

### The 3D Printing Revolution - Author Arnold Geelhoed

#### 3D printing, scanning and reversed engineering: The new technological revolution will change many practices as well as the landscape of Credit Risk Management

In July 2013 I published an article in [Business Credit](#) regarding 3D printing and the impact on certain industries informing the readers that the future is already here, it just needs to be distributed via 3D printing. In this article I will focus in more detail on the industries and countries which will be affected most, from a positive perspective, as well as from a negative perspective. I will also be touching on the possible downsides of 3D printing, which could herald a new crime wave. Furthermore I will explain to the uninitiated, what 3D scanning and reversed engineering is in terms of a technology which will soon be available to consumers at home.

The boost of 3D printing is expected to come from the fact that selective laser sintering, for which the patents expiring in Feb 2014, high quality 3D printers at lower prices will become available for the consumers. I wonder whether this would also be the moment that companies like Epson, Canon, Lexmark etc. would jump into the 3D printing market. I know that Xerox have already become active in this area. HP announced in Oct 2013 their plans to be active in this market mid-2014 for consumer 3D printers. This I fear, could curtail some of the future ambitions for new startup companies which have been very innovative so far in developing the 3D printing market.

US President Barack Obama mentioned in the State of the Union February 2013 that the 3D technology "has the potential to revolutionize the way we make almost everything." He announced plans to open a network of 15 self-manufacturing sites in the United States as a way of revolutionizing the economy. This video can be viewed using the following link: <http://www.youtube.com/watch?v=01gJYQEyBWc>



**Savings:** It could be that 3D manufacturing improvements combined with patents will lead to an 80 percent reduction in cost to print objects in five years. This will lead to a huge economic revolution from mass production to production by the individuals. It has been calculated that a US household can save around USD 2,000 a year when they would print the available possible end products themselves.

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**VAT/ GST/ Tax changes/copyright protection:** Printing 3D objects by consumers would mean that the GST/VAT (value added tax) or other government sales tax income would decrease substantially as these taxes will only be charged over the raw materials used by 3D printers. I wonder how the governments are going to deal with this treat. In the Netherlands, where I reside, the VAT is currently 21% on most products bought by consumers... Also the government should expect changes regarding the import duties. Currently, in certain cases, import duties are charged over the value of the imported finished product. After the 3D revolution has taken place import duties can only be charged over the value of the raw materials used in 3D printers (which is normally much lower) and the raw materials could be sourced from other countries as well with another regime regarding charging import duties. Perhaps it will be required that each printed product has to have a unique identifiable tag to ensure that the copyrights can be protected (some forecasted a loss of many billions, the analyst group Gartner have suggested something in the region of USD 100 billion, loss in copyrights per year already as of 2018 if things continue unchanged).

GST/VAT can only be charged when the tax authorities find a way to compensate for the loss in VAT, for example charging GST/VAT when a unique tag has been printed. All this could mean many changes for companies in terms of possibly having to set up new ways of charging taxes in their systems. Of course, as early adopter I will be embracing the 'going Dutch' philosophy and associated fun, at least for a couple of years before the Dutch government finds out where the loss in GST/VAT/ import duties derives from...

**Impact on Credit Risk Management:** There will be a major shift in industry risk (for more details please find the table which will be published in part 2 of this article in February 2014), payment methods (I would expect an increase of Credit Card payments from individuals as they will become the manufacturer) as well as changes in the risks associated with certain country. Also, for bankers, the biggest nightmare ever will start as all existing fundamentals of risk will be turned on their head. For example what should you do in case a customer manufacturing packing materials in Western Europe would ask you for a new loan for 15 years, and wants to expand his production line knowing that the packaging industry will be hit when 3D printing takes really off?

I am working in the publishing industry which has changed dramatically over the last 5-8 years. We have experienced a move away from printing for most of our products which are now available via the internet in E format. This has made Reed Elsevier the world's fourth largest paid content provider, after Google, China Mobile and Bloomberg today. The speed of changes which I have witnessed within this industry will now also apply to many other industries once 3D printing becomes the norm....The following has happened: Major shifts in customer segmentation (from agents/wholesalers directly to end users creating new types of credit risks and payment methods), a substantial increase in the number of customers / countries, alternative ways of supplying the products (less physical shipments via distributors as we focus now more on e-information). This may also include selling certain business activities which no longer fit into the current business strategy, but also making new acquisitions at the same time. All these fast changes will become business as usual for many of us once 3D printing really takes off.

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**Potential revenue:** I have seen many revenue forecasts for 3D printing from USD 3 billion in 2018 up to USD 10 billion in 2020. At the end of May, McKinsey published a report indicating potential revenue in 2025 between USD 230 and 550 Billion (source McKinsey Global Institute Analysis). Did you know that 3D printing already created over half a million jobs in the US during the last 3 years bringing back outsourced jobs from low production cost countries? I think that almost nobody can exactly predict the revenue created by 3D printing but I would not be surprised if the total revenue for the 3D printing industry alone would indeed hit the figures mentioned by McKinsey. In case you would add the revenue which is replacing the revenue of the current manufacturers.... 3D printing is an industry with unlimited growth and market potential so within Credit Management we can ignore the impact it is going to create.

**Investments:** In July 2013 China is going to invest USD 245 million in 3D printing to speed up the developments but private companies in China are already making similar investments as well. China wants to become the number 1 in 3D printing in 2016. Singapore is investing around USD 400 million over the next 5 years. GE Aviation and Honeywell Aerospace are going to invest USD 3.5 billion in 3D printing over the next 5 years. These are the announced investments I collected just in a week time...In Credit Management we should follow where the opportunities are created and identify those who cannot or do not want follow these changes as they can end up as the losers.

**3D scanning / reversed engineering:** 3D scanning gives new life to old (scanned) objects. There may also be an increase in patent and design violations as scanners can be used to reverse engineer objects without a design drawing or mold. Also you can make from a 3D scan and a wax 3D print. You can use the wax print to make a new mold yourself and reverse the engineering process. When you 3D scan an object, perhaps even damaged, and adjust it to your own needs / repair the damaged part on your computer before printing, you can make a new version of the object. You can scan objects of everything so buildings, cars, people, art (recently done with a Van Gogh painting and the reprinted painting, which is an exact copy of the original, is now for sale, under limited license of the Van Gogh Museum in Amsterdam, for USD 22.000 in Asia). Good 3D scanners are now available for USD 2,000 (but prices will drop fast) which are easy to use and do not require knowledge of CAD design software. Some 3D printers also have a scanner and fax included so that you have everything in one machine and they even look nice on your desk as well! You can make a scan in 30 seconds or so after which you can adjust the size of the print you would like to have and print it via Windows 8.1. In case you do not have a 3D scanner you can buy 3D scanned objects via internet sites. Another recent development is a small 3D Scan clip which you can put on your mobile phone or Ipad, allowing the user to harness the particular device as a 3D scanner. This means that 3D scanning will become available for the masses in just a few years' time. For those who are interested now, I would recommend taking a look on Shapeways.com , Thingiverse.com or other sites which will be developed sooner or later like perhaps a site called Youprint3D.US for made in USA designed objects or similar names which will be adopted by huge internet companies investing in 3D printing one day. Perhaps we will see even the name Youprint3D.space as NASA is starting in 2014 to print spare parts in space! It is really amazing what these sites offers already today and can print and mail it if you want to in case you do not own a 3D printer yourself.



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**Revolution:** We are about to see a revolution in design and manufacturing. Everything can be completely personalized. Imagine what famous inventors could have developed if he had a 3D printer and scanner. That is what many people all over the world are able to do soon, this author being an early adopter. I am going to scan and print my own Chinese Xi-An terracotta army chessboard, my own designed surfboard (but have still to learn how to use it properly), my own flip flops with toe straps in the shape of the Euro sign (but I will make a new design each year) and sun glasses in the same color. I am going to design jewelry for my daughter's birthday and print it myself and as last I will print my own Gaudi metal fence (and adjusted to the right size) for my entrance at home. I am really looking forward to the start of my new manufacturing hobby.

**Affected countries and Industries:** The part below is my personal view on certain developments I noticed and is not based on extensive scientific research.

**Mining industry:** All winners are the countries with a mining industry like South Africa (they are building a printer of USD 15 million to print large titanium objects so that these parts can be shipped directly to the end user), Australia and Brazil but also Guinea, Russia and Ukraine could be winners in case they adopt the new possibilities.

Companies like BHP Billiton, Rio Tinto and Vale, active mostly in these mining countries mentioned above, could also adopt a new strategy and print on demand, near a mining site, saving the end user lots of money. A 3D printed object utilizes only the necessary metal dust to fabricate a part compared to carving down a piece of metal. Processes, in which a large portion of the purchased material ended up as waste will, when 3D printed, create no waste at all. Metal to melt in ovens requires also extra shipments from the mining to the ovens and hereafter via the distributors towards the carving and cutting industry where on the end it will be delivered to the end user. This will not be required anymore when it is 3D printed near the mining site.



Please note that each month new metals are added to the list which can be 3D printed like iron, silver, stainless steel, aluminum and even a liquid metal which turns solid when printed at room temperatures.

**Country winners** will be (besides the countries already mentioned under the mining industry):

- US (investing heavily, see previous remarks).
- China is in the process to change from manufacturing for the whole world into an economy where 3D-printing technologies will play a key role. They will have to deal with the shift mentioned under the country losers though.
- Singapore is building a 3D research center which will be opened in May 2014.
- Israel wants to lead the revolution of 3D printing and is investing in the new technology.
- Europe, like Germany and UK who are investing in 3D printing.

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**Countries which will suffer** will be those reliant on the manufacturing industry for products that can be replaced via 3D printing like toys, apparel, textile, shoes:

China, Taiwan, Vietnam, Cambodia, Malaysia, Indonesia, Philippines, Bangladesh, India, Pakistan, Mexico, Brazil (excl. the mining part), Egypt.

**Downsides of 3D printing:** It could create a wave of new crime and it will impact values of respect, honesty and integrity. The list below is by far not complete and some crime mentioned below is already done...Each Credit Manager should think what the possible downsides are for the company he works for and start to take the necessary measures.

- Fake old precious coins for experts impossible to distinguish from the original coin when the same metal is used, I guess from the same time frame.
- Print your own untraceable gun or plastic knives hard to detect by security portals; already done.
- Print your own high security keys (take a picture of a key and turn it into a 3D file) of government buildings, elevators, handcuff's or prisons; already done by students as a test.
- Print your ATM slots for skimming credit cards; already happened and USD 100K was withdrawn with skimmed credit cards
- Print your own XTC party pills
- Scan an object from a friend and reprint it without paying the copyright; already done
- Pirated brand products: 3D printed and sold in Africa/Far East. It will be difficult to see the difference from the original product

**New developments of 3D printing (for more examples please see my article published in July 2013):** the items below are already possible to print:

- Print your own pizza / burritos so no couriers required anymore (they should shift to the delivery of 3D printing materials)
- Sugar: Print with sugar your own candy for kids in all kind of shapes and colors. But what will the impact on the existing candy industry be?
- Face masks, personal exact fitting bike helmets, drones.
- Printing chocolate, cheese or salt in all kind of shapes
- Sea scallops or snacks for dogs and cats
- Consumer grade leather.
- Printing material which can adapt itself to the environment in size or shape or even self-assemble itself (without human interference) from small parts into its final object, after it has been printed. This is called **4D printing** and it is using Nano technology. To give you some idea's this could be a camouflage uniform or a car coating which is changing colors or in brightness when it is dark, rain pipes adapting in size when a higher water capacity is required preventing them from bursting, furniture building itself without manual interference or a rubber summer car tire which morphs into the compound of a winter tire when the temperature drops below a certain point. For those who are interested in this topic please [click on this link](#)
- Print your own robot (still expensive though)

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**Here each Credit Manager should think what the possible downsides could be for the company he works for related to the new developments and start to take measures (where possible).**

**Population forecast:** The United Nations forecast in June 2013 was that the world's population will increase from 7.2 billion today to 8.1 billion in 2025. By 2050, it will reach 9.6 billion. This means that my forecast is made on the ceteris paribus clause with respect to the impact 3D printing. In certain industries and countries the outcome could be quite different due to a higher population, mainly in emerging markets and Africa and therefore level the impact of 3D printing and related credit risk developments.

**New medical care:** The increase in population is not only due to an increased population in emerging markets but also in well developed countries there will be growth as people will become much older. The person who will walk around with Nano robots in his body marking bad cells to be destroyed, fix damaged cells or fixing disconnected brain wires and which can become 130 years old with an acceptable quality of life, is maybe already amongst the readers of this article. In case the Nano robots cannot fix it we will be able to print new skin, bladder, heart, kidney, liver, cartilage, ligaments or sinew changing completely the speed of surgical operations, the world of transplants and the donation system. This will take another 5-10 years from now to print organs with a size big enough to transplant in a human body I am afraid. It will save hundreds of thousands, if not globally millions, people life's though as soon as this is possible. It does require a shift to doctors who are specialized in transplants instead of surgery on organs which do not function well. The medical Universities should already start now to allow more students in the medical area specialized in organ transplantation. Besides the possibilities, discussions should start on how and up till when to use this technology. There are a lot of ethical and social questions which need to be answered before we should start using this technology.

### **Impact on industries:**

**Pharmaceutical Industry:** When patents expires the pharmacist can print the required medicine (or you can print it yourself as soon as your doctor has mailed you the print file). This means a loss of revenue for those Pharmaceuticals which are producing medicines for which the patents expired like Ranbaxy or Sun Pharmaceutical in India or Teva Pharmaceutical in Israel. For the other Pharmaceuticals: at the end of the day we will have personal medicines fine-tuned on our own stem cells which can be printed at home from our chemical 3D printer. I therefore forecast that Pharmaceuticals will focus on the research and development only instead of the production of medicines. For those who are interested in this topic please see the following link: [www.ted.com/talks/lee\\_cronin\\_print\\_your\\_own\\_medicine.html](http://www.ted.com/talks/lee_cronin_print_your_own_medicine.html)

**(National) Health Insurance companies:** They can benefit from this change and they should stimulate the development of a printing program and equipment with Pharmacists to begin with. The savings can be huge in this area (no spoil of medicines in stock getting out of the expiry date, no shipment, packing, immediately available in any location) and money could be spend otherwise e.g. to support the growing number of surgeries required for 3D printed organ transplants.

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**Manufacturer's buildings and machineries:** a lot of huge manufacturing industries like Boeing, Airbus, BMW, and Ford, which are already using partly 3D printing, will require a lot of less space to produce cars or aircrafts when they would use 3D printing options in full. A lot of the current manufacturing machines will become obsolete and can be scrapped. I wonder what the use of all these buildings could be and what it will do with the real estate prices in the area of these manufactures. I fear for the future of manufacturers of the traditional machines these huge manufacturers are using for their current manufacturing process.

**Photo camera industry:** Digital cameras switching to 3D pictures and scanning so it will impact Nikon, Canon, Sony, and Olympus, Pentax. When they adapt quickly they can be winners.

Above are just a few examples. For the readers who are interest what the impact is in most industry sectors please find below the complete list I made for your review:

### Changes in industries (C.P. for global population developments)

For full specification SIC code list visit: <http://www.sec.gov/info/edgar/siccodes.htm>

3DP = 3D printing/printer/printed

=	Almost no changes expected
+ or -	Some changes expected (for the industry positive or negative )
+ or -	Many changes expected (for the industry positive or negative)

**Division:** Major Group:

#### A: Agriculture, Forestry, And Fishing

02: Agriculture production livestock and animal specialties	=	For some people printing meat will be used to reduce their carbon foot print
08: Forestry	-	More use of recycling wood/paper for individuals for printing wood and therefore less need for cutting trees

#### B: Mining

10: Metal Mining	+	3DP close to the location of the mine. Print of metal objects and direct shipment of product to the end user. Price of commodities will go down
13: Oil And Gas Extraction	-	Less oil is required, as transport of goods will reduce as well as the overall plastic consumption

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### C: Construction

15: Building Construction General Contractors And Operative Builders

-

Faster and more complex building is possible by using 3DP on site. As the needs of manufacturers in certain industries will reduce, also the need of new industrial buildings will be less. Old buildings (e.g. warehouses) will become available due to reduced demand which will put price pressure on industrial land and buildings. Less retail shops will be required; houses can be built much cheaper and with more personal creative design touches.

16: Heavy Construction Other Than Building Construction Contractors

=

Introduction of 3DP will speed up the building process as printing complex structures take less time and cost less than manufacturing it in the current way

### D: Manufacturing

20: Food And Kindred Products

-

For some people, printing meat pizzas / burritos etc. will be used as an alternative to reduce their carbon footprint. Printing your own designed candy in sugar or chocolate

22: Textile Mill Products

-

3DP will be used on a large scale in the textile industry replacing existing manufacturing process for clothing

23: Apparel And Other Finished Products Made From Fabrics And Similar Materials

-

3DP will be used on a large scale in the apparel industry replacing existing manufacturing processes

24: Lumber And Wood Products, Except Furniture

-

More recycling wood/paper for individuals for printing wood, printing cheap houses for homeless people

25: Furniture And Fixtures

-

Individuals will print their own wooden furniture in specialized shops instead of buying it and assembling it at home

26: Paper And Allied Products

-

More recycling wood/paper for individuals for printing wood. Less packaging will be required so less material required

28: Chemicals And Allied Products

+

Chemicals/plastics for 3DP will be shipped via distributors directly to the end users. Although overall less chemicals will be required, selling to an increased pool of consumers directly can be more profitable

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29: Petroleum Refining And Related Industries	-	Less oil is required as the transport of goods will reduce as well as the overall plastic consumption
30: Rubber And Miscellaneous Plastics Products	-	Rubber products as well as plastic footwear can be 3DP. There will be a shift from the distributors / manufacturers to end users
32: Stone, Clay, Glass, And Concrete Products	-	Glass/clay/ceramic products can be 3DP as well. There will be a shift from the distributors / manufacturers to end users
33: Primary Metal Industries	-	Metal products can be 3DP. There will be a shift from the distributors / manufacturers to end users
34: Fabricated Metal Products, Except Machinery And Transportation Equipment	-	Architectural and Ornamental metal work will be all printed. Bolt, nuts, screws, nails, tools etc. will be printed when needed by the consumer (no need to go to the stores and spend petrol and time or keep spare parts at home)
35: Industrial And Commercial Machinery And Computer Equipment	-	Some products will be printed by the end user (o.a. spare parts for cars, cartridges for printers etc.), less equipment in harbors is required like cranes, metal cutting/working, woodworking, textile machines will be replaced by printers. Less need for packaging machines
36: Electronic And Other Electrical Equipment And Components, Except Computer Equipment	-	Liquid metal which turns solid at room temperatures is also possible with a 3DP. This means that consumers can print partly electrical equipment or components themselves. For carbon and graphite materials there will be printing solutions and perhaps you can print your own solar cells (make your own electricity plant in the garden) or rechargeable batteries
37: Transportation Equipment	-	Equipment (trucks) will be required much less when we start to print on location. Air transport: will reduce so less planes required. Shipping: more shipment of raw materials instead of finished products so less container shipments
38: Measuring, Analyzing, Controlling Instruments; Photographic, Medical And Optical Goods; Watches, Clocks	-	Print your own cases for (Swatch, Samsung or Apple) watches or mobile phones, camera's (including lenses) , glasses, print medical equipment in the hospitals, the dentist will print a 3D scanned tooth to be replaced, Orthopedic/prosthetic items will be scanned and printed

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39: Miscellaneous Manufacturing Industries



As everybody can print almost everything including silver jewelry , toys, sport articles, pens, buttons when you lose one, esp. the specialized manufacturers who will have a hard time as printing will become much cheaper

### E: Transportation, Communications, Electric, Gas, And Sanitary Services

40: Railroad Transportation



Less transport required via railroad of metals and finished products

42: Motor Freight Transportation And Warehousing



Less warehouses and transport required. Courier services should specialize in 3D products printed in their location like UPS and others now are already doing but this could be temporary

43: United States Postal Service



Increase of parcel shipments directly to consumers of raw materials and 3D objects printed at the premises of the postal service stations but this could be temporary

45: Transportation By Air



Less transport required for urgent shipments as printing is faster and cheaper

47: Transportation Services



Less transport required, packaging and crating will be reduced

48: Communications



Other ways of commercial communications (directly to consumers instead of via manufacturers and distributors)

### F: Wholesale Trade

50: Wholesale Trade-durable Goods



Consumers buy directly from the owner and print it themselves for those durable goods which can be printed like furniture, medical tools. Used motor parts will be sold less and printed instead bought

51: Wholesale Trade-non-durable Goods



Consumers can buy directly from the product owner and print it themselves

### G: Retail Trade

52: Building Materials, Hardware, Garden Supply, And Mobile Home



(Cheap) houses can be printed including (spaces required for) utilities. Print your own nails, screws etc. when needed. Replace your door locks with

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Dealers		electronic locks to prevent theft as a key can be easily duplicated.
53: General Merchandise Stores	-	Less products will be sold via department stores
54: Food Stores	-	For some people printing food will be used to reduce their carbon footprint
55: Automotive Dealers And Gasoline Service Stations	-	Huge negative changes for the gasoline stations when we can print our own rechargeable batteries to be used in cars. For garages printing of spare parts will become possible, likewise by the car owners.
56: Apparel And Accessory Stores	-	3DP will be used on a large scale in the apparel industry replacing existing manufacturing process as well as the stores. Also clothes, shoes and accessories will be printed
57: Home Furniture, Furnishings, And Equipment Stores	-	Consumers can print parts for furniture/household appliances and assemble themselves
58: Eating And Drinking Places	+	People will have more free time and will have more to spend as the costs for printed products could become around 80% cheaper than to buy them in stores
59: Miscellaneous Retail	-	Retail in general will be impacted like jewelry stores, hobby and toy stores, gift shops, optical goods stores, stationary stores, used merchandise stores

### H: Finance, Insurance, And Real Estate

63: Insurance Carriers	-	Less insurance for transport required, less to be insured in manufacturing/products risk as the product risk mostly moves to the consumer
64: Insurance Agents, Brokers, And Service	-	Less insurance for transport required, less to be insured in manufacturing/products risk as the product risk mostly moves to the consumer
65: Real Estate	-	For real estate related to manufacturing, warehousing and distribution prices will go down as availability due to empty buildings will become much higher

### I: Services

70: Hotels, Rooming Houses,	-	Business travel related to the current manufacturing countries will become much less so this could impact the business hotels in these areas. On the
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Camps, And Other Lodging Places		other hand people will get more free time and spend more time on traveling (but they will probably avoid expensive business hotels)
72: Personal Services	=	Shoe repair shops will become less needed when people start to print shoes.
73: Business Services	-	Advertising agencies have to adapt and focus on the consumer directly instead of the retail sector
75: Automotive Repair, Services, And Parking	-	Spare parts can be printed by everyone else besides the dealer, better opportunities for non-brand auto repair shops
76: Miscellaneous Repair Services	-	Spare parts can be printed by everyone else besides the original dealer, better opportunities for non-brand repair shops
80: Health Services	+	Depending on the services provided the world in health will change and adapting will be required. Organs will be printed instead of organs of donors
81: Legal Services	+	More busy fighting piracy, protecting patents and copyrights
82: Educational Services	+	Adjustment is required in the education program focusing more on using 3DP techniques resulting in more specialized people developing and using 3DP hard and software
84: Museums, Art Galleries, And Botanical And Zoological Gardens	+	Reprint of lost or stolen art objects will become possible depending on the type of art. People can print their own copies of original statues when 3D scanned. In China they will build museums with copied art
86: Membership Organizations	+	Credit management organizations will be booming due to the increased risk in certain industry sectors
87: Engineering, Accounting, Research, Management, And Related Services	+	The engineering /architecting world will change dramatically and has to adapt to 3DP. The ones who can will be the hero's. Research will also change and can print just discover objects themselves for further research. Results can be delivered faster
88: Private Households	+	When a 3DP will become available in the household many things will change when the 3D images of objects will become available for printing. Households could save money by using 3DP

### J: Public Administration

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91: Executive, Legislative, And General Government, Except Finance	-	Copyrights need to be protected, printing guns needs to be controlled, new legislation is required also for printing medicines, printing coins should be prevented/controlled or coins should be abandoned as means of payment
92: Justice, Public Order, And Safety	-	New means of detecting guns /knives should be developed, drugs, fake coins used in all kind of vending/gambling machines, high security keys or printed dangerous goods
93: Public Finance, Taxation, And Monetary Policy	-	GST/VAT will reduce substantially, import duties where applicable for 3DP products could change or even disappear. Government need to prepare themselves for tax alternatives
95: Administration Of Environmental Quality And Housing Programs	+	Solid waste management will change due to less waste as well as housing programs. Houses for poor people can be printed and moved
97: National Security And International Affairs	-	New means of detecting guns /knives should be developed, drugs, fake coins, high security keys or printed dangerous goods



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