qualifications step by step. At the same time formal college certificates and degrees enable them to get into other companies and work places at a higher qualificational level. At least in the regional clusters this may be the starting point of a more occupational type of labour market. So, in a way the new mode of qualification supply seems to be a complement to the erosion of job security and the opening of internal labour markets.

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