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Running the machine faster: Acceleration, humans and warehousing

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Running the Machine Faster: Acceleration, Humans and Warehousing

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To reduce the lead-time, modern logistics seeks to respond faster by accelerating physical and information flows. However, what are the impacts on logistics workers of an ever-faster logic? The purpose of this paper is to examine the relationship between process acceleration and the autonomy of order pickers. The method is to use exploratory qualitative research, based on fifteen visits to different regional distribution centers (RDCs) in the retail supermarket sector. The contribution of this paper is to apply Rosa's (2013) social acceleration theory to the specific context of logistics warehousing and to demonstrate how speeding up order picking systems is a key driver of change that has an impact on worker autonomy.

Keywords: Acceleration; autonomy; warehousing; order picking

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1 Introduction

In France, the warehousing and transport sector employs 1.37 million people (Stratégies Logistique 2017) and the surface of the regional distribution centers (RDCs) of supermarkets now doubles in size every two years. Three reasons can explain this rapid growth in the sector: supply, internal capacity and demand. Firstly, on the supply side, the growth in world trade, maritime shipping and the trend towards global sourcing in the last forty years has resulted in more and more goods circulating that require an effective logistic industry to make them available to the final customer.

Secondly, technological advances enable the automation of processes and mechanization in RDCs. The demand for automated warehouse systems is worldwide. In the USA, forecasters expect the robotics market in warehousing and logistics to have increased more than tenfold to \$22.4 billion by 2021, up from \$1.9 billion in 2016 (Yale Materials Handling 2017).

Thirdly, on the demand side, the advent of e-commerce and omni-channel distribution has led to the further expansion of the sector, making the modern warehouse the place “where the virtual becomes physical” (Moore, 2018). Information technology now instantaneously relays point of sales information to the distribution center, requiring demand-pull systems to be more and more responsive. Indeed, following the acceleration of information flows, the acceleration of physical flows becomes essential in order to fulfil the demand promise.

Owing to earlier advances in communications technology and digitalization, accelerated information flows predate accelerated physical flows and this has impacted the order picking process in the intervening period. Pick-by-voice systems, introduced in the late 2000's, were symptomatic of speeding up information flow technology, while we are only now seeing the installation of fully automated and mechanized warehousing systems more widely in the sector. The consequence of this desynchronization of the two flows has been borne by warehouse order pickers. Before the introduction of pick-by-voice systems, order pickers used their knowledge and skills to plan a route around the warehouse and stack their pallet in an efficient manner. With its introduction, algorithm-based software instruct workers via headsets which product to pick next: “the savoir-faire of order pickers has been reduced to a physical engagement” (Gaborieau 2012, p.1). While process acceleration increases productivity, it can also have consequences for human operators.

Therefore, the research question is as follows: what is the relationship between the acceleration of warehouse processes in RDCs and the autonomy of order pickers? Fig.1 presents the research focus. We choose to focus on order picking, because it is an important and expensive warehouse operation that is either labor or capital intensive (Gu et al. 2007). As such, from a technical perspective it has been the subject of performance evaluation studies with a view to optimization (Gu et al. 2010). A research gap exists because, although studies into the role of humans in warehouses can be found from a sociological perspective (Gaborieau, 2012; 2016), logistics research into this subject is rare. One exception is a literature review by Grosse et al. (2015) which found that researchers' order picking planning models have focused on cost efficiency rather than on human operators. They describe the human factor as the "missing link" in order picking system design.

To explore this missing link and its relationship with process acceleration, we use exploratory qualitative research methods, involving 15 visits to warehouse sites managed by four brand name RDCs and two leading third party logistics providers. A questionnaire about order picking was administered at one of the sites and discussions were held with managers. We structure this paper as follows. Firstly we examine the literature related to acceleration theory, warehousing, desynchronization, dynamic capabilities and the notion of worker autonomy within the context of social sustainability. Then we explain the research methodology and present the findings and propositions. This leads to a discussion and conclusion.

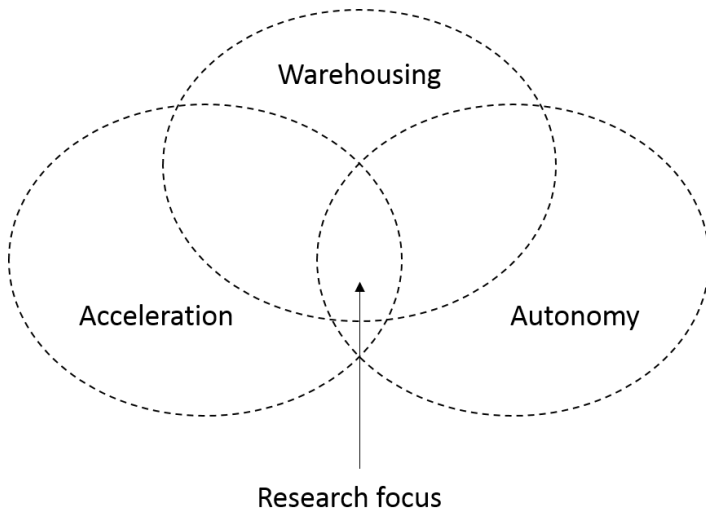


Figure 1: Schematic illustration of subject studied

2 Literature Review

2.1 Acceleration Theory

Writers have focused on speeding up movement as a defining characteristic of modern capitalism: “by far the greatest effect of industrialization...was to speed up a society’s entire material processing system” (Beniger 1986, p.427) and “everything that requires a long time lasts too long and everything that asks for time asks for too much time” (Rosa 2013, p.155). Underlying this drive for speed is a systems theoretical approach that concerns itself with “the securing of a ceaseless renewal of the elements of the system [...] not static, but dynamic stability” (Luhmann 1996, p.79).

From the perspective of critical theory, Rosa (2013) has developed a theory of social acceleration that relates to three domains. Firstly, technological accel-

eration is found in production and transport and is defined as “the intentional acceleration of goal-directed processes” (2013, p.74). Secondly, the acceleration of social change is defined as a contraction of the present in all areas of life and a growing instability of our time horizons and expectations. Finally, the pace of life speeds up despite the increased free time that technological acceleration should enable, as a result of a scarcity of time resources. Importantly, he asserts that technological acceleration not only alters our experience of space and time (put simply, things seem to be happening more quickly), it also changes the quality and quantity of our social relationships. Acceleration can be viewed as the antonym of ‘depth’ in relationships. For our purposes, this analysis is interesting because it relates technological acceleration, on the one hand, to its possible impacts on humans, on the other. Before we explore this connection in more detail, it is necessary to consider acceleration in the context of warehousing.

2.2 Acceleration and Warehousing

Acceleration is an imperative of the modern RDC for three main reasons. Firstly, because the quantity of goods moving through a given site is steadily increasing, due to rising demand and the advent of multiple distribution channels. In order to maintain performance levels, there is no choice other than to speed up the order fulfillment process. Secondly, commodities (and above all perishable commodities) progressively lose economic value for the producer the longer they are in storage. The role of the logistic warehouse is therefore to minimize the time goods spend immobile and to speed up processing time, thereby reducing inventory costs through faster rotation. Finally, margins are tight and competition is intense in the supermarket sector, so advantage can be gained through investing in speeding up processes and replenishing supermarket shelves with the right products rapidly.

For these three reasons of growth, value and competition, the notion of stocks/stores/storage as something stable or fixed, or as provisions set aside until need arises, is now outmoded. Gu et al. (2006) define the major roles of warehousing as buffering and consolidation. We can add that the underlying logic of RDCs is movement, not immobility. In a picker-to-parts order picking system minimizing the order retrieval time is the main priority, since it has been estimated that order picking comprises as much as 55% of warehouse operating costs (de Koster et al. 2007). The sooner an order is ready for shipping the better. In order to speed up manual order picking, travel time and therefore travel distance around the

warehouse has to be reduced to a minimum. This can be achieved by layout, grouping and storage assignment practices and by augmenting the work of the order picker by linking him/her to IT systems via headsets and microphones.

2.3 Desynchronization

However, warehouse acceleration risks the desynchronization of processes and functions (Rosa 2013) – a serious risk, given the importance of synchronizing flows for coordination, as advocated in the logistics literature (Simatupang et al. 2002). For example, speeding up warehouse materials handling will have an impact on inbound and outbound transport flows. Queuing and bottlenecks can occur because of improvements to one flow. Desynchronization, not only applies to material and data flows, but also to organizational functions: introducing an Enterprise Resource Planning (ERP) system, for example, will not produce the required results if the warehouse operations department is not appropriately trained in the new software. A reconfigured supply chain only operates at the speed of its slowest sub system with potentially dysfunctional consequences for the system as a whole (Rosa 2013).

Attempts to accelerate through automation and improved labor productivity always face risks, which are both technical and human. Because data processing and transmission now outpace material handling systems, the relative slowness of the latter becomes the weak link in the chain, demanding attention. Desynchronization and non-compatibility are an inevitable consequence of an acceleration of one part of the system, necessitating a holistic upstream and downstream vision of the whole system. For warehouse management, piloting parallel merging flows that function at different speeds becomes essential to avoid zero benefit from accelerating one of the flows.

2.4 Dynamic Capabilities

Efficient logistics increases the volume of transactions and availability of goods by managing time and eliminating barriers to circulation. The objective of a logistics warehouse is to minimize the lead time (the time taken from order reception to product delivery) by accelerating processing time. In the academic literature, a company's capacity to accelerate its supply chain is presented as "dynamic capabilities" (Teece et al. 1997; Beske et al. 2014). Specifically, Eisenhardt and

Martin (2000) define dynamic capabilities as “organizational and strategic routines by which firms achieve new resource configurations”. Logistics capabilities help to build competitiveness for organizations. Therefore, in the highly competitive retail sector, where margins are tight, the capability to accelerate processing time enables a firm to gain a competitive advantage over another.

Helfat and Peteraf (2003) introduced the concept of the capability lifecycle to develop further this notion of dynamic capabilities. In the same way that products have a lifecycle of growth, maturity and decline, so too do capabilities. Therefore, logistics processes are capabilities that develop and eventually lose their ability to provide a competitive supply chain advantage. Acceleration theory, postulating that society is in an incessant cycle of speeding up processes, suggests that the lifecycle of logistic capabilities in the modern RDC is becoming shorter and shorter, as the organizational environment becomes increasingly turbulent and complex, requiring adaptability and regular reconfiguration.

Reconfiguring resources in the food industry is seen as essential, given the constant changes in consumer demands (Wiengarten et al. 2011; Trienekens et al. 2012) and the need to respond to them. Faster communications technology cycles and big data (Waller and Fawcett 2013) mean that firms seeking to maintain or gain market share, have to constantly monitor, evaluate and reconfigure their resources. The pull flow logic of demand chain management places the final customer as the driving force that the modern logistics warehouse aims to satisfy through product availability via multiple delivery channels:

“The implication of today’s turbulent and unpredictable business environment is that demand chain solutions are required. That is, we need solutions that are flexible and capable of responding rapidly to structural change on both the supply side and the demand side of the business” (Christopher and Ryals 2014, p.29).

‘Responding rapidly to structural change’ involves accelerating warehouse processes. Yet the ‘ever-faster’ logic raises important questions about the social sustainability of the modern warehousing sector and the impact on the people who work in it.

2.5 Social sustainability and autonomy

This article considers the relationship between the acceleration of warehouse processes and the autonomy of workers. Of the three sustainability dimensions

(social, environmental and economic), Ahmadi et al. (2017) show that social sustainability in supply chains has been under-researched, compared with environmental and economic sustainability. They conclude that this is “a research topic that will only gain in importance in years to come” (p.105). The importance of the human dimension as a research agenda is confirmed by Wieland et al. (2016) in data collected from 141 SCM researchers. After analyzing the difference between what should and what will become important, the people dimension of SCM was ranked the most underestimated research theme out of 35 subjects, followed in second place by ethical issues. They write: “Feedback from participants notes that supply chains are not “soulless machines,” but complex socio-technical systems involving cognitive elements and impacted by face-to-face negotiations and conversations” (Wieland et al. 2016, p.207).

In a study of ten cases of sustainable supply chain management exemplars Pagell and Wu (2009) found that sustainable firms invest in human capital, aim to increase employee wellbeing, enhance organizational commitment and maintain a culture that values people and the environment. Workers in these organizations described their employers as thoughtful, caring, and committed. Varsei et al. (2014) evaluated the social performance of partners in a global supply chain. They focused on the four primary social dimensions specified in the Global Reporting Initiative (GRI 2012), namely, labor practices and decent work conditions, human rights, society and product responsibility.

2.6 Defining autonomy

In the warehousing context in France, where arguably, labor rights and systems of social protection exist, the focus for researchers into social sustainability is primarily on the experience of working conditions (Gaborieau 2012; 2016) and in the case of this research, on job autonomy. This has been defined as the degree of control that workers have over their own work situation (Brey 1999) and as spheres of independence that are directly or indirectly delegated by the organization to employees (Katz 1966).

In seeking to explain the paradox of disempowered industrial employees collaborating and engaging in a firm's activities, Katz (1966) argued that it was the undefined time left to workers within work time, to bring their culture into the bureaucratic workplace, which rendered the work tolerable for employees. In other words, worker autonomy engenders integration into an organization, through

allowing a continuity between non-work life and the working life. Therefore, reducing worker autonomy in a tightly controlled work environment, with little time for association, could negatively affect worker commitment to the organization.

Importantly, Brey (1999) noted that even if organizations limit goal setting by workers, deciding on the means to achieve those goals can still provide autonomous spaces for meaningful and rewarding work. However, Brey describes three ways in which autonomy can be compromised. Firstly, monitoring and constant surveillance, enhanced by digitalization, remove moral autonomy and cause a loss of a sense of dignity and a perception of outside judgement. Similarly, task pre-structuring by computer-defined systems imposes conformity on the employee and reduces his/her scope for freedom of action and decision-making. Finally, new computer systems create dependency on third parties, such as managers or system operators, who possess the necessary skills to install and maintain the technology, whereas the worker does not.

Vidal (2013) argues that there is a connection between an acceleration in the pace of work and low-autonomy work particularly in highly competitive sectors: the faster the process, the less time the worker has to decide what action to take or to communicate with colleagues. Where, as in the case of order pickers, a firm emphasizes and rewards the speed of a worker to complete a task accurately, little value is seen in allowing autonomous worker input.

This review of the literature relating to acceleration, autonomy and warehousing is summarized in Fig.2 below:

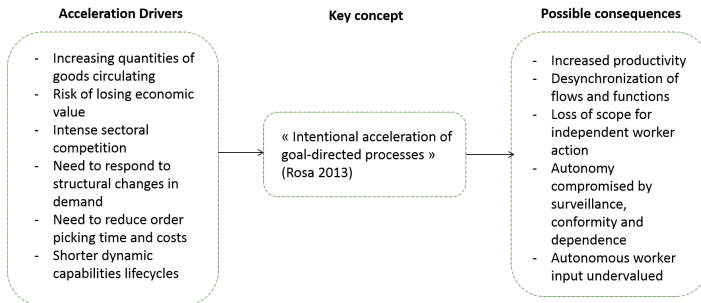


Figure 2: Proposed conceptual model for RDC acceleration

3 Methodology

Warehousing academic literature considers design, operation and performance evaluation, rather than understanding and contextualizing working conditions or the transformation of the modern warehouse. In a literature review of warehousing research, Davarzani and Norrman (2015, p.15) find that the “results of this study reveal a lack of reality-based investigations. Most of the scholars focus on quantitative research methods and mathematical modeling without any examples from real cases”. They conclude: “that more empirical investigations should be conducted to understand and capture complexities of the real environment”. Warehousing literature review articles (Gu et al. 2007; 2010; Davarzani and Norrman 2015) reveal an absence of theoretical frameworks and an emphasis on operational and technical solutions without reference to sustainability issues.

A systems approach rests on positivist assumptions of objective reality and independence from context. Such an approach, aimed at process optimization and improving productivity, encourages the progressive introduction of technological solutions, seen as neutral. Alternatively, complexity theory (Nilsson and Gamelgaard 2012) aims to take into account the diversity of human involvement in the organization of logistic processes.

The difference between the two approaches is made clear if we consider the question of self-organization or autonomy – to what extent is a worker able to plan his/her workload his/herself. For a systems approach, self-organization brings uncertainty and needs to be minimized. On the other hand, complexity theory recognizes that human intervention is an integral and inevitable part of the logistics process.

Table 1: Visits to warehouse sites during research

Firm	Sites and visits	Particularity of site
RDC A	3 sites and 4 visits	Ambient products only. Mechanized zone in each site.
RDC B	1 site and 2 visits	6 warehouses for fresh, frozen and ambient products on one site, including large fully mechanized warehouse.
RDC C	1 site and 2 visits	Site handling all product types, but shortly due for closure due to regional reorganization.
RDC D	1 site and 2 visits	Ambient and fresh products. Site shortly due for closure due to regional reorganization. Order picking questionnaire administered here.
3PL A	3 sites visited once	3PL specializing in fresh and frozen products. Clients include leading supermarket brands.
3PL B	2 sites visited once	Client is a leading supermarket brands. One site due to close shortly due to contract termination.

The primary objective of this exploratory research is to consider the consequences of acceleration for the autonomy of order pickers. The research is based on 15 visits to different warehouse sites managed by six different firms (see Table 1) in France in 2017 and 2018, connected with the supervision of logistics students on internships. The selection of sites is random, since the logistics school receives offers of internships from firms and the researcher is allocated to supervise a certain number of students. Each visit to a site lasted between two and four hours and included a tour of the warehouse itself, detailed explanations of site operations and discussions with managers. After each visit, notes were made to keep a record of the principal observations. The research has been supplemented by

discussions with and reports from logistics students on internships. Additionally a questionnaire was administered at RDC D that focused on managers' and order pickers' evaluations of pick-by-voice. The warehouses visited either handled frozen, fresh or ambient goods or in some cases all three types. The sites were also at different stages of automation and mechanization and had different strategies for their implementation. Supermarkets ran the majority of the sites visited, while specialist third party logistics service providers (3PLs) ran the minority.

4 Research findings

This chapter sets out four findings from this initial exploratory research, which are pertinent to the question of RDCs and acceleration and lead onto propositions, intended as possible future research directions. Table 2 sets out these propositions. The research initially focused on the impact of flow acceleration on worker autonomy. It has led to extra findings illustrating further consequences of acceleration on warehouse processes and organization.

Table 2: Summary of propositions

Concepts	Linked Propositions
Acceleration and autonomy	P1: Accelerating processes by intensifying an order picker's work rate reduces worker autonomy.
Desynchronization	P2: Desynchronization in warehouse processes is an inevitable consequence of speeding up flows, making global flow coordination essential.
Human Resources	P3: Process acceleration makes human resource management in RDCs more not less important.
Supply Chain	P4: Acceleration accentuates the role of RDCs as inward-looking, performance-focused and constrained logistics operations.

4.1 Accelerating order picking and worker autonomy

While other types of order picking exist (Richards 2011), the sites visited presented two types of acceleration of the order picking process. To start with the more recent, in France mechanized zones have been introduced in warehouses in the current decade, either as specific enclosed zones in a part of an existing site or as a whole building unit. These are defined as zones where all processes are mechanical and automated without human intervention in the sorting and picking process, except in a maintenance role. An enclosed zone handles heavier packages. It accepts full pallet loads, separates them and then prepares full pallet loads as ordered. While these specific zones have a high productivity rate, this is a capital-intensive solution to order picking and the return on investment is estimated at five years or more.

The second solution dates from the 2000's and is known as pick-by-voice software. A headset and microphone link order pickers to computer software, which determines the order of pallet preparation. BCP software estimate an increase in order

picker productivity of 15% with pick-by-voice technology. However, it increases the workload, leading to concerns about risks to health (Anact 2010).

To ascertain the appreciation of pick-by-voice technology, a questionnaire was administered to 8 managers and 24 order pickers at RDC D. This revealed different evaluations of the pick-by-voice technology by the two groups. Managers' average score out of ten was 7.4, while workers gave a score of 5.1. Managers appreciate the technology because it enables tracking of activity, optimizes picking routes, reduces picking errors and improves productivity. From a human resource management perspective, it enables an accurate planning of the number of pickers needed each day. It also leads to better ergonomics for the worker, who now has his/her hands and eyes free.

The order pickers, on the other hand, found that the computer voice leads to a sentiment of dehumanization. During a visit to this site by the author, the manager asked a worker to explain how the headset and picking process works. He replied: "I just follow orders like an idiot". Order pickers using pick-by-voice also reported a feeling of being monitored and controlled; an increased workload leading to tiredness; limited possibility of communication between colleagues; a diminution of collective working; no global visibility of an order, making the job less interesting. The technology itself was criticized for frequent malfunctions, failures of the network, headaches and lack of comfort caused by wearing the headset all day and the regular repetitions needed to communicate with the software.

These findings confirm those of Gaborieau (2012; 2016) that pick-by-voice accelerates the pace of work, renders the work repetitive, reduces the opportunity for socializing and increases the weight carried per day. The first proposition relates to the human consequences of acceleration.

P1: : Accelerating processes by intensifying an order picker's work rate reduces worker autonomy.

4.2 Merging flows and desynchronization

At a site managed by RDC A, a manager presented the following problem of four different types of flow, operating at different speeds, both push and pull, some predictable and others not. These flows have to merge to be loaded onto the same truck, requiring piloting to minimize delays. The first flow is that of order

pickers in pull flow using the pick-by-voice technology to stack pallets and deliver to the loading bays. The second flow is cross docking, where goods arrive from other RDCs of the same retailer for immediate dispatch to stores in the region. The third flow concerns special offers, launched by the centralized marketing department and operating in push flow.

Finally, the newly constructed mechanized zone, operating in pull flow, adds complexity to the site, for three main reasons. Firstly because there has to be a very careful selection of references that are suitable for this zone, which must respect both the specific materials handling criteria and the required pace of entry of goods into the zone. Secondly, because the zone handles 30% of references and the number of full pallet loads entering and exiting the zone is high, extra flows circulate within the same warehouse space. Finally, because the transfer of completed pallets from the mechanized zone to the loading bays is carried out by automatic guided vehicles (AGVs or robots). However, the route of AGVs from the mechanized zone to the loading bays crosses the “main highway” at the site and impedes the progress of order pickers and forklift drivers, whose pay is performance linked. (At another site of this group with the same configuration, this had led to incidences of sabotage of the AGVs by workers.)

Speeding up one flow or creating a new one and finding a solution to one problem - in this case that of heavy loads of 10 to 15 kilos, which can now be handled by the mechanized zone and not order pickers manually - has a knock on effect and sets up new challenges to be resolved. The shortening of dynamic capabilities lifecycles (Helfat and Peteraf 2003) suggests that the desynchronization of flows and the need to audit and pilot flows effectively are set to recur more frequently. The second proposition is about desynchronization. P2: Desynchronization in warehouse processes is an inevitable consequence of speeding up flows, making global flow coordination essential.

4.3 The roles of humans in warehousing

Changing flows in RDCs has an impact on the organization of work tasks. Because management realizes that order picking is an unattractive task, many of the sites visited had moved towards greater flexibility or polyvalence. In general, while order pickers were content to be trained to take on the role of forklift drivers, the inverse was not the case. One manager at RDC site D acknowledged this problem and refused to accept that staff could choose not to do order picking. It was clear

that within the site requiring staff to do order picking as part of their different tasks had become a delicate issue.

Sites visited had different levels of temporary staff, reflecting the recruitment difficulties that affect the sector. At RDC site C, due to close in 2018 and be relocated, the percentage of temporary staff had reached 50% and was making the task of management in planning and organizing a workforce difficult. The best run sites also had the lowest levels of temporary staff. The overall impression from the visits to the 15 different sites was one of a sector undergoing rapid change. Some sites were due to close as part of a national restructuring programme. Other sites were in the process of introducing mechanized zones and robotic systems. RDC site B had recently completed a fully mechanized warehouse for full pallet loads, where the only humans are those in the truck loading and unloading areas and maintenance workers. Some managers were aware of the impact of these changes on workers and stressed the need for retraining, upskilling and recruiting more highly qualified staff. This leads to the third proposition that concerns human resources. P3: Process acceleration makes human resource management in RDCs more not less important.

4.4 The bow tie metaphor

The structure of a supply chain, in which RDCs operate, can be likened to a bow tie, as they are at the center of high volume inbound and outbound flows. (Most RDCs stock around 10,000 different product references.) Here, the main feature of the bow-tie metaphor is that there are complex and variable inputs or inbound flows, that a compact core accepts, then recomposes and distributes what has been stored to a wide variety of destinations. Two observations can be made about the impact of acceleration on the organization of the supply chain. Firstly, due to the need to accelerate and reconfigure processes, the pressure to reach performance targets, the difficulty in recruiting and retaining qualified staff and their position at the center of massive inbound and outbound flows, RDCs focus purely on the management of internal flows and arriving and departing transport. A 50,000m² warehouse that serves as a conduit for many suppliers and customers only has contact with them in matters directly related to flow management, such as packaging problems. In concerning themselves primarily with their own logistics, RDCs exemplify the strict division of labor and functions along the supply chain and the rigid boundaries that characterize this sector of activity.

The second observation relates to what Carter et al. (2015), in their development of a theory of the supply chain, refer to as the “horizon or visibility boundary”. These authors suggest as a formal premise that: “the supply chain is bounded by the visible horizon of the focal agent”. Although RDCs are central nodes in the supply chain, they are more hidden from view than visible, bounded more by confidentiality and security than openness. Moore (2018) comments: “It is tempting to say that these buildings make the internet visible, except that their visibility is strictly limited”. It would be interesting to ascertain suppliers’ and customers’ level of knowledge of RDC operations, since they represent the next node in the supply chain. Furthermore, has the acceleration of processes in RDCs led to greater or lesser visibility of them by suppliers and customers? If the latter is the case and there is less visibility, following Carter et al.’s premise, can RDCs be viewed as part of supply chains or are they more accurately described as specialized constrained logistics operations. This leads us to the fourth proposition that relates to supply chain structure. P4: Acceleration accentuates the role of RDCs as inward-looking, performance-focused and constrained logistics operations.

5 Discussion and Conclusion

This exploratory research has shown that speeding up information flows through technology in labor-intensive order picking processes reduces worker autonomy and that process acceleration is an underlying logic of the modern RDC. In this final chapter, we discuss further the propositions made and consider where this might lead a warehousing research agenda.

To optimize information and physical flows the boundaries or borders, in the widest meaning of the terms, between and within firms have to be managed – boundaries between buyers and suppliers or between different departments within the same firm or between different zones in the same warehouse. For flows of goods and information to operate efficiently, boundaries have to be almost invisible or frictionless, soft rather than hard. The management of logistic processes across and within organizations aims to be seamless and the boundaries blurred.

Boundaries reflect the constraints imposed in the functioning of organizations and exist for purposes of control, channeling or connecting (Mezzadra and Nielsen 2012). However, process acceleration puts these boundaries under stress, disturbs established configurations, provokes desynchronization (P2) and requires

the reorganization of different flows. The disruptive power of acceleration sets in motion a series of impacts, both positive and negative, anticipated and unforeseen, that bring into question the stability of existing boundaries (Hernes and Paulsen 2003). As Vakkayil (2012, p.206) has observed: “In constantly changing environments it is impossible to draw permanent lines of demarcation”.

We have noted that one of the imperatives driving acceleration in warehousing is economic value loss. Rosa (2013, p.163) describes the time goods spend in storage and distribution as time when “the realization of created surplus value is delayed”. He sees one of the basic systemic problems of capitalist economies as the need to maintain accelerated circulation to avoid such value loss. He argues that it is for this reason that logistics has to be more technically advanced than production – to ensure that the sphere of potential value loss does not negatively affect the whole value creation process and eventually, value capture.

Through applying Rosa’s theory of social acceleration to RDCs, the contribution of this exploratory research is to demonstrate that there is an ongoing tension between the systemic need for acceleration in logistics warehousing and the existing boundaries or constraints that have been negotiated and established in the supply chain and in the workplace. An example of these tensions, presented in this paper, is the autonomy of order pickers (P1), defined either as control over the work situation (Brey 1999) or as spheres of independence (Katz 1966). A future case study research agenda could examine in more detail how this tension between the established boundaries, which allow a degree of worker autonomy in warehousing and the imperative to accelerate is evolving. Additionally the nature of relationships between RDCs and suppliers/customers, and the changes to these relationships and supply chain structure associated with RDC process acceleration (P4) could be studied. Finally, by moving away from technical performance-based optimization of order picking systems, as suggested by Grosse et al. (2015), research could consider the future role of human resources in warehouses (P3) and provide exemplars of valuing human input.

References

- (Anact), A. nationale pour l’amelioration des conditions de travail (2010). “Preparateurs de commandes quelles pistes de prevention”.
- (gri), G. R. I. (2012). *The GRI Annual Report 2011/2012*. Available at.
- Ahmadi, H. B., S. Kusi-Sarpong, and J. Rezaei (2017). “Assessing the social sustainability of supply chains using Best Worst Method”. In: *Resources, Conservation & Recycling* 126, pp. 99–106.

- Beniger, J. (2007). "The control revolution". In: *Communication in history: Technology, culture, society*, pp. 301–311.
- Beske, P., A. Land, and S. Seuring (2014). "Sustainable supply chain management practices and dynamic capabilities in the food industry: A critical analysis of the literature". In: *International Journal of Production Economics* 152, pp. 131–143.
- Brey, P. (1999). "Worker Autonomy and the Drama of Digital Networks in Organizations". In: *Journal of Business Ethics* 22, pp. 15–25.
- Carter, C. R., D. S. Rogers, and T. Y. Choi (2015). "Toward the Theory of the Supply Chain". In: *Journal of Supply Chain Management* 51.2, pp. 89–97.
- Christopher, M. and L. J. Ryals (2014). "The Supply Chain Becomes the Demand Chain". In: *Journal of Business Logistics* 35.1, pp. 29–35.
- Davarzani, H. and A. Norrman (2015). "Toward a relevant agenda for warehousing research: literature review and practitioners' input". In: *Logistics Research* 8.1, pp. 1–18.
- De Koster, R., T. Le-Duc, and K. J. Roodbergen (2007). "Design and control of warehouse order picking: a literature review". In: *European Journal of Operational Research* 182.2, pp. 481–501.
- Eisenhardt, K. M. and J. A. Martin (2000). "Dynamic capabilities: what are they?" In: *Strategic management journal* 21.10–11, pp. 1105–1121.
- Gaborieau, D. (2012). "«Le nez dans le micro». Répercussions du travail sous commande vocale dans les entrepôts de la grande distribution alimentaire". In: *La nouvelle revue du travail* 1.
- Gaborieau, D. (2016). "Des usines à colis: trajectoire ouvrière des entrepôts de la grande distribution". PhD thesis. Paris 1.
- Grosse, E. H., C. H. Glock, and W. P. Neumann (2015). "Human factors in order picking system design: a content analysis". In: *IFAC-PapersOnLine* 48.3, pp. 320–325.
- Gu, J., M. Goetschalckx, and L. F. McGinnis (2007). "Research on warehouse operation: a comprehensive review". In: *European Journal of Operations Research* 177.1, pp. 1–21.
- Gu, J., M. Goetschalckx, and L. F. McGinnis (2010). "Research on warehouse design and performance evaluation: a comprehensive review". In: *European Journal of Operations Research* 203.3, pp. 539–549.
- Handling, Y. M. (2017). *The ROI of Robotics: Financial and Operational Sense*.
- Helfat, C. E. and M. A. Peteraf (2003). "The dynamic resource based view: capability lifecycles". In: *Strategic Management Journal* 24, pp. 997–1010.
- Hernes, T. and N. Paulsen (2003). "Introduction: boundaries and organization". In: *Managing boundaries in organizations: multiple perspectives*. Springer, pp. 1–13.
- Katz, F. E. (1965). "Explaining informal work groups in complex organizations: the case for autonomy in structure". In: *Administrative Science Quarterly* 10.2, pp. 204–223.
- Luhmann, N. (1996). "Soziale Systeme". In: *Grundriss einer allgemeinen Theorie*. Frankfurt: Suhrkamp.
- Mezzadra, S. and B. Neilson (2012). "Between inclusion and exclusion: On the topology of global space and borders". In: *Theory, Culture & Society* 29.4–5, pp. 58–75.
- Moore, R. (2018). *A shed the size of a town: what Britain's giant distribution centres? tell? us about modern life*.
- Nilsson, F. and B. Gammelgaard (2012). "Moving beyond the systems approach in SCM and logistics research". In: *International Journal of Physical Distribution and Logistics Management* 42.8/9, pp. 764–783.
- Pagell, M. and Z. Wu (2009). "Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars". In: *Journal of Supply Chain Management* 45.2, pp. 37–56.

- Richards, G. (2017). *Warehouse management: a complete guide to improving efficiency and minimizing costs in the modern warehouse*. Kogan Page Publishers.
- Rosa, H. (2013). *Social Acceleration: A new Theory of Modernity*. New York: Columbia University Press.
- Simatupang, T. M., A. C. Wright, and R. Sridharan (2002). "The knowledge of coordination for supply chain integration". In: *Business Process Management Journal* 8.3, pp. 289–308.
- Teece, D. J., G. Pisano, and A. Shuen (1997). "Dynamic capabilities and strategic management". In: *Strategic Management Journal* 18.7, pp. 509–533.
- Trienekens, J. H., P. M. Wognum, A. J. M. Beulens, and J. G. A. J. van der Vorst (2012). "Transparency in complex dynamic food supply chains". In: *Advanced Engineering Informatics* 26, pp. 55–65.
- Vakkayil, J. D. (2012). "Boundaries and organizations: a few considerations for research". In: *International Journal of Organizational Analysis* 20.2, pp. 203–220.
- Varsei, M., C. Soosay, B. Fahimnia, and J. Sarkis (2014). "Framing sustainability performance of Supply Chains with multidimensional indicators". In: *Supply Chain Management: An International Journal* 19.3, pp. 242–257.
- Vidal, M. (2013). "Low-autonomy work and bad jobs in postfordist capitalism". In: *Human Relations* 66.4, pp. 587–612.
- Waller, M. A. and S. E. Fawcett (2013). "Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management". In: *Journal of Business Logistics* 34.2, pp. 77–84.
- Wieland, A., R. B. Handfield, and C. F. Durach (2016). "Mapping the landscape of future research themes in supply chain management". In: *Journal of Business Logistics* 37.3, pp. 205–212.
- Wiengarten, F., M. Pagell, and B. Fynes (2011). "Supply chain environmental investments in dynamic industries: Comparing investment and performance differences with static industries". In: *International Journal of Production Economics* 135.2, pp. 541–551.