Additive manufacturing flickering at the beginning of existence

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Abstract

The tremendous fluxes of innovations are likely to funnel and channel the most rapid change of overarching activities. The wider needs of the society are the impetus for the development of new technological substitution processes. Additive manufacturing using inkjet have broken new ground in rapid manufacturing and transform the way some products are made. The advent of this embryonic technology will born the aptness of applying judgement in assessing the implications and consequences on business, accounting and tax, rather than relying on the application of predefined rules. In this light, the article investigates the trend away from current traditional technologies to the next generation of custom manufacturing, additive manufacturing, as a cure for „ills” like : intermediation, stocks flow, divergence of functions, workforce productivity and labor cost savings. Connections to practice may become a double edged sword because these recent technological advances are the springboard for charging, billing, accounting and tax to evolve.

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Keywords: additive manufacturing, technology, product, cost

1. Introduction

Firms face an increasingly uncertain environment as changes in global competition, customer expectations and needs which have become tightly specified, and technology accelerate Buganza and Verganti, 2006. The economic downturn has affected almost every industry sector and manufacturing has been suffered a lot, many companies being forced to make unwelcomed decisions: job cuts, budget freezes. In Designer Magazine, march 2009 it has been postulated that design is often one of the first victims of cost-cutting measures. So, this new

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competitive and challenging economic landscape as long with increased customer expectations requires as an strategic imperative, product flexibility development which implies: range, mobility (speed in changing) and performance uniformity (even in the case of switching alternative) Thomke and Reinertsen, 1998 and goes to avoidance of costly changes in production. In the humankind history, civilization was set up on the base of forming but today the economic ecosystem claims for improving forming precision, velocity, reduction in equipment and material cost, developing new products and materials and thus in an emerging of an advanced, flexible manufacturing method as additive manufacturing, whose ignition point was the laser technologies applied in manufacturing in the 1970’s. The paper shows a generalized, big picture overview on the additive manufacturing as a revolutionary emerging technology that could assist and influence the geopolitical, economic, social, demographic, environmental, and security implications. In these uncertain economic times additive manufacturing it’s what companies need to survive, it is a technology whose time has come. As in the case of Kodak where digital camera caused the demise of film based cameras, in the case of the traditional supply chain the shift could be additive manufacturing. This article also provides some guidance for the relevant tax issues stemming from this technology, issues which piqued our interest in order not to be lured into a tax trap.

2. Rebirth of manufacturing

Additive manufacturing also known as generative manufacturing, eManufacturing, direct digital manufacture, freeform fabrication, 3D Printing or rapid manufacturing, is the general term for all technologies based on the dispersed-accumulated forming principle and is defined by American Society for Testing and Materials as “the process of joining materials to make objects from 3D model data, usually layer upon layer”. This layer based manufacturing „print-out” solid „end-use” components such as aerospace, motorsport and automotive parts, communications devices, medical implants, hearing aids, lamps shades, dental crowns, surgical aids, fashion and jewellery to lighting, furniture, collectables and toys. The advantages incumbent by additive manufacturing are already being commercially exploited by organisations such as Siemens, BAE Systems, Boeing, NASA, Freedom of Creation and many others commercial technology vendors who make small components, on the ‘desktop’ scale, although specialist companies such as Materialise have machines which can build component with large dimensions, using for example “Concrete Printing”, an automated extrusion based process. Automation for optimizing the engineering process plays a core role in the construction industry as long with issues like: a reduction in labour for safety reasons; reducing construction time on site; production costs; and/or increasing architectural freedom and uniqueness in contrast to replication.

3. Additive manufacturing benefits

In contrast with subtractive techniques associated with traditional manufacturing processes (casting, machining, molding), additive manufacturing technologies could reduce the life cycle material mass and energy, water consumed by eliminating scrap and harmful ancillary process enablers, thus having a positive impact on sustainability. Some additive manufacturing techniques facilitate recycling and disposal and permit repairing or remanufacturing/ refurbishment/ redesigning of obsolete or failed tooling/product rather than being replaced or disposed as long with production of new tooling. Parts could be manufactured closer to the point of consumption, so a geographically delocalized production. Manufacture could be distributed or done in multiple locations, diminishing single source supply chain risk and meaning a reduction in transportation (a minimised used of freight and lower fuel burden) which will impact carbon footprint and overall energy consumption. Additive Manufacturing offers huge potential cost savings in formula 1 racing or production for the aerospace and aeronautic industry like reduction in fuel consumption for commercial side and product performance, improvement efficiency for military side through weight component reduction. In the aerospace industry it is used the Buy-to-Fly ratio (how much material you need to purchase in order to manufacture the final flying
part) which reaches 15-20 for many flying components due to complex geometries. But additive manufacturing has the potential to produce light-weight titanium components with high resolution and good surface finish, with a Buy-to-Fly ratio close to 1 (achieve a material efficiency up to 97%).

Additive Manufacturing is particularly useful where:
- Production volumes are relatively low or very low (small economic batch production)
- Part geometries and assemblies are complex (it embedded the design for functionality rather than design for manufacture, thus discharging the traditional manufacturing processes constraints)
- Design complexity and capability should to be maximised with no cost penalty
- Is a need for a drop in the lead times (manual modification is time consuming)
- Product personalization is required
- Additional and multiple “functionality” have to be added to parts during a single build process.
- Fixed cost tooling cannot easily be amortised into piece part price
- Product launch risk is high
- Investment is problematic
- The customer base is widely distributed
- The customer (or supplier) has ethical or environmental concerns
- Materials used are expensive and difficult to process by conventional means.

As an example for the life cycle economic benefits which a monitor arm manufactured through the additive manufacturing technology had given to Boeing company is the next. One monitor arm made by additive manufacturing saved 0.49 kg in comparison to a monitor arm machined from solid, so a $1,500 per annum in fuel savings, $45,000 if we consider 30-year aircraft life and estimate a product life span of 5-7 years. The difference in the cost of machined monitor arm ($500) beside additive manufacturing monitor arm ($2500) is $2000, so the capital investment is repaid in less than 2 years.

4. Additive manufacturing disadvantages

In this kind of manufacturing, the material and physical process principles are interdependent, so it requires a specific resolution and dedicated components and thus a limited choice. According to some studies of more than 90% of 200 products, components, parts and business models are not immediately suited to additive manufacturing. Moreover, in order to raise productivity additive manufacturing is knowledge driven (CAD designer-makers) and demands high level skills. Furthermore, the design of a product could take significantly longer time than the manufacturing time. It is not suggested that additive manufacturing will play a key role in the future development of food and drink sector.

5. Do the benefits outweigh the manufacturing limitations?

We have a balance problem between the additive manufacturing advantages: distributed manufacture, stockless supply chains, reduced fixed assets, zero tooling and no associated tooling cost amortisation, risk mitigation, less organisational cost and burden, inferior carbon emissions, complex shapes (freeform) and limitations: capacity limitations, mechanical property limitations, surface finish, part accuracy; process variance; quality assurance & validation, post process machining. To redress the balance we should look at product life cycle rather than production process. It is considered that products obtained through additive manufacturing technologies are submitted to a “gate to grave” life cycle. In order to full benefit from the additive manufacturing technology, firms have to plan its implementation and compare the advantages from analysis such as additive manufacturing versus conventional technology breakeven analysis and additive manufacturing life cycle value studies, make or buy analysis, supply chain configuration, materials selection and staff development. The economic and environmental gains from raw material saving, light-weighting for life-time benefit, can off-set the process inefficiency (waste of time, low speed, etc) and the cost of additive
manufacturing adoption, which is still prohibitive. Further, a carbon tax credit value for saving should be granted for those who choose additive manufacturing as a manufacturing process. To sum up, when a technology offers besides economic benefits to the customer, social and environmental benefits to society it can pay dividends to embrace it.

6. What will product businesses look like in the future?

Future uncertainty could be summed up using the next characteristics: volatility of fuel suppliers, prices fluctuation, raw shortages (the „china-effect” will continue to stretch the global supply of commodity materials such as copper, titanium and steel), political instability, non-renewable raw materials, infrastructure and utilities weakness as a fact of increasing global population, higher landfill taxes, limited space availability, environmental protection from chemicals. In order to maintain a competitive advantage against low cost overseas competition, companies have to innovate ever more complex product, in ever decreasing volumes, which are either highly personalised to small consumer groups or unique to an individual customer. The impact of additive manufacturing on business is therefore significant enabling both large and small enterprises alike to compete within the global economy, as this technology changes all aspect of a company’s business strategy, from product design and development, through manufacturing, assembling and supply, to delivery, logistics and after sales service. This enables new products and associated services to be launched to market much quicker at far lower cost (little financial investment in tooling and almost no up-front fixed costs) and with far less risk. In a future scenario, society will pass into a ‘tool-less’ one, where consumer products are printed to order, using the consumer's own design data practice upon a globally distributed just-in-time supply chain or a manufacture within the consumer's own home (3D printers in the home) at an affordable cost.

7. The inevitable taxes

As the line between the real and virtual is blurred, technological advances have far outpaced current tax laws. As famed economist Milton Friedman predicted in 2000, “cyberspace is going to make it...much more difficult for government to collect taxes” Schlimgen, 2010. Because additive manufacturing technology meets the requirements of sustainable development: a reduced use of resources (non-renewable resources, fuel, energy, water), a reduced waste production and carbon emissions, the environmental protection expenditures and the associated taxes will collapse. On the long term, this technology is distinguished by costs controlling, depressed imports and exports, lessened need for labour which is equivalent to a lower tax burden. Tax revenues collected by the state will suffer a significant downturn, so a recasting of the entire tax system will be requested. Additionally, as a consequence of diminishing the need for labour, contributions to social insurance systems will drop considerably which raises the question whether these taxes will be able to uphold the healthcare and pension systems or not. In the case of remote access and virtual goods, the purchaser receives access codes on a printed receipt that provides the customer to access content on a third-party server over the Internet or download a 3D design. The content downloaded should be treated as taxable. Now, virtual cash is taxed at the point of exchange as a cash equivalent. Digital „STL” files could be compared to digital goods: software programs, music, videos or other electronic files that users download exclusively from the Internet. They should be referred as analogous of their physical counterparts. As physical goods purchased online (through mail order) are subject to sales taxes even the virtual goods in the form of CAD design files which are transmitted electronically should be subject to these taxes. Even Beekman argues that there is “no good conceptual justification for treating virtual world activity differently from real world activity for tax purposes” Beekman, 2010.

Because the tangible personal property would be in electronic form instead of in physical form, each download should be taxed like a purchase in physical space, no matter the method of delivery. The additive manufacturing technology will rise the problem of a fair local sales tax assessment because the business operators will not be connected to a physical location (a physical store or sales representatives) in the taxing
jurisdiction. Moreover, there will be a problem of tax assessment because inherently transactions will involve multiple parties and locations: when and where the income should be taxed?, where does the property actually reside?, whose jurisdiction will benefit from taxes such as sale taxes, property taxes (the customer’s billing address jurisdiction or another jurisdiction in which the purchaser received the digital property, this also applies to taxes paid by sellers). In other words, the questions are: should tax apply?, where would tax apply?, what taxes do the buyer and seller pay, when a property in a virtual realm is purchased and at which point in the supply chain should the transaction taxes be applied? In this context, new types of taxes that will only apply to the digital realm, will emerge as a digital download and digital service (STL files, 3D printing analysis and production drawing) specific tax. A strategic tax approach to remove the difficulty in trying to identify and levy all methods of commerce which are capable of generating income is to tax all forms of income, with some exemptions which will be clearly mentioned. This could also serve for businesses operating in the virtual industry, relating online content and by remote access, to determine their tax obligations. Thus, the core concept of tax consciousness and tax morale will not be as controversial and there will be no means to avoid taxation as it is now, when virtual worlds offer people the impetus to avoid real-world taxation with relative ease. The discharge of the outdated tax regulations and the enforcement of another one will be a challenging activity. The best solution to tax collection is that the operator of the virtual platform which provides the CAD design file to withhold a percentage of each transaction and remit it to state. To sum up, there should be a proper identification and definition for a "taxable event" in a virtual world or virtual economy, so a new tax policy should be shaped (definition and realization of income, recognition events, and characterization). From practical considerations, a tax system for virtual economy could be implemented, because this environment has the advantage that it can be controlled.

8. Discussion and conclusion

With the help of pervasive technology of internet and on-line payment culture for products and services, information is moved in real time and now, through additive manufacturing, the barrier of distance was outpaced even for the material world. It has been cited that additive manufacturing is the catalyst for a potential „industrial revolution for the digital age”. Digital files „STL” which incorporate the design of a product are sent via the internet on the customers’ demand in order to be printed in 3D, thus going to discarding the need to build-up and maintain inventories of new products and spare parts, so a true just-in-time. So, the product is at the disposal of the customer who will pay only the price for digital design purchased and at the location where it is used. But it is also possible that a concept design file piracy will emerge as a new form of fraud related to intellectual property rights, because everything in the virtual world is intellectual property. Production in a single process and distribution of material products will lead off to decentralization, deglobalization and consumers will be capable to produce at home what they desire. A printing machine will be able to make a production with a huge range of types of materials without retooling and so additional cost. Countries known as “manufacturing platforms” like China will suffer a decreasing demand in exports and importing countries will contract their imports, and this in effect will reduce global economic imbalances. Also, the use of workforce is lowered because fewer people are demanded to produce more goods, so fewer jobs. A reduced need for labour in manufacturing could be politically destabilizing in some economies while others, especially aging societies, might benefit from the ability to produce more goods with fewer people (a displacement of workers’ burden who have to support the elderly retired people) while reducing reliance on imports. Nowadays, additive manufacture is still an emerging technology but in the near future we will see an increased number of additive manufacturing products into commercial markets because the future mainstream will be a high integration of customized production (clients will freely design the structures and define the materials, and then transfer the scheme to manufacturing centre by network), internet-based production, machines easily controlled, of low cost and high reliability, high precision and high mechanical strength. Additive manufacturing provides a step forward in environmental protection and resource productivity issues, offers reduced waste and improves material efficiency, which is an imperative for non-renewable resources raw
materials; minimises the use of harmful chemicals, such as etching and cleaning solutions; and provides the possibility to use recycled materials.” The cost-savings through the scale economies could be compensated by simplifying and shortening the supply chains, eliminating global distribution and the risk associated with new product introduction but also driving down the cost of storage and maintaining of inventory, spare parts and final products unsold. The additive manufacturing along with a new lean yet agile business model (which entails a lower need for haulage, warehousing, logistics, disposable packaging) will stimulate the local manufacturing and use of local materials and thus revive local economy and productivity. Also, because additive manufacturing is an environmentally friendly technology, it will lead to a drop in the cost of health care (personnel health, safety and security).

For fiscal reasons, at this time, the adoption of such a technology would involve only benefits because research and development activities are stimulated (for the calculation of taxable income, these expenses are fully deductible and also qualify for an additional deduction), the profit invested in the acquisition of additive manufacturing technological equipment could be exempt from taxation, etc. But the virtual content has enjoyed less tax certainty. States will have to weigh in on this issue and address tax guidelines in order to improve tax clarity and tax treatment in the virtual business, because these new business models implied by additive manufacturing do not fit into a traditional model of taxation. Merely, the uncertainty which we’ve grown accustomed to will continue to persist until the law catches up with the virtual world. To conclude, additive manufacturing technology converts the way how product is purchased, produced and delivered and will lead to a manufacturing renaissance in high-wage economies but also will respond to the attributes of flexibility, reconfigurability and sustainability which could uphold the myriad primary production demands of the future society. The customers, consumers, suppliers will merge as one and additive manufacturing applications will be part of our lives, our homes, our vehicles, our bodies.

References


