Robotic Process Automation in Beef Supply Chains

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The beef supply chain is large and expanded and has a complex supply chain system which makes it challenging. Technological adoptions such as Robotic Process Automation allow beef supply chains to enhance their operational efficiency and speed up the production line to meet consumer demands. The beef industry has relied heavily on the human workforce in the past; however, RPA adoption allows automating tasks that are repetitive and strenuous in nature to enhance beef quality, safety and security. Successful RPA adoption allows managers, decision-makers and stakeholders to enjoy RPA's full potential and promising benefits which are social, strategic and economical. This enables beef supply chains to produce safer and high-quality beef with less processing time, energy and costs.

beef supply chain | beef supply chain management | robotic process automation | simulation | Simul8

1. Introduction

“Supply chain” is a broad term from the perspective of the business world. It is described as a network of goods and services in accordance with supply and demand [1]. The food business produces products and services to meet the needs of people and their activities. Food supply chain management operates and assures food safety and quality through effective methods of production, distribution, and consumption. Because of its complexity and difficulties in administration, the food supply chain differs from other supply chains. Food safety, food quality, traceability, and freshness of food products all contribute to the complexity, which makes it difficult. Technological breakthroughs such as Robotic Process Automation have ushered in significant improvements and developments in the FSC by automating operations in food processing and packaging, ensuring food freshness and quality for greater customer satisfaction. There are so many manufacturing processes or procedures in the FSC; as such, it demands careful control [2][3][4].

The beef supply chain is large and expanded and has a complex supply chain system which makes it challenging. Technological adoptions such as Robotic Process Automation allow beef supply chains to enhance their operational efficiency and speed up the production line to meet consumer demands. This research aims to critically evaluate and investigates the role and impact of Robotic Process Automation in beef supply chains. It further inspects the associated barriers or risks to the adoption of RPA in the beef industry. The features and

characteristics of the beef supply chain are critically analysed to understand the overall business process for successful RPA adoption within it.

The rationale is to support the beef industry by offering a generic process model which can be used by managers, decision-makers, and stakeholders for the effective adoption of RPA. The process model is generic and can be modified by organisations according to their individual needs and circumstances. Over recent years, a lot of interest has been given to the adoption of Robotic Process Automation in the beef supply chains. However, there is no thorough assessment of the potential barriers to RPA adoption within beef supply chains, which creates a research gap. An in-depth study and scenario analysis are assessed in Simul8 to investigate the potential barriers to allowing the successful adoption of RPA and overcoming the possible risks. The significance of the study is to assess the role and impact of RPA in beef supply chains and identify the potential barriers to the efficient adoption of RPA technology. The study contributes to both practical and theoretical aspects as it examines and identifies the barriers to RPA adoption in the beef supply chain and allows managers to utilise the process model for effective RPA adoption. Enhanced RPA potential allows beef supply chains to achieve strategic, financial, and operational goals and alleviate risks in terms of beef quality, safety, and security. The process model projects the various stages of the beef supply chain and is analysed using scenarios in Simul8 software. The research parameters which are beef capacity, shelf-life, and safety, are the base for developing the scenarios in the process model. Two scenarios are analysed and assessed in the Simul8 software to evaluate RPA accuracy and benefits in the beef supply chain. It also helps in the identification of any risk factors involved in beef production stages, in a virtual environment. The research parameters are further discussed in the results section below.

There are four simulation types used in supply chain management, i.e., discrete event simulation (DES), system dynamics (SD), spreadsheet simulation and business games. Discrete event simulation is used in this entry to form the process model which maps the beef supply chain stages in a process. The DES is one of the popular and desired modelling methods used to model real-world systems in supply chain systems. The DES maps the processes or events separately that progress with time. The DES simulation model has many benefits including a variable and flexible level of detail along with the possibility to model dynamic behaviour and uncertainties of a real system [5][6]. It is advantageous to use such a model in manufacturing supply chains to map and integrate individual stages of a supply chain. The DES model also supports the supply chain network design and evaluates it analytically. However, on the contrary, the DES tools focus on logistical trends in a supply chain more than sustainability or quality. The key capabilities of DES modelling involve pointing out supply chain uncertainties related to product quality and logistics, along with their interaction. The DES tool is implemented extensively in food supply chains to improve food supply chain design in terms of speed and quality production. The DES simulation model also helps in effective decision-making and helps save operational costs whilst speeding up the process by identifying any supply chain risks [7].

The discrete event simulation model also provides key benefits related to the operational efficiency of meat processing supply chains. Operational efficiency remains one of the biggest concerns for the meat processing industry and organisations constantly strive to enhance it. The DES simulation tool analyses the current operational efficiency and tests it by providing variations in the parameters to give results. This further allows researchers to

evaluate the efficiency of the meat supply chain at various stages and identify any uncertainties or risks associated with it. The DES tool allows stakeholders and managers to improve the meat supply chain efficiency in real-life environments and enhance meat quality, safety, and security. It also further enables them to better understand the factors that increase operational efficiency and production levels and allows them to improve managerial practices to alleviate potential barriers. The DES simulation used in the meat processing supply chains allows critical evaluation of the supply chain stages in a virtual environment and helps in understanding the key factors that can lower production costs and enhance operational efficiency in real-life scenarios [8].

2. Robotic Process Automation in Beef Supply Chains

The long forecasts for the beef industry are progressive and good due to the constant increase in population. The consumer demand for beef has enhanced which increases its demand and supply in the market. The beef industry constantly strives to maintain beef quality and safety to add value to its supply chain systems. The beef supply chain constantly faces socio-economic pressures due to escalating environmental and health concerns. The major concern and challenges for the beef supply chain are to produce quality and hygienic meat and maintain beef quality standards [9][10]. Innovation and technological advancements play a vital role in effective beef supply chain management to respond actively to the growing beef market and meet consumer demand promptly. The introduction of advanced technological systems such as Robotic Process Automation (RPA) automates manual and repetitive tasks that were previously performed by humans. This improves business procedures and activities in the beef industry and offers task completion through automation, thus making it simpler and more efficient. The implementation and adoption of Robotic Process Automation create the opportunity to lower hygiene risks in beef production, cater to a scalable beef market, produce quality beef, and improve consumer satisfaction [11][12].

The food supply chains are challenging and complex and so require improvements in business performance. It is important to acknowledge performance improvements in business processes related to quality, delivery, flexibility, and costs. Organisations seek supply chain management capabilities that enable and allow them to achieve value creation, customer satisfaction, competitive advantage, and exceptional returns. It is significant for organisations to gain a competitive advantage and achieve market-oriented goals to enhance their performance level. Effective management of materials, control of supply chain operations and active coordination between internal activities also help decrease supply chain complexity. Hence, many factors can influence the performance level of food supply chains [13]. The meat crisis and growing demand in recent times have increased the attention on the meat industry. Meat quality, safety and customer satisfaction are among the greatest prevailing concerns in the meat market. Technological requirements, business and customer needs and identification of regulatory guidelines are important aspects to consider in a productive meat supply chain. Transparency is a crucial factor to consider in meat supply chains to ensure quality, safety, and security in meat production. Efficient collaboration between networks for the purpose of forming supply chain transparency systems leads to lower management costs and enhanced food safety. Meat supply chains need to stress internal engagement and efficient information-sharing systems to address safety concerns related to meat production [14].

The beef supply chain is crucial to understand due to its complexities and difficulty in management as the overall supply chain phases are complex [15]. The characteristics and dynamics of the beef supply chain are unique and have distinctive features. The demand for this sector and its mechanism has experienced increased focus and attention within organisations and its supply chain process. The main challenge in the beef industry is to produce high-quality, nutritious, and hygienic beef for consumers. The freshness of the red meat, healthy appearance and visible fat are some of the features of superior quality beef [16][17]. **Figure 1** illustrates the various stages of the beef supply chain which begin at the farming stage and end at the consumer stage.

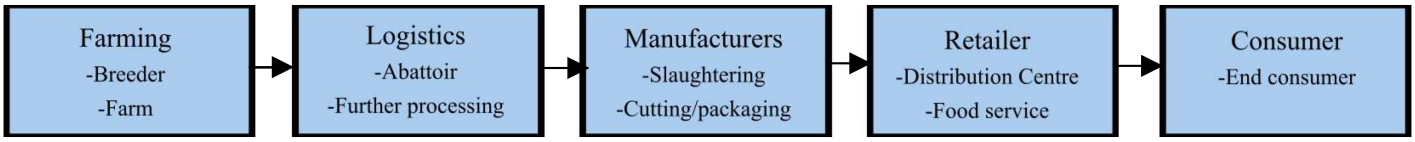

Figure 1. Beef supply chain stages (adopted from [18]).

Human health is also a key factor to consider when evaluating supply chain management since COVID-19 has occurred. Future waves of the pandemic (or future pandemics) heighten the risk of random workforce disease epidemics disrupting food processors' operations. Unlike the situation in early spring 2020, however, there has been time for food processing plants to adopt methods to avoid these hazards. Within manufacturing plants, attention to hygienic practices and social distancing measures serve to limit the danger of the disease spreading among employees, hence protecting workers' health and well-being. Moreover, producing high-quality beef is also important and the chances of beef contamination due to human touch are a cause of concern for the beef industry. Adaptive solutions include Robotic Process Automation technology, which involves employing software robots to do jobs and improve supply chain processes and lower the risk of beef contamination. Beyond the technological viability of Robotic Process Automation in beef processing, an individual firm's or larger organization's economic feasibility is a significant decision factor. Increased automation is cost-effective to the extent that robotics increase production, improve quality control, and reduce food safety issues [19][20].

The RMIF allows and encourages all industry players to communicate their challenges and concerns to eliminate all risk factors and discover solutions to problems for long-term supply chain processes. The RMIF lays forth a ten-point strategy for beef or red-meat stakeholders to increase profitability and performance. The red meat industry's operations and functions have evolved because of digital development. The RMIF forum can track red meat marketplaces and make them more accessible, and trade can be carried out more efficiently by cutting expenses and improving earnings. To improve consumer satisfaction and provide value to achieve a competitive edge, it is critical to observe people's demands, maintain meat quality, and provide high-quality and healthy meat (beef) to merchants. The Red Meat Sector Forum allows everyone involved in the industry to discuss their thoughts and concerns [21].

Beef is one of the most popular foods in the United Kingdom. Beef production in the UK produced roughly 9.6 billion British pounds in 2020. In 2017, the value of UK beef production doubled compared to the preceding ten years, reaching an all-time high. Since 2015, the population of cattle and calves in the United Kingdom has been

steadily declining, with an estimated 9.4 million in 2020. Only 3% of the cow population in the UK was organic that year. Beef product sales generated roughly 4.4 billion British pounds in 2021. From 2015 to 2019, the value of beef exports climbed by more than 200 million British pounds; however, it plummeted by more than 20% in 2020. The top destination for UK beef exports was Ireland, followed by France. The value of beef and veal output in 2020 was estimated to be around 2.93 billion British pounds [22].

Robotic Process Automation provides appealing workplace benefits because it frees human employees from monotonous activities in supply chain systems, allowing them to focus on company goals. RPA also collects and organises data, which aids supply chain systems in making future forecasts and process optimization. The activities that RPA carries out are typically structured, straightforward, and recurrent, such as automated email queries. RPA deployment in supply chain systems has resulted in significant cost reductions in terms of full-time equivalent (FTE), as well as a beneficial influence on corporate productivity and strategic goals. It also offers 24 h service delivery without any break, thus reducing the time cycle of production whilst improving operational efficiency and accuracy [23]. Robotic Process Automation tools can also adjust to demand, are more scalable, and can reuse components to assist in the automation of different jobs. Due to the enormous benefits of RPA technology in supply chain systems, businesses are likely to spend more on it [24][25][26]. RPA has several properties that make it distinctive, productive, and advanced enough to be adopted by FSCs and simplify SC processes. There are different perspectives through which RPA is explained by various authors in **Table 1**.

Table 1. Definitions of Robotic Process Automation.

Definition of Robotic Process Automation (RPA)	References
RPA focuses on automation of rule-based, repetitive, routine tasks to make supply chain processes easier.	[27]
RPA is a term used to replace human workforce and automate tasks.	[28]
RPA is described as using software bots to automate individual activities or tasks.	[23]
RPA is a technique or tool to execute administrative or scientific tasks to benefit organisational processes.	[29]
RPA can be described as a non-invasive automation method which does not require any major changes to existing business systems.	[30]
RPA is used to increase process efficiency and reduce business process costs by automating tedious, routine tasks.	[31]
RPA is a tool to improve supply chain processes and lower financial burden on organisations by automating tasks.	[32]
RPA is the use of ‘virtual workforce’ also called software, to operate applications effectively just as humans would do.	[33]

RPA tools attempt to relieve employees of the strain of repetitive, uncomplicated activities [34]. The demand for RPA products from commercial providers has increased dramatically. Furthermore, in the previous two years, numerous new vendors have entered the market. This is unsurprising, given that most businesses are still looking for

methods to save money and instantly connect legacy systems. RPA is viewed as a means of achieving a high Return on Investment rapidly (RoI). Automation Edge, Automation Anywhere, Blue Prism, Kryon Systems, Softomotive, and UiPath are dedicated RPA providers that only sell RPA software [35][36]. Robotic Process Automation can help with loading/unloading, slaughtering, cutting or deboning and packaging tasks in various meat processing factories, such as beef supply chains. The enormous variety of carcass forms and sizes is one of the biggest obstacles to increased automation in meat processing plants [37]. Nonetheless, technological improvements have the potential to enhance the use of robotics in the food industry, and the COVID-19 epidemic is expected to drive the trend toward greater automation. The requirement for labour-intensive plants to run at lower processing line speeds to safeguard worker health, as well as the need to avoid major revenue losses if production is halted or suspended owing to illness within the workforce, may have been added to this arithmetic by the pandemic.

Many supply chain specialists are unsure how to proceed considering the rapid advancement of digital technologies. RPA is frequently the initial step in a company's digital transformation. Over 60% of supply chain experts questioned in 2018 said they were researching or adopting RPA to automate supply chain business activities [38]. Many repetitive jobs in sourcing, operations, and logistics can be automated by RPA in supply chains. For a variety of reasons, businesses begin their digital transformation using RPA. First, software bots from top vendors such as Automation Anywhere, UiPath, and Blue Prism make RPA deployment simple. Tech-savvy supply chain employees can quickly build up their own RPA programs without the help of their company IT teams with minimal training and without the requirement for coding experience. However, IT is included in RPA adoption decisions so that systems are interoperable and IT skills can be efficiently exploited. Second, rather than revamping a whole end-to-end process, RPA can be implemented to a single, manual pain point in a process. Before automating a process, companies must ensure that it is running well and that they understand how automating one aspect of a process can affect its entire performance. Third, once established, adding, or removing capacity and scaling up or down bots based on business needs is simple. Finally, making the case for RPA based on ROI is simple [39]. RPA requires a small investment. Speed and fewer errors are other advantages, which improve overall customer service and supply chain procedures.

The beef sector in the United Kingdom is highly fragmented, with powerful and massive merchants, leading to mistrust and a lack of common goals and objectives. Consumer faith in the beef sector has also been affected by the industry's intricate supply chain. The government, on the other hand, implements risk management procedures, while the beef sector focuses on developing innovative designs to improve beef marketing and quality. Quality can be described as a degree or attribute that meets the cattle industry's specifications. Requirements are defined as mandatory or necessary acts that must be executed successfully to improve supply chain performance. Safety, service elements, quality food, and ethical production are the quality criteria that are relevant to the beef sector [40][41][42]. Another important aspect of beef quality is features that are closely related to its nutritional and consumption properties. This covers the beef's fat content, fat composition, look, flavour, colour, and texture, among other things. All these characteristics are influenced by the animal's breed, sex, production method, feeding regimen, and age. The Meat and Livestock Commission (MLC Services Ltd., China), which is responsible for its categorization in the United Kingdom grades beef carcasses according to their quality. On an alphanumerical scale, the EUROP grid is utilised to classify a carcass according to its conformation (shape) and fat level. The market most suited for each

type of carcass is determined by combining conformation and fat ratings. Any abattoir in the United Kingdom or Europe that slaughters 150 cattle or more per week must classify beef carcasses. In the United Kingdom, there are two grid versions. Most cattle processing plants employ the standard grid. Conformation is graded on a scale of E to P, with E representing a convex and shapely carcass, R representing an average shape or straight profile, and P representing a plainer carcass with a concave profile. Fat is graded on a scale of 1 to 5, with 1 being very lean and 5 being extremely fat. In the United Kingdom, conformation classes U, O, and P are classified as high (+) or low (–), whereas fat classes 4 and 5 are classified as low (L) or high (H) (H). There are 56 distinct types of carcass categories in total [43].

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