Business models for 3D printing

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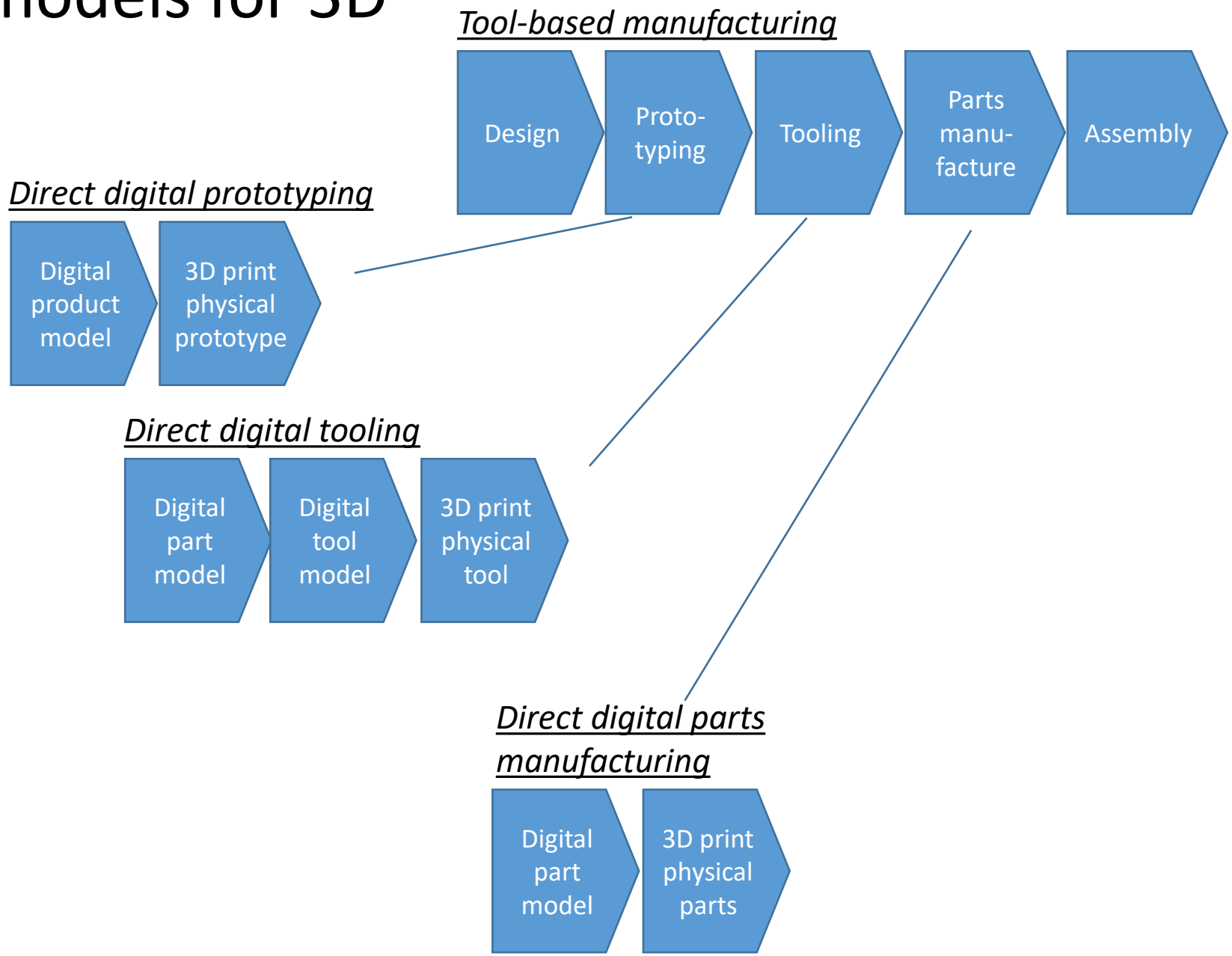
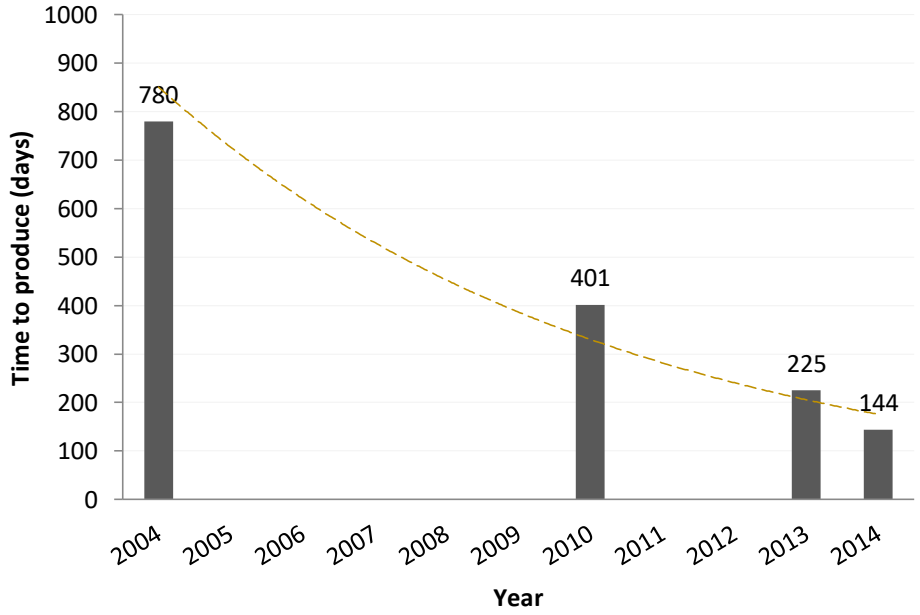
Manufacturing technology characteristics

3D printing	Tool-based manufacturing
Product model based	Tool based
Generic resource	Specific asset for product type
Direct	Indirect
Digital	Analog

Current business models for 3D printing



Constraint: Speed of manufacturing

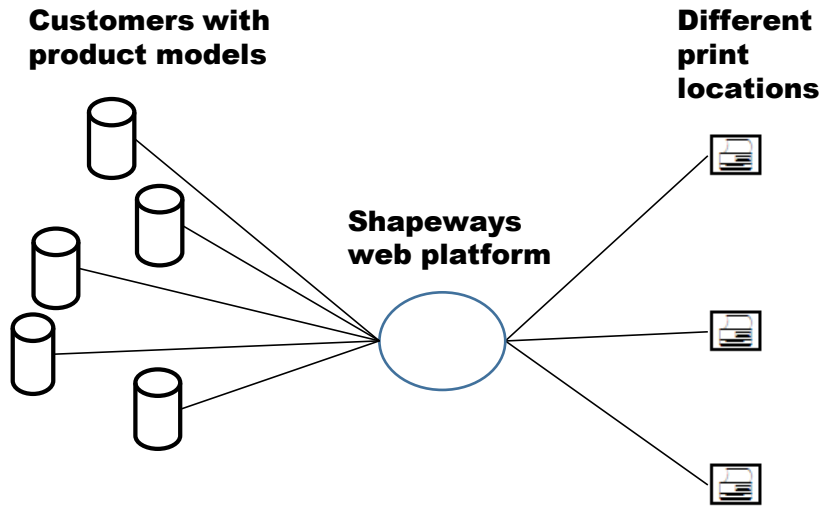


Estimated days to print the steel parts of a passenger car on a single SLM 3D printer

Note: Data is based on manufacturer performance data for the best available 3D printers in 2004, 2010, 2013 and 2014, respectively, for an assumed volume of steel parts to be printed of 135,000 cm^3.

Shapeways: build-to-model of individual items

- Customers place orders online:
  - select or upload 3D design models website for manufacture
  - order may consist of a number of items of the same or different materials
  - uploaded new designs go through a printability test
- Build-to-model manufacturing
  - two in-house 3DP factories (Europe, US)
  - partial outsourcing
    - Most builds in a Shapeways' factory
    - Some builds distributed to a subcontractor by sharing of model online
- All order items consolidated to Shapeways facility for quality control and shipping to customer



Bi-directional and partial outsourcing

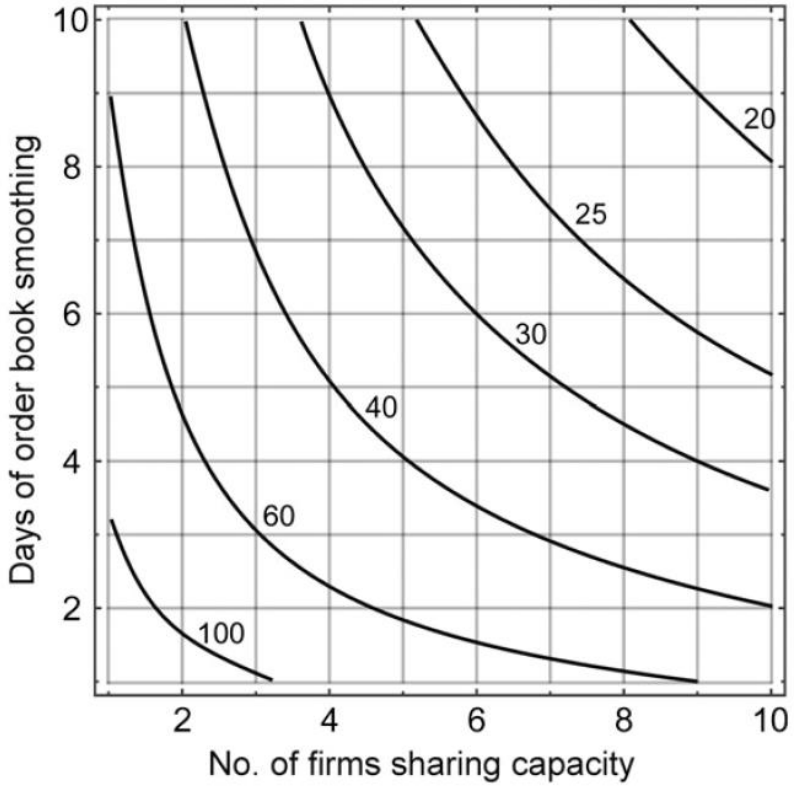


FIGURE 3 The cost of demand variability: The trade-off between the number of firms in the outsourcing network and the smoothing days in the order book

Hedenstierna, C. P. T., Disney, S. M., Eyers, D. R., Holmström, J., Syntetos, A. A., & Wang, X. (2019). Economies of collaboration in build-to-model operations. *Journal of Operations Management*.

Bi-directional and partial outsourcing

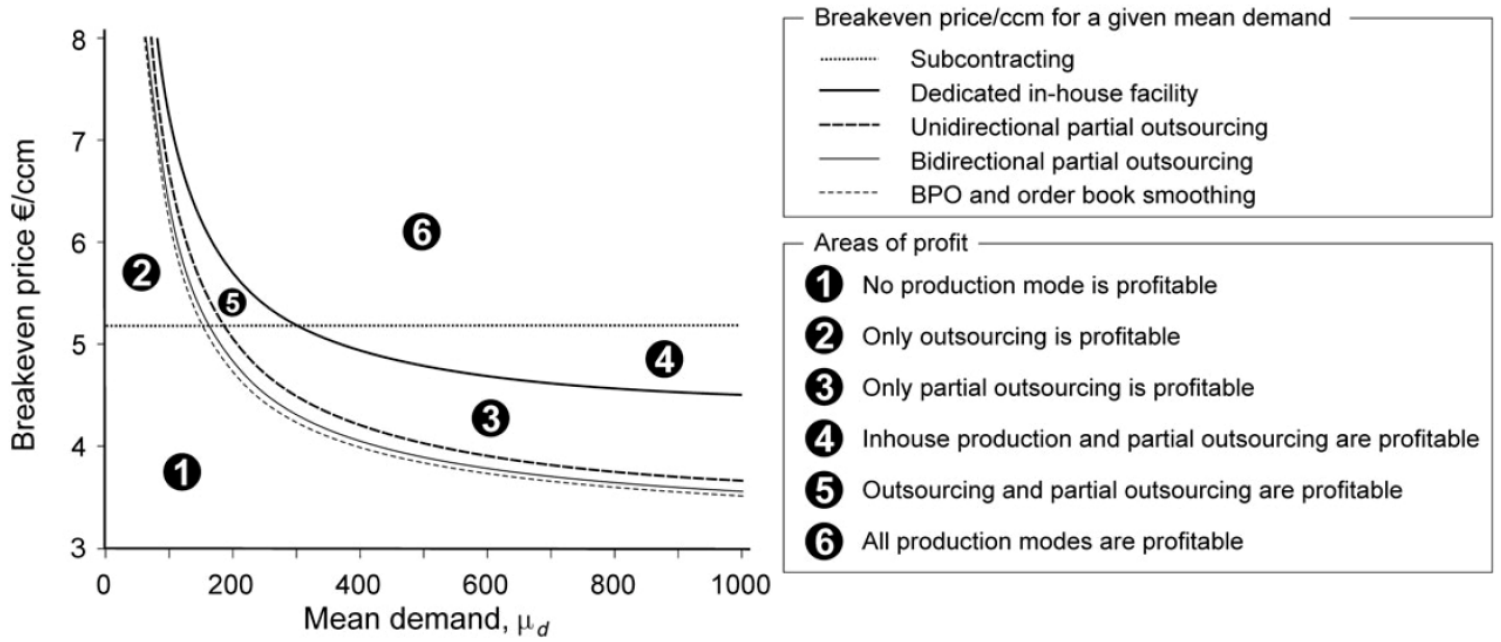


FIGURE 4 Break-even price/ccm for a given mean demand per day

What if build-to-model was widely adopted?

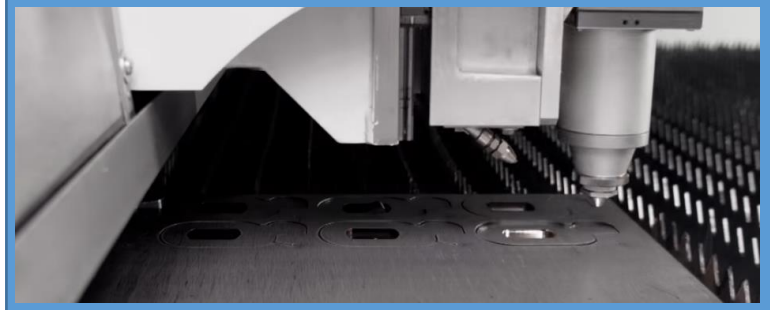
- Effect on current OM?
- Effect on SCM?
- Effect on products?

Let us examine an example: Innovative heavy equipment OEM

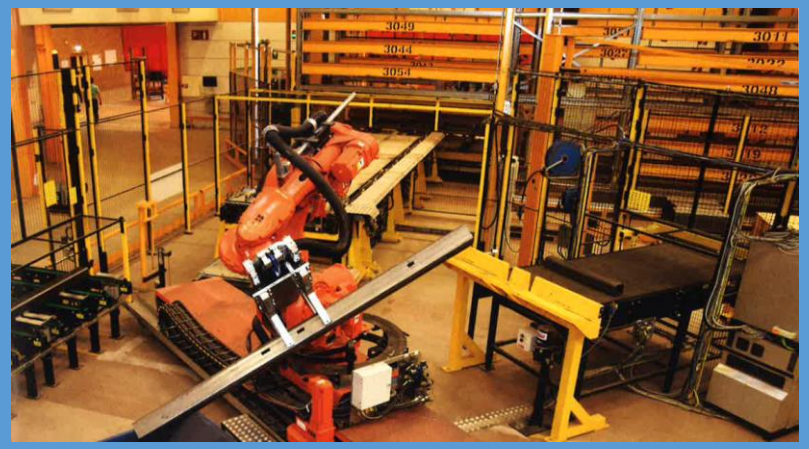
Build-to-model process using laser cutters

Rawmaterial

Laser cutting to model
https://www.youtube.com/watch?v=9TjBTG-ShCQ



All handling by robots, kitting over 1-2 days into an automated warehouse



Parts positioned in kit as specified in the digital design model

Assembly to order

Outcome of Build-to-model laser cutting

2D manufacturing, not 3D printing. Indicative never the less!

Direct kitting

- Produce parts to a kit directly
- Parts individually placed to pre-planned locations in a ”canoe” according to specifications in product model
- No use of identification schemes: all handling preplanned and specified, robots used for all handling in part production and kitting

1500 parts taken inhouse and make-to-model mode

Outcome:

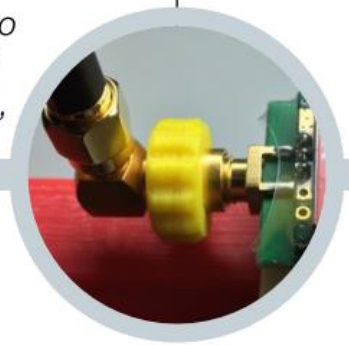
- No SKUs => No warehouse => No suppliers
- No product ramp-ups/ ramp downs, customization, prototyping in production

Remixing for Improvement: Basjohan's finger tightening ring for hex nuts

Basjohan: *"Originally I am technical officer of the Swedish navy but then I switched to the defense industry defense electronics and now I am currently studying to became a software developer on computer science."*

"The basic model that I used for inspiration was like this one but ***it was slightly too big*** *so it felt lost … "*

"I decided to remix it more modular ***for more people to use****."*



"Usually I come to the decision [to remix] when I find a product I think it's a good idea or a very good idea, but it's not quite good enough for my purpose so ***when it is a basic good idea and good concept then I want to make it a little bit better, that is when I decide to remix it.****"*

"… ***I wanted to make it more adjustable*** *I made it customizable so that you can select yourself, what size of nut you want to use."*

Basjohan has been following the development of desktop 3D printers for years. When a colleague got a reasonably priced 3D printer, he bought the same one. This way, they were able to exchange information about the construction and operation of the printer on a regular basis. Often Basjohan finds Things on the platform which can be improved. One of Basjohan's remixes is a small tool which can be used to tighten hexagonal nuts by hand. Such nuts are used, for example, on antenna cables and are often hard to reach with a wrench. Basjohan remixed the original Thing and re-published it as a customizer. From his point of view, the new Thing is an improvement for the community, since it can now be adapted in various dimensions: "I wanted to make it more adjustable. I made a customizer so that you can select yourself what size of nut you want to use, or how big you want the wheel […]".

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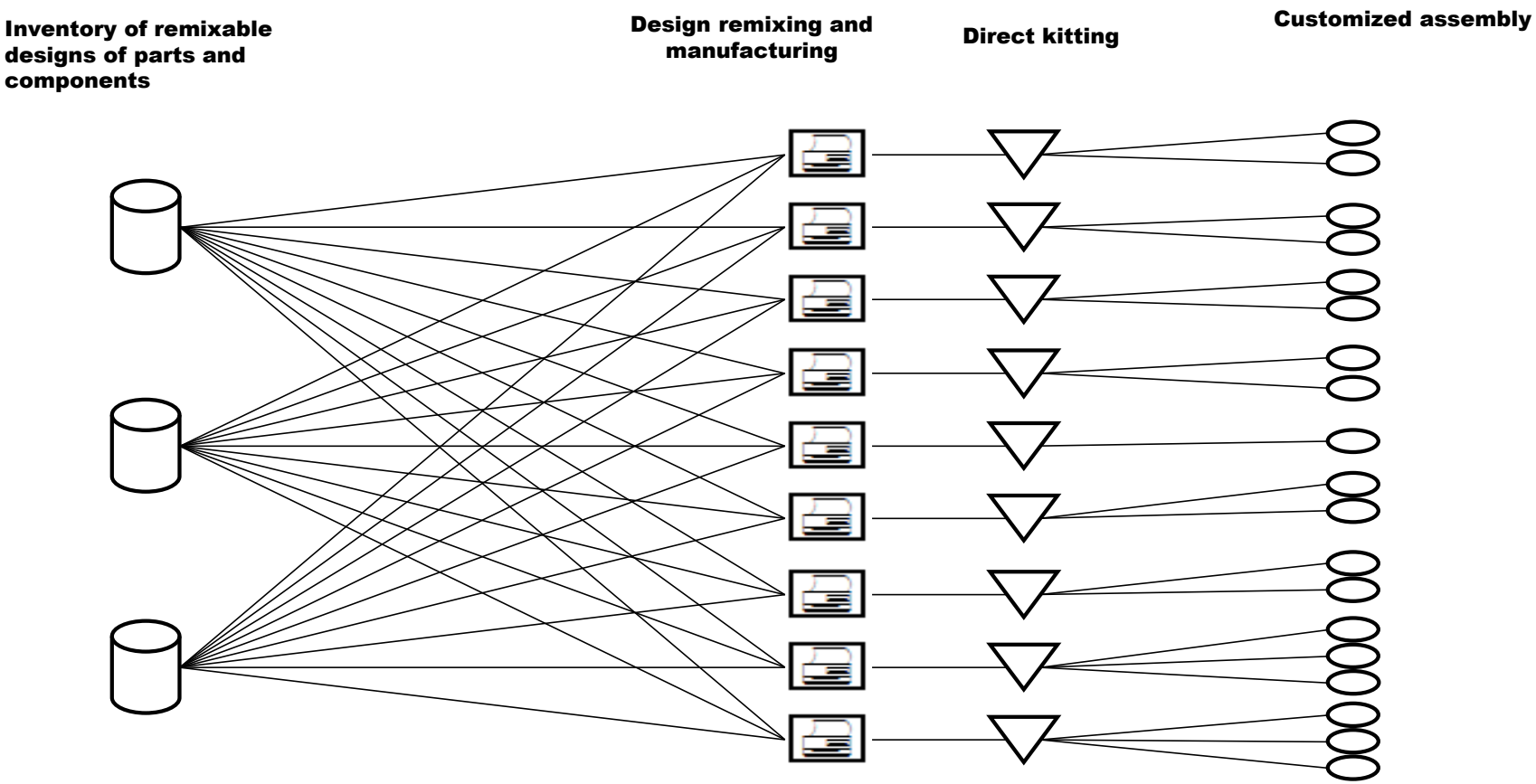
Sources: *Yellow nut: Thing1141381; Black nut: Thing1145242*

Friesike, S., Flath, C. M., Wirth, M., & Thiesse, F. (2018). Creativity and productivity in product design for additive manufacturing: Mechanisms and platform outcomes of remixing. *Journal of Operations Management*.

Potential business ecosystem: Remixing designs for customized assemblies



Extended Build-to-model