De-coupling Value Creation and Production in Auto Steel
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Introduction

Theme 3 of the CDO project deals with the diffusion and impact of ICT across the Canadian economy. My own work focuses on advanced manufacturing, specifically the steel industry and auto industry.

Two major research findings have emerged.

First, that most innovation in manufacturing now takes place in software. A specific example is the next generation of productivity gains, in the range of 20-40%, that arise from the development of physics-based machining, where the entire gains are driven by the enhance ability to model the physical object and refine the tool paths of machine tools by inverting the traditional interaction between cutting speeds and chip loads.

Second, because of the impact of ICT, the mobility of productive functions along global value chains. The example referenced below is the emergency of microstructural manufacturing in the auto supply chain driven by the new materials competition in automotive lightweighting. The fundamental attribute of the new materials is not just that they are stronger and lighter but that the microstructures enable new geometries. What we seen then in the supply chain is the permeability of the traditional boundaries between manufacturing and design functions.

This paper seeks to articulate a third research finding from examination of the impact of ICT on manufacturing, that is the de-coupling of value creation from the immediate site of production. I will present the auto-steel case, but this theme overlaps with my colleague Peter Phillip's work on the mining industry.

E-Steel

POSCO of Korea, along with Voestalpine of Austria and Thyssen Krupp of Germany are three of the technology leaders in the global steel industry. They combine new production technologies with advanced ICT and big data in steel.

POSCO, in the Spring of 2017 is bringing on line the first e-steel mill in the world at Yangpang. It produces flat-rolled steel plate and is part of a new strategic vision for what it means to be a steel company. Digitalization involves storing, analyzing, utilizing, and emulating the data generated by people, products, assets, and operations. In the words of the POSCO technical director:

> A smart steelworks is a facility that gradually evolves through "smart sensing," "smart analytics," and "smart control." Smart sensing means collecting, translating and connecting data from production sites in real-time, increasing data's visibility. Smart analytics predicts the status of production processes, that is, the flow of products on the factory floor and the conditions of manufacturing assets, based on the integration of technological (metallurgical) theory, expertise, and big data analysis. Smart control means that intelligent machines learn best practices and optimize production.
> Duk-Kyeon Jeong, POSCO, January 2017

At the strategic level, POSCO suggests that the steel company of the future will be a software engineering company that makes steel.
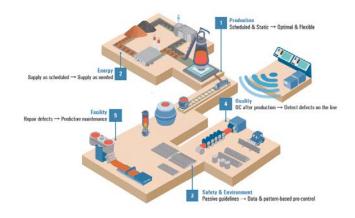
> A steel company in the Fourth Industrial Revolution might need to become a "software engineering company that produces steel," not a "company that buys and uses software well." It may sound odd that a steel company needs to become a software engineering company. However, what actually increases productivity, determines the quality of products, and ensures that facilities work properly is not visible hardware, but the engineering and processing knowledge behind it. Software is not merely algorithms and code, but the embodiment of this knowledge.
> Je-He Cheung, POSCO, January 2017

The second half of the ICT advanced manufacturing story is related to the new materials revolution. ICT enables microstructural manufacturing and that engenders a new form of industrial organization. Patrick Cohendet predicted this 25 years ago.

About 80% of manufacturing involves metals and the skill sets and forms of industrial organization in a manufacturing plant basically followed the stages of the metallurgy. In a steel mill this meant the organization of departments into: coke ovens, blast furnace, oxygen furnace, casting, rolling, finishing. In an auto plant this meant: the body shop, paint shop, assembly and finishing.

That can be compared to the industrial organization of POSCO Yangpang.

A so-called 4th Generation steel plant is organized around five units, with comprehensive sensors and data flows linking them and being 100% transparent to the downstream steel manufacturing value chain. The units are: Production, Energy, Safety & Environment, Quality and Facilities. This is as far from the organization of a mid-20th century steel mill as we are from Henry Ford's assembly line.

Big Data and Industrial Data Models

Everyone now talks about how big data, as an outcome of ICT diffusion, is transforming all industries. I believe that this is true, but we have to go deeper into specific sector and industrial processes to understand the underlying architecture and dynamics. They are different. Take the two examples of steel and automotive.

The Big Data Model in Automotive is a logistics-based model based on discrete production functions and incorporating primarily logistics, labour, etc.

In Steel, because of the linkage to the microstructures of the materials, is instead building their data model on the human genome project. There is a big difference between the assembly process for producing automobiles and the continuous process for making steel. It is very difficult and expensive to apply a decentralized, unmanned autonomous system, which is useful in assembling components, to the continuous process of steel, which involves liquid steel at high temperatures moving at high speeds. As the share of labor cost is relatively low in the steel-making process, automation will not bring tremendous benefits in the short term. Furthermore, the steel-making process is mostly automated because it handles heavy raw materials and equipment.

> The answer is the development of the "data genome map" based on data and software. The Human Genome Project aims to determine the sequence of the three billion chemical base pairs that make up human DNA, eventually allowing personalized diagnosis and disease prevention. A smart steel factory mimics this idea, aiming to collect and analyze all microdata generated in the production process, and determine the cause of every event. By identifying the exact cause of quality and production issues, and reviewing the status of facilities, steelmakers will be able to solve chronic problems and create new value
> Je-He Cheung, POSCO, January 2017

This is an intriguing suggestion that requires much more investigation.

Dis-aggregation in Auto Steel

In autosteel, materials manufacturing has always been linked to design, ever since the all-steel autobody emerged in the 1920s. This remains the dominant design across the industry. Until and unless that changes, steel will remain the dominant material.

Autosteel customers, while focusing on lightweighting, are also faced with meeting improved safety performance. For instance, the award-wining 2014 Honda MDX had to meet both emissions and safety standards and has a body using 59% high-strength steel, 36% mild steel, 2% Mg, and 3% Al. This may be a representative picture of the trend for near-future vehicles.

The changed role of materials suppliers is demonstrated in the Honda MDX Door Ring case. The existing Honda design, like all other SUV models, could not simultaneously comply with both emissions and safety standards. It was the steel company Arcelor Mittal using new Usibor and Ducibor grades along with a holistic Body in White (BIW) design that solved the dilemma.

Traditionally, autosteel design parameters were based on 2G: gauge and grade. The future is 3G: geometry, gauge and grade. Academics talk about a shift from traditional Design for Manufacturing to Manufacturing for Design in the new stage of advanced materials competition. The above case of the design of the door ring was only possible because Arcelor was able to produce the new steels.

Traditionally, Tier 1 suppliers are invited early into the design process. The auto OEM finalizes the platform design in year 1 of the traditional five-year cycle. Tier 1 parts suppliers and lead stampers are invited into the process in years 2 and 3. Steel companies have not been admitted until years 4-5, when the product design is already frozen. Steel companies are now lobbying for entry in years 2 and 3 so they can have an impact on materials decisions affecting final product design. They are seeking to play the role of materials consultants to design teams that include OEMs and Tier 1 design engineers.

There is a larger process at work here. The impact of lean production models on the auto supply chain has been accompanied by the rise of shared engineering responsibilities, as suppliers move away from merely producing parts to blueprints supplied by their customers. Software and digital manufacturing capabilities are the bridge that allows new materials to be brought into a vehicle, but they also pull in other actors across the supply chain.

Steel Case

The steel industry case reflects the merging of design and manufacturing. The new materials are not just stronger and lighter, they enable new geometries so steel companies move into design and challenge the proprietary production architecture of the auto OEMs.

Location has always been critical for steel companies. In the future of autosteel, the critical locational variable will not be where the assembly plants are, but where the engineering is being done.

Most of the auto supply chain is comprised of SMEs. Overcoming the challenges of change for such companies will require new perspectives, new partners and new public policies. For both steel companies and automotive OEMs, future success will critically depend on raising the game of the SME supplier base.

As mentioned above, the locus of engineering work has changed significantly.[1] The 2008-09 financial crisis was a seismic event. For example, in 2011, 70% of US auto suppliers were engaged in engineering design efforts, compared with 48% in 1989.

In terms of new engineering software, finite element analysis (FEA) has become a pervasive new tool and is a good indicator of where supply chain firms are along the innovation curve. FEA is the assessment of a component's suitability for its operating environment, incorporating scientific knowledge to evaluate an auto part's strength and durability in a given situation, including withstanding pressure, heat, impact, and other known environmental stresses.

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[1] Helper, Susan & Kuan, Jennifer. (2016) "What Goes Under the Hood? How Engineers Innovate in the Automotive Supply Chain." In Freeman, Richard & Salzman, Hal, eds. *Engineering in a Global Economy.* Chicago: University of Chicago Press.

By this measure, about 25% of firms are in the game.

The engineering intensiveness of the sector is also reflected in employment data. In the Helper study, over 20% of auto supply chain firms had no engineers at all, and nearly one-third had just one to three engineers on staff. The picture that emerges is of a spectrum of firms ranging from low engineering-intensity and low customer engagement to high engineering-intensity and customer collaboration.

The context is important. Intensified international competition and cost pressures have combined with stricter CAFE environmental regulations and consumer safety standards to drive innovation further down the automotive supply chain. The range of technologies that are important to success in the industry has expanded–from electronics, to digital platforms, new fuel and power technologies, and lightweighting materials. The need for more systemic innovations has led to a process of shifting the locus of innovation from within a single firm, the OEM, to a wider range of firms along the supply chain, and also research institutes and end-users.

Auto Case

In addition to the technical de-coupling and spatial re-location, there has been an important transformation in the economic geography of the automotive supply chain.

New micro-datasets from the Chicago Fed reveal the trend on the ground in Auto Alley where production, admin & sales and R&D functions are being increasingly de-coupled in a manner that re-enforces the disaggregation of value creation.[2]

There are appreciable differences in the spatial distribution of occupation groups within most manufacturing industries. These differences have important implications for our understanding of the sources of industrial agglomeration, the spatial agglomeration of innovation, the effectiveness of local economic development initiatives, and the spatial properties of particular industries.

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[2] Goldman, B., Klier, T and Walstrum, T. (2016) "Evidence on the within-industry agglomeration of R&D, production, and administrative occupations", Federal Reserve Board of Chicago, November 2016, WP 2016-20
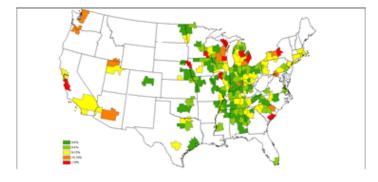
In the automotive case, the authors find that while all types of workers are concentrated in the Detroit area, production workers appear to be the most spread out, with greater density in Auto Alley and the Appalachians. Administrative and R&D workers also appear to be more concentrated in urban areas.

Dis-Aggregating Value Creation in Automotive

Production   Admin, Marketing & Sales   R&D

Source: Klier et al January 2017

Distribution by Occupation & Commuting Zones: Auto R&D Workers

Source: Klier et al January 2017

The conclusion flowing from this work is that R&D occupations likely cluster to take advantage of knowledge spillovers and labor market pooling, while production occupations likely cluster to take advantage of supplier linkages and proximity to customers. Because there are likely different forces behind the agglomeration of R&D and production occupation groups, the variation in their spatial patterns could help further clarify the relative importance of the sources of industrial agglomeration. The literature on the spatial agglomeration of innovation may benefit from the ability to identify the location of R&D workers within industries and possible knowledge sharing linkages across industries. Finally, the literature on local economic development could evaluate, for example, the payoff to subsidies to certain industrial clusters depends on the occupational composition of the cluster.

Conclusions

What are the implications of these research findings for understanding the impact of ICT on traditional industries?

First, in critical Canadian industries, value creation is being de-coupled from production. This is taking place in as diverse sectors as mining, agriculture, steel, automotive

Second, most innovation takes place in software but it has to be understood within the industrial processes in which it is embedded. At the macro level, Big Data models differ substantially between industrial sectors.

Third, in the age of global value chains we no longer have stand alone national industries, we have varies industrial nodes within larger systems. Traditional industries and supply chains are dramatically changing. Technical tasks and the distribution of economic rents are shifting. About 8-10% of SMEs are ready. What characterizes the successful firm are three capabilities: materials science, software tools, technology roadmapping