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Circular Economy in HealthCare Challenges and Issues

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Some major countries like India investing in biopharmaceutical industry have designed new business models of circular economics called the "Uber for HealthCare" for instance by Basu et al., for medical equipment in India (Euro, Healthcare Stream, & Dublin 2018). This raises major challenges for global supply of medicine and Value Chains in life science. This contribution will provide a review of recent experiences and an analysis of how it impacts current global value chains. Current economic model development strengthening the demand side of the system and applications of choice modeling to capture heterogeneity of demand at individual level face with new circular strategies implemented by health care organizations and economic suppliers. The all-value system is challenged by such models including the critical decision points at prognostic, diagnostic, and treatment stages; platforms such as the Her2adaptive technology platform with cost sensitivity indexes proposed by Huttin and Liebman (Technology & HealthCare, 2011) face also potential adaptation to integrate new priorities: for instance, in circular economy with integration of circular touch points. Research results like Van Boerdonk et al. (2021), demonstrate that reaching cleaner production with higher environmental values may become "paradoxical with lower or unimportant customer value". Government and payers may need to create new policies for waste management and for sustaining reasonable and fair value for money in the health system. Moreover, the economics of sharing economy may need to find appropriate forms of centralization or decentralization in the organizations of health systems and decision-making processes. Circular models in health care in sharing economy may benefit single pathway models, often too expensive for affordable welfare contracts. This paper will continue the previous research agenda and papers on global value chains with the use of TiVa OECD database (joined in the WB-WTO project) and a quality paper on the biotech development chain and Covid-19 (Huttin, 2019; 2021).

Keywords: circular models, shared economy, health care, global value chains, biotech-life science

Introduction

Circular economics is a major source of potential strategic move to invest in critical sectors for national economies in the South hemisphere and emerging economies; India especially has been at the front line in the medical markets to promote some business models for medical equipment, using re-cycled and re-used equipment.

On the contrary, in the Western world and especially in the USA, this type of economics is not very developed but supply chain management for biopharmaceuticals has used for a long time very secured systems

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such as RFID, well before Blockchain in other industries. During the Covid-19 Pandemic, serious warnings tended to alert on potential disruption of the supply of critical drugs and vaccines or their ingredients (APIs); but so far, it did not lead to a breakdown of global supply.

However, after the pandemic, shortages of important products have increased and governments re-invest in industrialization of medicines (e.g., paracetamol in France) to relocate manufacturing in Western countries and secure the supply for domestic demand.

The South hemisphere often claims more fairness in the distribution of such public goods and criticized overuses. Therefore, demand is often questioned, and even in the West many stakeholders (especially NGOs) aim to re-engineer health systems to focus more on patient needs and insist to address wicked governance issues.

This paper aims to discuss several issues and challenges, related to the expansion of circular business models in health system and life science sector, using a few examples presented at Ifors/Euro meetings (case study on a pharmaceutical company) or from previous research on cost models for biobanks and use of specimens (case study on a biobank management). The case study materials may address some limitations of existing economic frameworks for a better understanding of circular economy.

Major Business Models Used in Circular Economy: Some Applications for Medical Markets

The concept of circularity is opposed to linear business models; it is at its infancy in the life science industry and even in the health care sector, in comparison with other industries such as plastics or energy where already all global value chain analysis called circular value chains is analyzed with different types of business models. Table 1 provides an overview of main types of business models. To examine issues of circular economies in the life science industry, it will be useful to analyze separately pharmaceuticals markets and medical technologies, especially medical devices, where consortia are very active and where a roadmap towards circular economy is already well implemented.

Table 1

Circularity of Different Types of Sustainable Supply Chains Operations

Types of Sustainable Supply Chains Operations	References
Reversed logistics	Govindan, Soleiman, and Kannan, 2015
Remanufacturing	Ostlin, Sundin, and Bjorkman, 2008
Re-use	Atasu, Guide, and Van Wassenhove, 2008
Re-cycling	Papachristos & Adamides, 2014

Source: Genovese, Acquaye, Figueroa, and Koh (2017); Batista et al. (2023).

Circular concepts used for supply chain operations in life sciences and value chains in health systems may impact study designs of pricing studies. In this paper, we analyzed the reversed logistics model used in circular supply management, since this concept of "reversed engineering" is also examined in a previous paper discussing a mechanism algorithmic design to correct market failures in medical markets (Huttin, 2022).

(1) Reversed logistics applies the "reversed" concept to a type of supply chain; this concept is also used in engineering economics (reversed engineering combining game theory and computer science for algorithmic mechanism design); it was also used for previous study designs for cost sensitivity simulators in healthcare financing (see also Appendix 1).

The impact on pricing of medical markets includes the impact on relative prices of products and services on primary markets (e.g., with re-purposed products), secondary markets with re-used or recycled products and interactions of supply and demand sides, with potential changes in games' rules coming from regulators or big Tech, as well as conventional stakeholders in life science and health care providers.

For pricing methodologies, controversies still prevail between valuation methods. To incorporate behavioral modeling, the fusion of stated and revealed preference data can be very useful (Mark and Swait, 2004; McFadden, 2001). Prof Huttin' s application of conjoint and reversed conjoint models allows generating micro data in prospective pricing studies or for calibration of macro models of supply and demand. Conjoint designs for product economics have been used for a long time, for pricing studies of pharmaceutical and medical technologies. The "reversed conjoint" original applications for drug pricing studies (Huttin, 2017; 2011) to understand the influence of implicit information on cost of care to patients and physicians' decisions, also generate new metrics for preferences measurements at individual level. More recently, other discrete choice experiments (Huttin & Hausman, 2021) were also used to incorporate individual level data for forecasting the demand system for care (price parameters with or without random generators). However, such valuation methodologies on medical markets are challenged by the new circular economy. The sources of creation of value in circular business models are the following (Ellen MacArthur Foundation, 2015):

- Increasing the inner circle
- Cycling longer
- Cascading
- Pure circles

In life science, such circular business models are rare; linear supply chains remain a dominant model for drug supply (2).

(2) Interested readers can see circularity applications in the bioeconomy in OECD report on bioeconomy.

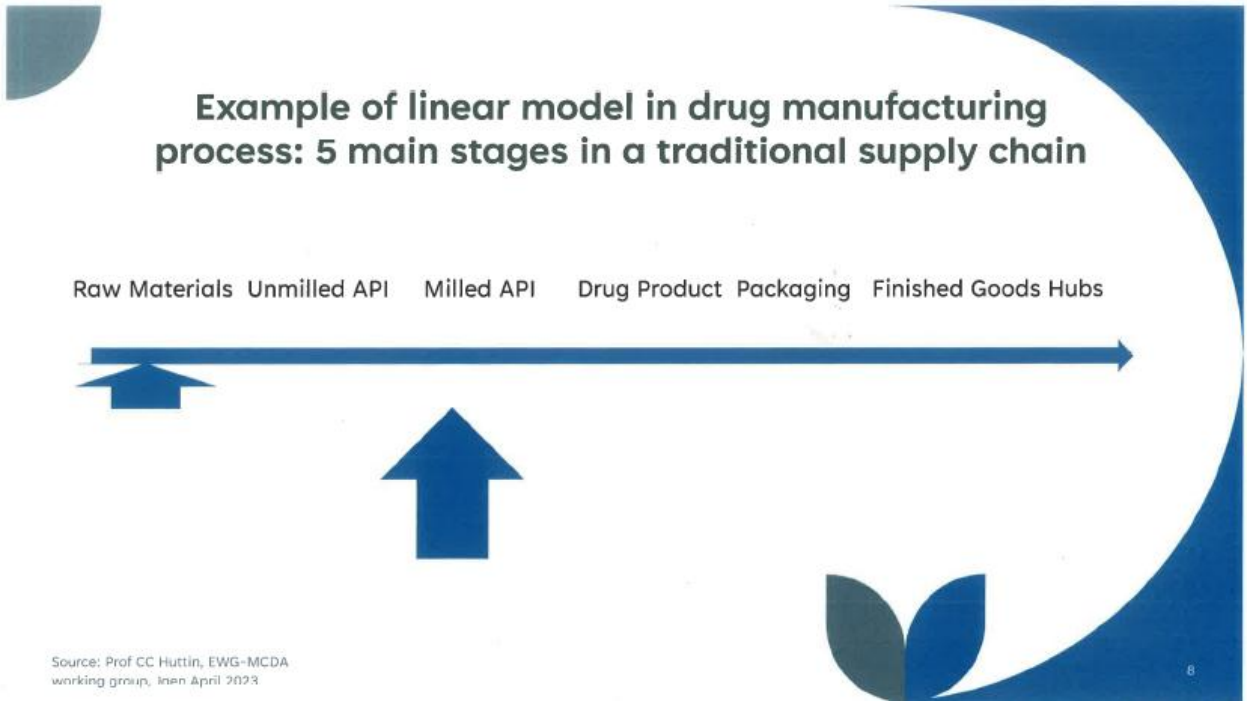
However, the boosted demand for vaccines during the Covid-19 Pandemic not only changed the economics between drugs and vaccines in term of profitability and return on investment (especially R&D investments), but it also led to major strategic changes in supply management strategies, especially from linear models in "silos" towards data-driven supply chain strategies, with a main objective to reduce Cost of Goods Sold (COGS) (cost reduction strategy).

This data-driven strategy is well described in Table 2. It is a case study of a big multinational pharmaceutical company with major operations in US and India, presented at EURO 2022 (Prateek et al. EURO, Helsinki 2022); this supply chain strategic change not only illustrates the effects of increased competition especially from China or India, but also a shift of optimization methods, by using especially Machine learning tools to reduce the Costs of Good Sold (COGS) and adjust more quickly to global demand. Machine learning tools allow such data-driven strategies: operational researchers invested in advanced methods to advise on such new optimization methods (e.g., root relaxation, speeding up using nodes, cutting Golmory planes, etc..). It gives more priority to the cost equation COGS = F (Demand), with introduction of more parameters to predict the demand (capturing more patients' needs of different regions of the world). A reduction of COGS usually implies reduction of stocks or stockpiling in the case of vaccines, it may impact infrastructures and the design of loop systems for introduction of circular value chains (3).

(3) In drug supply chains, steps of un-milled or milled ingredients, packaging, or final product (steps described in Table 2), may be impacted by circular principles such as cascading; they may apply to all upstream

Table 2

Example of Linear Model in Drug Manufacturing Process: Five Main Stages in a Traditional Supply Chain



or downstream operations or steps to transformative supply chains into circular operations.

This shift of strategy transforms an industry, traditionally driven by technologies or "induced supply. This may also change the equilibrium adjustments between supply and demand on global markets and critical parameters on global pricing (heterogeneity of demand is also more researched on the demand side (e.g., Huttin & Hausman, 2021) or in the retail ecosystem (e.g., Aburto & Sanchez, 2022).

The objective to use recycle medical equipment or to re-purpose drugs leads to price reduction on the secondary market, to reach populations who cannot afford care. However, the creation of secondary markets leads to a form of price discrimination, and on a global pricing policy level for pharmaceuticals; for instance, it can take an additional form of differential pricing. As the demand for such essential medicines and medical equipment is so high in developing countries, it may not distort global competition or only at the margin. Estimation of secondary market sizes for instance in the case study presented on Indian markets, for recycled equipment did not exceed 10% of the domestic demand. Moreover, WTO mechanisms usually provide rules of conducts in case of trade diversion from such domestic submarket to supply other demands with a substantial margin for import export traders. If the dynamics of circular economy expands, effects (known in the Internal European market as parallel imports) on the price differentials between high- and low-priced countries may happen, in some important market segments of medical markets and therefore on global drug supply chains.

The data-driven strategy described previously is a good illustration of the intensification of competition on global markets for medicines and health services. It may contribute to creating sustainable supply chains; However, several barriers limit the implementation of circularity economy in such dangerous products and services. One main barrier is the problem of quality uncertainty. It may introduce risks like the ones analyzed in the well-known Akerlof's paper a "market for lemons" or discussed by Light and Lexchin for pharmaceuticals.

Akerlof suggested the following types of counteracting institutions to avoid it: guarantees and certification procedures, brands or generic brands, licensing practices for professionals; these have been already largely implemented in pharmaceutical markets. Circularity requires additional certification procedures, more licensing or professionalization of new categories of professionals either involved in IT transformation (e.g., portal managers) or in the management of biological resources. Other barriers for implementation of circular business models in highly R&D intensive sector like pharmaceutical supply chains, may be the mismatch between R&D and manufacturing steps. Main decision-makers are the R&D directors to sustain research pipelines, but decisions to opt out and disinvest in research are different from product portfolios management for market access, especially with the new economics of drugs and vaccines (Prashant, et al., 2014).

Contrary to the pharmaceutical market where linear models remain dominant partly due to barriers described above, the market for medical technologies is driven by faster innovation and already promotes more circular business models. Some countries also implement a roadmap agenda for circular economy in medical devices in their health policy (e.g., US roadmap, cited in Health Affairs, 2020, with statistics on impact of health systems on global green gas emission or DALYs: "4.6% of green emission and 614,000 disability adjusted life years lost annually"). One main reason is that devices help to quickly transform the health sector. Principles of circular economy are well developed in the recycling area of devices. However, the scope of recycling is very dependent on the level of complexity of the devices: low complexity (e.g., intravenous catheters, tubing, syringes, needles) is easy to recycle but quality uncertainty is a challenge, so it may be cheaper and safer for healthcare organizations to avoid recycling procedures and purchase new devices. The more complex are the devices (e.g., imaging) the less obvious it is to implement circularity. Moreover, the increased number of operations for re-use may increase the value but also faces the trade-off with safety. Therefore, circular operations need to be controlled by powerful regulatory agencies. Table 3 illustrates the steps of an approval procedure for re-processing a medical device in the USA.

Table 3

Reprocessing of Medical Devices: FDA Regulation.*

Three steps in sequence of reprocessing of medical devices
(1) "Point-of-Use Processing: Reprocessing begins with processing at the point of use 5 (i.e., close proximity to the point of use of the device), to facilitate subsequent cleaning steps (FDA definition: "point-of-use processing includes prompt, initial cleaning steps and/or measures to prevent drying of soil and contaminants in and on the device)".
(2) "Thorough Cleaning: The device should be thoroughly cleaned after the point-of use processing. Generally, thorough cleaning is done in a dedicated cleaning area. Devices that will likely not become contaminated with pathogens during use (e.g., room vital signs monitor) may not require disinfection, and therefore may be suitable for use after cleaning only".
(3) "Disinfection or Sterilization: Depending on the intended use of the device, the device should be disinfected or sterilized, and routed back into use".

* Definitions of the FDA: "Reprocessing is defined as validated processes used to render a medical device, which has been previously used or contaminated, fit for a subsequent single use. These processes are designed to remove soil and contaminants by cleaning and to inactivate microorganisms by disinfection or sterilization". "Reprocessing of reusable devices encompasses appropriate steps that begin in close proximity to the point of use of the device and, in general, involves the above three steps in sequence".

Circular Economy in Health Systems: A Case Study on a Hospital Biobank

The previous section provided some case studies from the drug supply chain or medical technologies. The principles for circular economy are now discussed in health systems and especially for major health care organizations such as hospitals.

Usually, the main objectives in health policies are to provide fair and affordable care to populations and

patients. Traditionally, fairness or equity competes with efficacy or comparative effectiveness of medical technologies. If social values are usually important and compete with economic value systems, the circular economy also brings additional dimension in the value framework assessment: environmental values especially through the Sustainable Development Goals (SDGs) under the WHO framework. Hospitals may have to follow national or regional green deals (e.g., in Europe within the Social Green Deal). In such cases, it leads to an additional performance dimension and requirements to health care organizations, in addition to their economic and social performances. The requirements to fit the eco-system will also be used as an additional benchmark with their competitors. In the move towards advanced genomics medicine and personalization of clinical pathways (e.g., single pathway in cancer care), biological resource centers and their organizations inside the eco-system become more critical too and represent key players to optimize value chains and circular principles.

In this paper, a case study is used as an example for exploring how an economic analysis may integrate such new concepts in hospitals or other healthcare organizations. It comes from a previous research stream on cost models in biobanking (Huttin & Stubbs, 2016) and various interviews inside the organization. During visits to the Bio-IT department, at Erasmus Medical hospital, Prof. Huttin collaborated with Prof. A. Stubbs on software developments. Various options for cost reduction and optimization in the use of biospecimens both for treatments and research were discussed. Re-purposing for different uses of biospecimens, especially by hospitals' biobank managers, inside the organization or the whole organization of care inside a national health system, was also identified as a key source of creation of added value (Huttin & Stubbs, 2016). It complements the previous study by Huttin and Liebman on Adaptive technology platforms.

In Healthcare organizations, platform designers with the help of computational modelers, identify flows of information for different uses inside and outside hospitals (e.g., federations of hospitals that may opt for centralization of some of the tasks to save on storage costs, facilitate logistics and re-purposing of biospecimens). Software development is critical for optimization; so, bioinformatics departments contribute to cost reduction of various tasks involved in biobanks or warehouses.

The implementation of circular economy in health systems implies organizational change: for instance, the creation of a portal provides services to facilitate the biobank management. The portal for tissues biobanks, called the DNTB-BBMRI portal for Dutch hospitals allows online requests for samples, as secondary use of residual tissue Formalin Fixed Paraffin Embedded (FFPE) blocks and associated data from pathology laboratories (Huttin & Stubbs, 2016). The portal manager facilitates the least expensive way to increase uses and users of tissues and identifies new types of tasks and needs. FFPE materials are re-used after a few years and stored for patient care.

The value chain approach is useful for the development of a comprehensive economic model. It helps to list all the steps that may be required to increase number and types of uses as well as number of users. In the case study of the FFPEs portal, we could identify main cost drivers: costs of requests from various users: doctors, pathologists, researchers, service providers, tool companies, or laboratories (inside the hospital where biospecimens are needed for patient care, or outside). In addition, since teaching hospitals combine patient treatment and research activities, additional steps include different scientific committees, additional checks to ensure quality of the research or additional checks to ensure that enough biospecimens are for patient care. The portal case illustrates how additional value may be created for international research and treatment uses of departments inside the hospital and external users, under necessary ethical guidelines. However, at this stage, no

economic evaluation of the portal has been performed since it is difficult to provide calculations on potential savings in such organizational forms. Data access is usually very restricted to internal use of such organizations and only financial or resource managers could contribute to an economic evaluation and cost simulations; in this case of FFPE tissues, costs such as freezing of specimens are very unexpensive, but for other tissues, this type of cost may vary a lot to secure a cold chain.

Conclusions

Business models for circular economy in health care or life sciences are used in developing countries to speed up access to healthcare. However, big countries with high R&D investments also engage in activities such as re-purposing, to generate additional values especially in the management of biobanks for research and treatments. The series of cases mentioned in this paper demonstrates that forms of circular economy are implemented in both hemispheres. Research on impact of circular business models in health care and life science on global value chains is limited. It may help sustainable global chains, but it also raises major challenges for global supply of medicines and the push on the medical device sector will speed up the process of change. The examples on biobank management show a path towards principles of circular economics. However, main drivers, especially in western economies, are usually to increase the value for money, especially with increase of the number of uses and types of users; cleaner production with environmental values may conflict with value for population health and may need additional checkpoints (e.g., "circular touch points" in Van Boerdonk, et al., 2021). If the priority setting for patient care is not jeopardized, it may however require serious additional safeguards (e.g., with patient consent procedures).

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Appendix 1: Uses of Reversed Concepts

Reversed logistics refers to a concept "reversed" also used on the demand side of the market, for instance "reversed conjoint models", designed for cost sensitivity simulators (Huttin et al., 2017). In medical markets, contingent valuation methodologies (especially initiated by market research companies) for pricing of medical products and services have been very used since the early 60's. However, such valuation methods are also increasingly implemented on the demand side with innovative applications. The original study of "a reversed conjoint model on physicians" (Huttin et al., ENDEP USresearch) was designed to incorporate patient economics (financial restraints, in addition to billing information) or office economics. The use of counter-detailing information may incorporate not only competitive information on products, but also different valuations of cost to the patient (or "net prices") or cost to the physician. Such valuation methods generate micro data (e.g., with conjoint surveys from Sawtooth or NGene software's) and may be used for pricing studies in medical markets.