

The Possible Effects of 3D Printing on the Freight Industry

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Abstract: This essay considers the assumptions that have been made about mass 3-D printing production and tries to fit them into the subject of Ireland. Through an evaluation of the industrial Revolution with its demand increases for raw material, the possibility of a rail freight increase, the effects of the over-efficiency of a 3-D printing market, and by evaluating what state Ireland is currently in if 3-D printing in mass quantities were to begin at the present date.

Keywords: Freight, 3D printing, supply chain changes, domestic manufacturing, Ireland

On the 18 January 2013, the announcement¹ by Nokia to allow customers to use their blueprints to design personalised *Lumia* covers through the means of additive manufacturing made the idea of mass 3-D production suddenly more real. Since its creation in the 1980s this form of creation has made huge advancements in the last couple of years leading to much speculation of a second industrial revolution. While the question of 'how?' is still been work out in global R&D department the question of 'what will happen?' has been widely assumed. The object of this essay is to consider these assumptions and to try to fit them into the subject of Ireland by looking what's happened in similar occasions in the past and how it currently shapes up if a revolution were to begin today.

3-D Printing and the Industrial Revolution

Despite the vast majority of the literature available on this subject still only in the form of internet blogging there appears to be two reoccurring theories of thought on the outcome of manufacturing from 3-D printing. First, there is a possibility that a good's production would move to single location where the product's whole line of assembly will be carried out from creation to end in a single process. From here, like today, the finished good would be dispensed globally. Second, alternatively the line of production would involve the movement of raw material to a nation so that domestic production occurs solely for that markets' consumption. This form of manufacturing would either be done from the consumer's home, hired specialised depots or from the national franchise plant of a particular product.

The particular case of the latter theory, where substantial amounts of raw material are moved globally for domestic use, is very similar to what happened during the Industrial Revolution. From 1750-1850, Britain was becoming heavily specialised in the manufacturing sector. To fuel this even, the Kingdom saw its total imports rise over sevenfold from £20.3million in 1784-86 to £151.8million in 1854-56 (Findley & O'Rourke, 2007) which resulted in the drop of import manufactured good from 10.5% to 5%, and the substantial rise of raw materials from 47% to 60% (ibid, p.329). O'Rourke, in many of his collaborated works, would suggest that the causes of this dramatic shift in the composition of the British economy were due to Transport Revolution effect on transport prices.

From 1820-1850 the length of navigable waterways quadrupled through major canal construction (ibid, p.379) lowering the time and cost to transport large goods throughout England. Then, the advancements of steam technology soon led to the development of the railroad and the steamship. The Liverpool-Manchester line which opened up in 1830 highlighted the manufacturing dominance of the North of England. The creation of the steamship dramatically cut the international travel time by as much as 34 days between Liverpool and New York (Hugill, 1993). This sort of headway across the Atlantic of travelled to a considerably change in cost of transport. As the diagram (Williamson & O'Rourke, 1999) there was a steady decline in the Atlantic economy transport costs of about 1.5 percent per annum, or a total of 45 percentage points up to 1913 (ibid, p.36). This measurable transformation that ensued, along with the advancements in container refrigeration, changed the class of goods being transport

long distance from very-high value-to-weight ratios goods to simple raw materials needed for manufacturing (O'Rourke and Williamson, 2000).

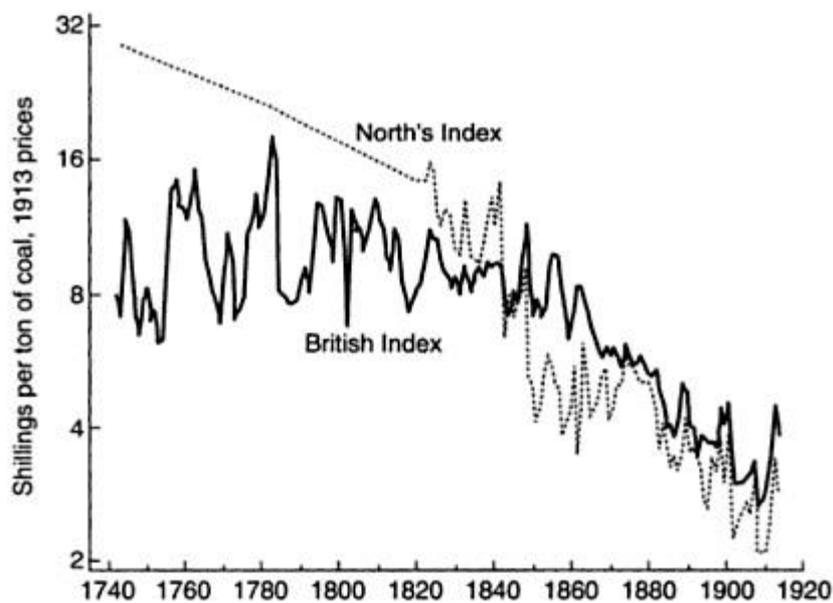


Figure 1: Freight rate Indexes, 1741-1913. Sources: Harley, (1988, figure 1), nominal rates deflated by UK GNP deflator².

It is worth noting that these events occurred in a time of strong national views towards Mercantilism following the Napoleonic Wars. Tariffs in the Atlantic economy were quite high at this time so the globalisation that took place in the second half of the nineteenth century was due to the falling of transport costs (ibid, p.35) which underlines O'Rourke's given assumption. The time saw rising tariffs as a defensive response to the competitive winds of market integration as transport costs declined: "artificial oceans" being substituted for the real thing (Bairoch 1989, p.55-58). This may be worth noting as with strong increases in demand for global raw material and the mass movement of patent designs may result in international trading friction.

Possible Shifts in Transport Mode

Adding to the idea of an increase in demand for raw materials may rekindle the need of rail freight in Ireland whether it is in the form of the movement of mass quantities of raw material of Irish origin for domestic and foreign use or in the form of the movement of mass quantities of foreign raw material straight to a manufacturing site. The rail freight industry's importance has been dwindling in the last couple of decades. Despite expensive programmes to accommodate the pre-existing infrastructure for larger and higher freight wagons on the railway lines there has been a major contraction of freight volumes in the last couple of years even during the built up "boom" years. Rail freight traffic in the Republic went from 399 million tonnes per km to 92 million tonnes per km in 2010, and even prior to the crisis, in 2007 had fallen to 129 million tonnes per km (Gimenez et al, 2011).

Much of its business moved to road haulage as after it saw its own deregulation that led to the significant lowering of prices in the newly competitive market. Where distances in Ireland tended to be too short and subsequently uneconomic for the freight businesses, the development of the internal road infrastructure allowed the door-to-door service of road haulage to cover large sized areas in a much quicker time frame, for example Galway to Sligo in terms of rail journey and road journey (ibid p.6). Because of the more accessibility from road haulage the railway lost some major business in the form of the An Post for inter county dispersal (Barrett, 2003). With his response to the *2003 Strategic Rail Review*, Barrett highlights the problems of the regulatory capture and the monopoly in the Irish rail freight industry (ibid p.2). Despite the problem of low-productivity of the State's owned company Iarnród Éireann the government have

shown persistent support for investing in the industry's infrastructure which saw a spending on average of €200 million per year between 2000 and 2007.

However, a significant increase in the private sector's demand of raw material may create positive spill-overs to the Irish economy. If deregulation was to occur in the industry, in the face of increasing market demands and an increasing of manufacturing depot sites, a more competitive market may allow new entrants to follow in the footsteps of IWT, Coillte, Boliden and DFDS who at the moment combine most of the freight market (Gimenez et al, 2011). While there is an absence of large scale industry, such as coal and iron ore mining, a reversal role to the example of Boliden's transportation of lead from the Tara mines to Dublin mines may see the increase of imported raw material freighted straight to site of manufacturing in Ireland. In such scenarios the extra revenue caused by this new form of activity may counteract the previous Government's commitment to introduce a subsidy per tonne for freight transported while also possibly responding to its proposal for an increase of investment in the rail infrastructure proposed in the *2030 Rail Network Strategy Review*, which was built on Booz, Allen and Hamilton's 2003 proposal.

Supply chain changes

It is worth noting that the implication of the "all-under-one-roof" style of manufacturing may also have descending aspects to the business sector also. As manufacturing is streamlined down to a single entire product to match the consumer's exact the desire the requirement of line production; the need for externally created parts; warehousing; along with removal of waste from production will all of a sudden be wiped out.

Therefore a dramatic shift in the supply chain of manufacturing due to a 3-D printing

boom may lead to the de-industrialisation of other industries, something similar to what Britain's manufacturing industry saw during the last century.

In 1950 Britain continued its dominance as a highly specialised industrial producer and many cities were extreme examples of a "workshop economies" (Rowthorn, 1986).

These manufacturing cities throughout the state were pulling the balance of trade in the post war era to a small surplus. However in the following decades the decline in domestic market, along with the two oil crisis, had negative effects on the competitiveness of the British manufacturing industry and the constraints imposed by the underlying imbalances in Britain's industry with the rest of the world were having a major negative effect on the country's manufacturing sector with a national decline of manufacturing output of about 35 per cent in two decades (Rhodes, 1986).

To reclaim the loss in competitiveness, firms resorted to extreme internal "shake-downs" which enacted reducing labour costs by cutting jobs and dropping productive capacity (Martin, 1986, p. 260). The switching of production overseas saw that whilst unemployment was falling rapidly the top fifty British manufacturing companies increased their overseas production between 1979 and 1982 for 36 per cent to 44 per cent of their global output. The likes of British Steel, Talbot and BSR International witnessed declines in employment by as much as 69% (Martin 1986). Between 1955 and 1970 the freight market saw a reduction of 37.3% to 19.9% in ton-mileage terms whilst the carryings fell by five thousand million ton miles. During same period road haulage saw similar diminishing results but it was partially due to the strict regulation of the industry right up until 1968 (Gwilliam and MacKie, 1975).

In Ireland of late we have seen the same similar, negative shifts in the supply chain. From the movement of Dell productions in Limerick to Poland in the second half of the year in 2009 saw a rapid decline in the high-technology exports of Ireland from its peak in 2001 with \$34 billion to \$21 Billion in 2010 (World Bank, 2012). Diageo's decision on cost grounds to transfer their output from rail distribution led to a huge inflow of road traffic through its own road logistics department after the deregulation in the road haulage market. The rail freight was adversely impacted by the cessations of both the Irish fertilising industry's trading in 2003 and later the sugar refining in Ireland which faced a particular loss of the beet traffic as international demands for sugar shifted to Eastern Europe for a cheaper supply (InterTradeIreland, 2008).

If a revolution started today

Since the financial melt-down in 2008, the Irish market has been in demand for tertiary services like never before. This is a particular point to note as the construction, administration and maintenance of an additive manufacturing industry would be heavily IT based. Following the lines of the proposals for a "smart economy" made by the Government in 2008 in '*Building Ireland's Smart Economy*', employment in the services sector has risen from 65 percent of total employment in 2000 to 76 per cent in 2010 while the numbers of researchers in the industry has rising by 50% (Worldbank, 2012). The output of this sector has considerably grown since 2000 and in 2011 the value for total commercial service exports pasted the value for total merchandise exported in the previous year (ibid).

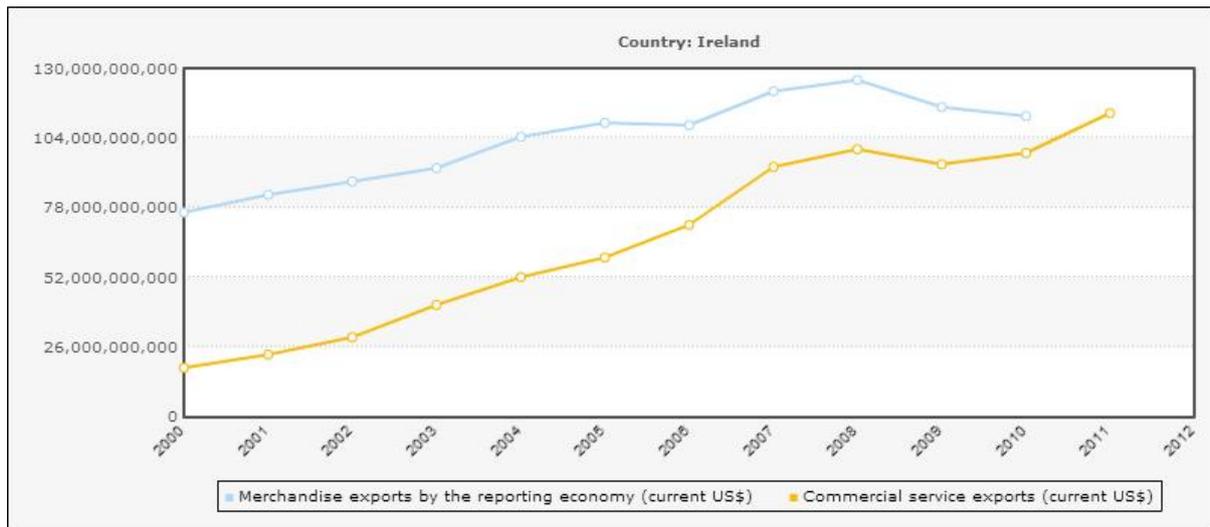


Figure 2: Merchandise exports and Commercial Services exports (2000-2010/11). Source: Worldbank.

While much of this growth in employment and output are financial institution based, there has been a slow but steady growth of IT jobs foreign investment inflows from such companies as Apple, and EA Games. These companies, whose products have considerably changed into the form of downloadable digital media, have had a significant effect on the high services output of last decade resulting in the decline of a physical, transportable good. This is also certainly highlighted with the increase of the IT infrastructure of the country as businesses, as well as residents, have become more connected via internet broadband resulting in the considerable increase in internet servers based in the state leading to perfect conditions for the administration of a 3-D printing industry.

While previously noted regarding the “streamline” aspect of additive manufacturing, it is hard to predict what would happen with the Irish total output and domestic consumption with a manufacturing boom through 3-D printing. We have seen a the decrease in both the merchandise exported and imported as both aspects fell in-line with the decline of the economy in light of the current crisis. The statistics of the road freight industry have halved across the spectrum especially in tonnes carried which has dropped from 300 million to 110 million (CSO, 2011, see table 1). In the mix of less consumer demand along with rises in oil prices there has been a major decrease of the vehicle numbers in the field. However in spite of this, there has been a rise of Air-freight volumes over the last decade instigating that the average Irish consumer, regardless of economic situation, maybe moving towards a quality over quantity market of consumption with shorter temperament of waiting for the end product. But if the quality of goods are unchanged, if not increase, then it would assumed that the day-to-day element of road haulage should increase that industry’s volume, and possible its cost, with an increase in consumer’s changing ability to buy specific goods.

Year	Tonne-Kilometres	Tonnes Carried	Vehicle Kilometres	Average Number of Vehicles
	<i>million</i>	<i>thousand</i>	<i>million</i>	<i>number</i>
2001	12,291	199,829	1,585	70,825
2002	14,282	224,907	1,851	71,005
2003	15,679	251,791	1,966	71,459
2004	17,011	273,557	2,139	73,075
2005	17,819	291,883	2,312	79,916
2006	17,322	299,030	2,242	87,135
2007	18,707	299,307	2,332	97,752
2008	17,289	245,788	2,207	97,640
2009	12,071	148,328	1,585	87,616
2010	10,924	125,865	1,457	84,025
2011	9,941	110,260	1,338	81,178

Table 1: Road Freight Result for 2001-2011. Source: CSO, 2011

In conclusion, the exact outcome of what will happen in the face of a manufacturing “boom” through 3-D printing remains ambiguous with the only real certainty that the demand for raw material will probably increase: but by how much? The question, being a result of the possible disruption of the present supply chain as it becomes the “perfect” efficiency of consumers getting exactly what they want resulting in little if no waste and little if no spin off to surround sectors as from what we have seen, customers buy for quality. This will certainly have an effect on the price of transporting goods. The question can also be a result of the notion of where will manufacturing happen? If large demand in raw material is required at a constant supply then is rail freight the possible, best solution? In this confusion all that can be said for is that the freight industry will most like change if not by composition then definitely by quantity. If a study were to preformed at a much later date it may explore: the legality and constrictions of the protection of design; the administration in 3-D printing manufacturing; and whether national protectionism may change international trading policy as these issues may come more into play if 3-D printing becomes more of a reality.

Notes

1: The BBC news website's article concerning Nokia Lumia and 3-D printing

<http://www.bbc.co.uk/news/technology-21084430>

2: The index labelled North is based on North, Douglas (1968) whose indexes are based on the US sector only.

Data Base:

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