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FACTORS INFLUENCING THE STEEL WORK FORCE: 1980 TO 1995

DONALD F. BARNETT, PH.D

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FACTORS INFLUENCING THE STEEL WORK FORCE: 1980 TO 1995

DONALD F. BARNETT PH.D[1]

The steel industry in OECD countries has undergone profound change during the past several decades. Capacity has been reduced significantly, while substantial investment has been made to improve processing efficiency and product quality. Two key technological developments have driven this process. The first is rapid expansion of the use of continuous casting, a technology that has improved product quality, reduced energy consumption and greatly increased efficiency. The second is significant growth in electric furnace steelmaking, particularly at highly efficient small-scale mini-mills, that produce an expanding range of steel products using ferrous scrap as the principal raw material. These and other technological changes, combined with plant closures and other restructuring, have greatly reduced industry employment. Despite growth in finished steel production, employment has fallen by close to 40 per cent in the OECD area since 1980.

This document examines how the employment situation in steel has changed in the European Union, Japan and the United States between 1980 and 1995. It identifies the principal factors that have affected the size of the work force and the skill requirements, and examines how each factor has affected the overall employment situation in steel. The different approaches that governments and countries have adopted to address problems associated with changes in the work force are also reviewed.

Le secteur de l'acier des pays de l'OCDE s'est profondément transformé au cours des dernières décennies. Les capacités ont été fortement réduites, tandis que d'importants investissements ont été consacrés à l'amélioration de l'efficacité du traitement et de la qualité des produits. Deux importantes avancées technologiques ont donné l'impulsion à ce processus. La première est la diffusion rapide de la coulée continue, technique qui a amélioré la qualité des produits, réduit la consommation d'énergie et considérablement accru les rendements. La seconde est l’essor rapide de la fabrication d'acier dans des fours électriques, en particulier des micro-fours très efficaces, qui produisent une gamme de plus en plus étendue de produits d'acier en utilisant la ferraille comme principale matière première. Ces progrès et d'autres changements technologiques, combinés à la fermeture d'aciéries et à d'autres opérations de restructuration, ont fortement réduit l'emploi dans ce secteur. En dépit de la croissance de la production d'acier fini, l'emploi a chuté de près de 40 pour cent dans la zone de l'OCDE depuis 1980.

Ce document étudie la manière dont la situation de l'emploi dans le secteur de l'acier s'est modifiée dans les pays de l'Union européenne, au Japon et aux Etats-Unis entre 1980 et 1995. Il identifie les principaux facteurs qui ont affecté les effectifs de la force de travail et les critères de qualification, et étudie la manière dont chaque facteur a affecté la situation de l'emploi dans le secteur de l'acier en général. Les différentes approches adoptées par les gouvernements et les pays pour faire face aux problèmes liés aux changements dans la force de travail sont également étudiées.

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[1] President, Economic Associates, Inc. Opinions expressed in the paper are personal and do not engage the OECD or its Member countries.

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Background

The last 15 years have seen dramatic changes in the structure, ownership, location, competitiveness, and overall nature of the steel industry. Many large firms have scaled back operations, some small firms have merged into larger entities, much government ownership has been replaced by private ownership, many integrated operations have been replaced or augmented by scrap-based electric-arc-furnace (EAF) operations, or what is commonly referred to as mini-mills (an historical misnomer considering that many mini-mills are now larger that their traditional integrated rivals), and new technologies are being introduced rapidly especially in ironmaking, steelmaking and casting. The pace of technical change in the steel industry is currently faster than at any time in its history.

Changes in Overall Steel Industry Parameters

Over the past 15 years, changes in the industry have significantly reduced employment in the leading industrial steel producing countries, as shown in *Table 1*. To some degree the employment decrease can be attributed to low (or no) growth in product shipments or crude steel production, due to increased steel imports (e.g. the United States) or decreased steel exports (e.g. Japan and the European Union) or to slow market growth (all three areas). The lack of growth in steel shipments may also be due to net increased indirect steel imports (e.g. in steel consuming goods) or net decreased indirect steel exports. Japan and the European Union (twelve countries) are both believed to have lost ground through decreased net indirect exports, especially due to lost competitiveness and appreciating currencies, but in the United States net indirect steel imports have recently declined due to the increased competitiveness of the American steel industry and to a weaker US dollar.

Table 1 also shows trends in production, estimated equivalent finished shipments, as well as steel furnace shares and the shares of steel produced via continuous casting. As the *Table* shows, US crude steel production fell but finished shipments rose (due in part to increased use of imported semi-finished steel and better yields); similarly, EU crude steel production was flat while shipments rose (due to improved yields); and Japanese crude steel production fell but shipments were largely flat (due to improved yields). The rising trend in US and EU shipments in part kept the decrease in employment lower than it would have been otherwise.

As *Table 1* shows, the EAF share of steel production rose in all 3 areas, and since EAF's have neither coke ovens nor blast furnaces, EAF production reduces manning requirements. Moreover, since most EAF's are mini-mills with simpler, more efficient processes and usually produce lower quality, products are younger and have more recent technologies, this implies a still further decrease in manning.

As *Table 1* further shows, in all three areas, there was a pronounced move to increased continuous casting, improving finished product yields from raw steel (as shown by comparing the trends in shipments vs. crude steel production) and eliminating semi-finished rolling processes, thereby significantly reducing manning requirements.

It should be pointed out that the *Table 1* employment levels shown are misleading indicators of total manning requirements. All three areas use outside contracting and outside sourcing/processing of regular steelmaking functions, in varying proportions. In the United States, outside contracting is estimated at about 5 per cent in 1980, rising to about 8 per cent in 1995, while in Japan outside contracting fell from about 33 per cent in 1980 to about 20 per cent in 1995, and in the European Union outside contracting rose from about 5 per cent in 1980 to about 12 per cent in 1995. Outside sourcing/processing has increased rapidly in the United States with about 20 per cent of coke, and 7 per cent of semi-finished steel acquired outside the defined steel industry; in addition 25 per cent of pickling, 5 per cent of cold rolling and galvanising and 10 per cent of finishing was done outside the industry in 1995, while virtually none of this was done in 1980. Similar estimates are not available for Japan and the European Union, but in each region outside sourcing/processing is believed to be somewhat less important than in the United States, and in each region the change over time is seen as less significant. Hours worked per year have also increased sharply in the United States, but less so in the European Union and Japan (although only partial data are available for the European Union and Japan, and this conclusion may be premature); this in itself will decrease employment. The increase in hours worked is a result of a significant move to a non-union workforce (with the entry of non-union mini-mills), changes in employment contracts that have made paying overtime more profitable than paying benefits to more workers, changes in work schedules and in particular the move to a 12 hour vs. an 8 hour shift (with 12 hour shifts the worker works 4 days one week, three the next), resulting in use of 3 vs. 4 crews, and the integration of maintenance work into the operating crews' duties.

Changes in Detailed Industry Parameters

As the reader can tell, using the employment data shown in *Table 1* is fraught with difficulties. *Table 2* attempts to get a better picture of improvements in productivity within the steel industry itself. For purposes of this *Table,* we have compared man-hours per ton (MHPT) for the same or similar plants, making similar products, from 1980 to 1995. The MHPT shown include contract hours, plant and corporate overhead. The plants are defined the same over time, so for example the integrated plants chosen are entirely self-contained from coke to finished product (with no outside purchases of coke or semis), and the mini-mills are all EAF/caster/rolling mill complexes). The inter-regional MHPT comparisons (integrated to integrated, EAF to EAF) by product at any point in time are meaningful because all integrated and EAF plants are defined the same across regions. This is made possible by a very detailed modelling of actual plant costs, which has been going on since the mid-1970s.

The time trends in MHPT for each region for each product, in *Table 2,* give a clearer picture of productivity improvements within the industry, providing estimates of all the structural changes also at work. The products chosen for the trend comparison in the *table* are representative but are on the lower end of the MHPT intensity range for each of flat-rolled and long products. For example, carbon cold rolled coil has lower MHPT than the hot-dip galvanised, electrogalvanised, tin-mill products, than alloy stainless flat-rolled, and indeed than any flat-rolled other than hot-rolled and light plate. Similarly carbon wire rod is on the lower end of the MHPT intensity compared to shapes, rails, special quality bars (SBQ), alloy and stainless bars, and indeed than any long products other than rebar and some light shapes and commercial bar. For these reasons one cannot take the MHPT for the respective products in *Table 2* and try to reconstruct absolute levels of industry employment as per *Table 1.* However on a trend basis these products are excellent examples of changes at work in the industry.

As shown in *Table 2,* in an integrated plant making cold-rolled coil there has been a 42 per cent decrease in MHPT in the United States, a 25 per cent decrease in Japan, and a 40 per cent decrease in the European Union. Assuming the same shipment volumes over time in a given integrated plant, this would, all other things equal, imply a similar reduction in manning. However, hours worked per year rose by 12 per cent in the United States, by zero per cent in Japan and by 6 per cent in the European Union, implying a proportionate further decrease in employment in the respective plants, assuming no change in shipment volumes over time.

Turning to a mini-mill (EAF-based) making wire rods, there was a 50 per cent MHPT improvement in the United States and Japan, and a 53 per cent improvement in the European Union, with the same employment implications as in the previous paragraph.

To complete the matter, over the 1980 to 1995 period, integrated mills were displaced by much lower MHPT mini-mills in wire rod production (and indeed all long product production, especially in the United States) and are beginning to be displaced by mini-mills in cold-rolled coil and other flat product production. In part this is a technical change due to thin slab casting and near net shape casting, and faster progress in improving mini-mill operations (specifically the EAF, as compared to coke ovens through the basic oxygen furnaces) than integrated, but it is also a structural change to a new kind of industry. In any case, the net result is that industry-wide MHPT (and implied employment) reductions in each product exceed those shown in *Table 2* for each product category in each of the two major processes. Against this trend is the fact that over the 1980 to 1995 period, there has been an increased shift to higher valued products (e.g. more galvanised and less cold rolled, more SBQ bar and less rebar) within each region which tends to raise industry-wide MHPT and employment.

Intra-Product and Major Process Technical Improvements

Table 2 delineates the MHPT changes occurring within selected major product types and between major process types (integrated vs. scrap/EAF-based) from 1980 to 1995. *Table 3* attempts to break this down into major sub-categories of change within the steel plant itself. As *Table 3* shows, MHPT in integrated plants producing cold-rolled coil fell between 1980 and 1995 -- by 42 per cent in the United States, by 25 per cent in Japan and by 40 per cent in the European Union. For wire rod produced in EAF based plants, the comparative decreases in MHPT were 50 per cent in the United States and Japan and 53 per cent in the European Union.

Most of the decreases in MHPT in integrated cold-rolled coil were due to increased continuous casting and improved yields, plus facility-by-facility operating improvements. In the integrated steel production of flat products, there has been no major technical change in the past 15 years, but there have been many technical refinements which are responsible for much of the MHPT improvements observed. Pulverised coal injection in the blast furnace plus increased oxygen and natural gas injections, and higher blast furnace pressures and temperatures have reduced coke rates and increased blast furnace productivity. Shifts to more hot charging, higher charge temperatures and greater power and temperature-control have improved hot strip mill throughput. More continuous cold finishing, higher power, hydrogen batch annealing and more continuous annealing have improved pickling and cold mill productivity. Advanced computer controls have made faster order/melt/roll/ship times possible, reduced inventories of semi-finished materials and enabled more precise production controls and tailoring to orders. Approximately 65 per cent of the MHPT improvements observed in integrated cold-rolled coil production can be attributed directly to technical change, with the balance attributable to better operating practices and better utilisation of higher skilled human resources, although operating improvements can be indirectly related to technical improvements.

Much of the decrease in MHPT in EAF-based wire rod production can also be attributed to more continuous casting, but the most significant improvement has been in EAF productivity, as well as improvements in other facility productivities. In mini-mills making wire rod there has been no major technical change but many important refinements. In EAFs, higher power, eccentric bottom tapping, off-gas recovery and scrap preheating, DC (direct current) furnaces and improved refractories, have all improved productivity. In casters, near net shape casting and changes in mould shapes have improved productivity. In hot rolling, more hot charging, greater power and greater temperature control have improved throughput and productivity. Approximately 75 per cent of the improved MHPT in EAF-based wire rod production can be directly attributed to technical improvements and the balance to operating improvements; the two are, however, closely intertwined and hard to separate.

Table 3 does not take the shifts that have occurred in production from integrated to mini-mill operations into account. *Table 2* illustrates the difference in MHPT between integrated and EAF-based operations for cold-rolled coil and wire rod. *Table 1* illustrates the shift from integrated to mini-mill production overall. The growing proportion of EAF production has lowered industry MHPT (and employment) overall. One can argue that this shift is not, *per se,* a technical improvement. However this shift has been made possible to a large extent by technical changes. For example, the entry of mini-mills into large structural steel production was made possible by near net shape (e.g. beam blank) casting, and now in the United States only EAF-based mini-mills make large shapes. Similarly, the entry of EAF-based mini-mills into flat product production was made possible by thin-slab casting. In fact, the whole basis for the existence of competitive EAF-based steelmaking can be attributed to technical changes. In cases where scrap is not available, technical changes in ironmaking, resulting in various forms of directly reduced iron (DRI), have made EAF-based steel production possible. Indeed the successful continued expansion of EAF-based mini-mills into flat products depends upon the successful development of new technologies to make low-cost iron for use in EAFs.

Industry Aggregate Employment Reducing Factors

Table 4 attempts to explain the decreases in employment shown in *Table 1* for the United States, Japan and the European Union. The total percentage employment decrease from 1980 to 1995 in each region, is shown at the top of *Table 4*. Note that positive numbers refer to factors adding to the employment reduction, while negative numbers refer to factors reducing the employment reduction. *Table 4* results should be taken as indicative, not definitive.

The top segment of *Table 4* illustrates the structural factors contributing to the decreased employment trends shown in *Table 1*. Changes in hours worked (more per year), more contracting out, plus increased outside sourcing and processing all usually contributed to lower employment levels. Changes in product mix (to higher MHPT products) and increased shipment levels, all contributed to higher employment levels. Overall the structural factors largely cancelled each other out, except in the case of Japan where they would actually have made employment higher than otherwise.

The bottom portion of *Table 4* provides estimates of the productivity/technology factors contributing to the decreased employment trends shown in *Table 1*. *Table 4* is based in part on the results in *Table 3* -- for the estimates of the impact of increased continuous casting, improved yields, improved plant operations and reduced corporate overhead. To this estimates were added of the impact on employment of the shift to lower MHPT, EAF operations and interplant rationalisation, which eliminated high MHPT plants.

Assuming all the shift to EAFs can be regarded as a technical improvement (indirectly), and that 66 per cent of all other productivity enhancing factors except interplant rationalisations can also be called technical improving factors, some 59 per cent of the US employment reduction shown in *Table 1* can be estimated as due to technical improvements, 38 per cent due to operating improvements and 3 per cent to structural factors. For Japan, some 87 per cent of the employment reduction can be estimated as due to technical changes, 43 per cent due to operating improvement and 30 per cent due to structural factors. For the European Union, the percentage contributions to decreased employment are 59 per cent due to technical changes, 41 per cent due to operating improvements, and zero per cent to structural factors.

The Human Factor

The changes taking place in the industry have obviously had a significant effect on overall employment. Directly and indirectly, most of the changes are due to technical change. Many people have been laid off, retired, retrained or moved to new plants or operations. Many functions that used to be done by steel plant employees are done by contract workers, especially in the areas of material handling, maintenance, shipping and packaging. Other functions such as coke production and semi-finished steel production may be done in other countries. Operations such as pickling, cold finishing, coating and warehousing, may be performed by other firms not normally considered as part of the steel industry but still in the same country. Remaining steel industry workers have found themselves working longer hours and different work schedules. In some plants operational and maintenance functions have been integrated and are being handled by the same workers.

The entry and expansion of EAF-based mini-mills has had a dramatic effect on steel industry employment and job skill requirements, as well as the age distribution of the workforce. To take the US experience as illustrative, these mini-mills usually locate a plant where there is no steel production, so as to be near the market they serve and/or near low cost inputs; they recruit locally trainable young people with virtually no steel experience, and teach the necessary skills, with only a small proportion (less than 10 per cent) of the plant's workforce with initial high levels of technical competence (usually from other plants of the same firm) and even fewer (less than 5 per cent) from traditional integrated steel producers. The mini-mill view is that it is more difficult to retrain former workers from integrated firms than to train intelligent unskilled workers. In a mini-mill, a worker has to be highly competent, but flexible, switching from job to job (or even plant to plant), from operating to maintenance jobs, or even damage control, and vice-versa, as the need requires. In a mini-mill the management is small, flexible and on the job with the workers. In a mini-mill, a worker's pay is largely (often over 66 per cent) dependent on performance and plant or firm profitability. In a mini-mill, the search for performance improving technical/operating changes is continuous, but it is an on the job effort (there is no separate R&D department) and the person who comes up with an idea is individually rewarded. In contrast to mini-mills, traditional integrated operations are older and more fixed -- with established departments responsible for specific functions and where employees are assigned to specific jobs. The companies tend to be more resistant to change, with only a small proportion of employee’s pay related to performance and profitability. There is therefore less individual incentive to introduce technical/operating improvements. In a traditional integrated mill, management is usually large, but these mills are changing as mini-mills expand. Some traditional mills have decided that if you can't beat then, you have to join them; as a result they are building their own mini-flat mills far from existing sites with new workforces, new plant technologies, new infrastructure and attitudes, new pay incentives and new management.

Employment trends in the industry have seen internal research functions (engineering, metallurgical, commercial, market etc.) sharply reduced and replaced by outside entities. They have also seen increased requirements for computers and computer experts, with mill builders becoming mill operators. Nucor, for example, uses its future mill operators to supervise construction first. Trends have also seen departmental functions increasingly eliminated, to be replaced by operating work crews functions. Layers of management have disappeared, to be replaced by a few senior officials and on-the-job supervisors. Job skill categories are being reduced or eliminated; the low-skilled job in steel, in particular, has virtually disappeared. It is the case that mini-mills recruit low skilled but trainable people, but they then train them up to two years so that they are skilled, at which time they are promoted or dismissed.

In the steel industry there used to be many professional job classes (e.g. electricians, millwright and metallurgists). These functions still exist, but today's workers, especially in mini-mills, must not only be highly skilled but flexible, moving from function to function and need to need as required. In the steel industry of today training is continuous. It is claimed that in today’s leading plants a worker spends about 30 per cent of his time being retrained (as compared to about 10 per cent in 1980) and acquainted with new operating procedures, new technical refinements, new control practices and new product quality standards. In practice however training is perpetual as technical improvement is continuous; competition in steel demands no less.

Many firms provide on the job training to improve on the job skills, but in a dynamic world where some plants fail and others take their place, this training may do little good in such circumstances, especially if the failing plant is a traditional mill being replaced by a mini-mill rival. Within a traditional firm of similar types of plants, where one plant closes, some high-skilled workers may be moved, but if the work force is older, most will be laid off. If the traditional mill is replaced by a mini-mill, virtually none will be hired and the job location will probably be in a different area and require total retraining.

What it comes down to is that, in the steel industry of the mid 1990s, high job skills are required, with continuous improvements and retraining necessary. While this may help prolong the life of the plant one is working at, it probably will not improve one’s own standing within that plant/firm and is unlikely to enhance one’s chances of finding a job at another steel plant if one closes. In a sense, steel jobs are for life, but in the United States with continuous restructuring, unemployment may occur in less than 5 years. The above has been written from a US perspective, but on recent trips to Europe and the Far East, the same issues are beginning to be raised and are going to have to be dealt with.

Generally the types of jobs lost in steel have been low-skilled, those associated with obsolete technologies (e.g. ingot mould preparation, soaking pit operators and open hearth operators), jobs in declining operations (e.g. coke ovens) or jobs in low priority internal functions (e.g. commercial research, library, R&D and human resources). In contrast the types of jobs gained in steel are high skilled, skills in new technologies (e.g. thin slab casters, DRI, ladle metallurgy, shaft furnaces, tunnel furnaces and continuous cold mill mills), jobs in expanding operations (e.g. EAFs) or jobs in high priority internal functions (e.g. product quality control and computer control systems). Generally the new jobs are in mini-mills, but they are sparse because manning is very low, and the lost jobs are in traditional mills where manning is comparatively high. As *Table 2* shows, MHPT for cold-rolled coil in a mini-mill is about one third that in a traditional fully integrated mill). Further, the new hires are much younger and in different regions of the country than those made redundant.

Manning Policies

In the United States, government policies are minimal, with some states making efforts to keep plants running longer than they would have otherwise in order to avoid redundancy problems. There is some federal and state assistance for retraining and unemployment, but generally it is left to the market and the individual. US firms have funds set aside for early retirement and layoffs to ease the transition and some have outplacement services. Some US firms have "guaranteed" job security but the value of such a policy depends on the firms continuing to operate.

In Japan, firms have for years provided job security although they have occasionally engaged in “outplacement” where redundant workers are "lent" to another firm and the lender pays much of the cost. Japan also had a high ratio of contract workers but these contracts were downsized to avoid internal layoffs. The mini-mill impact has been less in Japan but the appreciation of the yen has made the Japanese steel industry less competitive generally, and the industry is only just beginning to face the problem of massive layoffs which the United States faced years ago.

In the European Union the policies/strategies are mixed, but there has been, generally, a much more activist government policy to ease the transition to a restructured industry. Funds, for example, have been available for retraining, relocation and unemployment.

Whether EC and Japanese policies/strategies eased the burden of restructuring on the individual involved is uncertain, but what is certain is that they did not increase the pace of restructuring. Europe and

Japan are now behind the United States in terms of introducing new mini-mill technologies, which has 15 million tonnes of mini-flat mill capacity (about 25 per cent of flat product capacity) under construction or in operation in the United States currently while there is virtually none in the European Union (although the leading purveyors of thin slab casting technology are European). The US industry, for at least a period of time, will therefore have a very low cost, highly efficient, but low MHPT (and employment) steel industry. Since employment costs are one of the most important reasons for international competitiveness differences, the US disadvantage of higher employment costs (particularly vis-à-vis non-OCDE countries) will therefore become moot. A US$35 per hour vs. US$20 per hour labour cost disadvantage is a huge international competitive differential in a 4.6 MHPT integrated plant, but insignificant in a 1.7 MHPT mini-mill, given transport costs for steel.

The most successful firm strategies in dealing with new technologies and training seem to be exemplified by the leading mini-mills entering the flat product business. The strategy seems to be to recruit new workers (in their early 20s), transfer in some "experienced personnel" (probably 28 years old) from an existing mini-mill plant, hire a few specialists from traditional mills (for their marketing expertise, galvanising expertise, etc.), train the new staff while the plant is under construction and let them oversee the construction (under the supervision of the "experienced personnel") so that they are intimately familiar with the technologies being employed, then let them start up and run the plant (again under the supervision of the experienced workers). This has, with occasional exceptions, reduced start-up times to less than one year, and created an operating workforce which is familiar with all the maintenance requirements. It also provides a workforce that can be drawn on to provide the "experienced personnel" for the next expansion. This creates a highly efficient but small workforce (generally about 400) to build and run a 2.0 million tonne per year mini-flat mill.

The above, however, while highly successful in creating a new competitive low MHPT entity, is contributing to the employment problem of the industry as a whole. The United States, for example, is about to enter a new round of down-sizing employment due to the new growth in new mini-mills that will produce flat rolled steel. No adequate policies have been developed to retrain those laid off. Their training, excellent though it may be, is not "required" in the new steel industry; these workers will therefore often find themselves in service industries with menial jobs, although they may get financial settlements or assistance which partly relieves adjustment difficulties. At least in the United States, the reality on entering steel employment is that it is not a good choice for a career.

Conclusion

The steel industry world-wide is in the midst of a technological revolution of major proportions. New markets and industries are appearing and thriving in the third world (e.g. South East Asia), old markets are stagnating and old industries are being reborn with new technology. The technological revolution in steel has, and is, drastically reducing the cost of building a steel plant (by about 80 per cent), thus lowering entry costs, as well as the cost to operate a steel plant. Older, traditional steel producers have made significant efforts to maintain competitiveness.

The major cost savings in steel are across the board, but the consequence has been a drastic reduction in MHPT in steel production (put positively, a significant improvement in steelmaking productivity) and in steel employment. The nature of the steel work force required has also changed with newer, higher and often transitory skill needs, but with less job security. While governments and firms are interested in easing the adjustment to the individuals involved, they have to be careful not to slow down the transition to a newer high tech industry or the adjustment problems, while being postponed, will be much greater.

Table 1: Employment and Production Trends 1980 to 1995

	USA	Japan	EEC-12
A. Employment trends excluding contract workers		Thousands	
1980	512	271	737
1985	334	265	509
1990	270	195	386
1995 est	225	190	335
B. Crude steel production trends		Millions of tonnes	
1980	102	111	141
1985	80	105	120
1990	90	110	137
1995 est	92	99	140
C. EAF share of production		Per cent	
1980	27	24	25
1985	34	29	29
1990	37	31	31
1995 est	40	33	34
D. BOF share of production		Per cent	
1980	61	76	75
1985	59	71	71
1990	59	69	69
1995 est	60	67	66
E. Open hearth share of production		Per cent	
1980	12	0	0
1985	7	0	0
1990	4	0	0
1995 est	0	0	0
F. Continuous cast share of production		Per cent	
1980	21	38	30
1985	44	91	71
1990	67	94	89
1995 est	90	98	95
G. Estimated shipment trends		Millions of tonnes	
1980	76	95	109
1985	66	92	100
1990	77	99	118
1995 est	87	91	126

Sources: OECD; American Iron and Steel Institute and World Steel Dynamics.

EAF: Electric Arc Furnace.

BOF: Basic Oxygen Furnace.

Table 2: Estimated Manhours per tonne (of Finished Product) 1980 to 1995

	US	Japan	EU-12
A. Integrated MHPT for CRC (from coke) including contract workers			
1980	7.9	6.4	8.3
1985	6.5	6.0	6.8
1990	5.2	5.6	5.7
1995 est	4.6	4.8	5.0
B. Integrated MHPT for wire rod (from coke) including contract workers			
1980	7.1	4.6	6.9
1985	6.5	4.1	5.5
1990	N/A	3.7	4.8
1995 est	N/A	3.3	3.9
C. Mini-mill (EAF) MHPT for CRC (from EAF) including contract workers			
1980	N/A	N/A	N/A
1985	N/A	N/A	N/A
1990	1.7	N/A	N/A
1995 est	1.1	N/A	N/A
D. Mini-mill (EAF) MHPT for wire rod (from EAF) including contract workers			
1980	3.5	3.8	4.3
1985	2.5	3.0	3.3
1990	2.1	2.4	2.7
1995 est	1.7	1.9	2.0
E. Average manhours worked per year			
1980	1950	2100	1750
1985	2000	2100	1800
1990	2135	2100	1825
1995 est	2175	2100	1850

Notes: All integrated plants assumed to be supplying their own coke and semi-finished steel. Data includes all plant and overhead employees (SG&A) and contract workers.

EAF: Electric Arc Furnace.

CRC: Cold-Rolled Coil.

MHPT: Manhours Per Tonne.

Source: Economic Associates, Inc.

Table 3: Estimated Intra-plant MHPT Reducing Changes 1995 vs 1980

	USA	Japan	EU-12
	Per cent change		
A. Integrated plant making cold-rolled coil			
Total MHPT reduction	42	25	40
1. Reduced coke rates	3	1	3
2. Increased cont. casting	9	5	8
3. Improved yields	5	2	5
4. Improved ironmaking	4	2	5
5. Improved steelmaking	1	1	2
6. Improved casting	4	2	3
7. Improved hot rolling	2	2	1
8. Improved pickling/cold processing	2	2	1
9. Improved finishing	3	2	2
10. Reduced corporate verhead	7	5	9
11. Other operational improvements	2	1	2
B. Scrap/EAF plant making wire rod			
Total MHPT reduction	50	50	53
1. Improved EAF operations	18	18	19
2. Increased cont. casting.	8	8	9
3. Improved cont. casting.	6	5	6
4. Improved hot rolling	6	6	7
5. Improved finishing	7	6	6
6. Reduced corporate overhead	4	6	5
7. Other operational improvements	1	1	1

EAF: Electric Arc Furnace.
MHPT: Manhours Per Tonne.

Source: Economic Associates, Inc.

Table 4: Factors contributing to changes in the size of the workforce between 1980 and 1995

	USA	Japan	EEC-12
	Per cent change		
Total employment reduction	56	30	54
A. Structural contributors	2	-9	0
1. Change in hours worked	10	0	6
2. Change in contract out	3	-6	3
3. Increased outside processing	3	1	3
4. Shift to imported semis	3	0	0
5. Shift to purchased coke	2	-2	1
6. Changed product mix	-4	-3	0
7. Changed shipment levels	-15	1	-12
B. Productivity/technology contributors	54	39	54
1. Shift to EAF	9	7	8
2. Increased cont. casting	8	6	8
3. Improved yields	3	1	3
4. Improved plant operations	20	18	21
5. Reduced corporate overhead	5	5	6
6. Inter-plant rationalizations	9	3	9

EAF: Electric Arc Furnace.
MHPT: Manhours Per Tonne.

Source: Economic Associates, Inc.

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