The Application of 'Just in Time' to Reverse Logistics: A Feasibility Study from the UK Multiple Retail Sector

Abstract

Purpose: The purpose of the research is to assess the operational feasibility of applying just in time (JIT) practices to a UK multiple retailers' reverse logistics (RL) function for waste packaging materials, whilst also assessing possible benefits which may be derived from such an application.

Research Approach: The research adopts an embedded case study approach, which included multiple analyses at different nodes of the retail and distribution operational units within the organisation. Interviews were undertaken which allowed for the creation of a narrative outlining the organisation's operating environments and RL function dynamics, this was then compared to key JIT success factors.

Findings: At the functional level there are a number of attributes within the case organisation which would positively influence the adoption of JIT processes, given their relationship with critical success factors outlined within the literature. It is also observed that where negative relationships do exist, they are mainly attitudinal in nature and thus through process reengineering and appropriate training could be averted. On balance the findings indicate that with minimal restructuring and investment the case organisation would be capable of supporting JIT processes. Possible implications of a successful JIT implementation are also discussed. These suggest that although duplicate movement within the network may occur, there would also be efficiency increases in both forward and reverse operations allowing for significant savings.

Practical Impact: A new process model is proposed for the case organisations forward and reverse operations which incorporates JITP elements into the RL function. This creates a new just in time reverse logistics (JITRL) environment where collection activities are removed from forward operations, resulting in possible cost savings for the overall distribution network derived from increased efficiencies and capital expenditure.

Originality: The research presented provides a unique and novel approach to the application of JIT systems, not only showing that it is possible in operational contexts, but also that JITRL systems may offer significant benefits beyond this organisation, to distribution networks in operations within a similar environment to that of the case organisation.

Introduction

This paper considers the logistical issues at play during the recovery of recyclable materials and reusable plastic containers (RPCs) from retail units. It is relatively common for multiple retailers to utilize returning vehicles for the purpose of collecting these materials, offloading them within a dedicated recovery area within their regional distribution centres (RDCs) (Fernie & Sparks, 2009). From a company perspective, these forms of reverse logistics (RL) activities offer the chance to both capitalise upon unused capacity of returning vehicles as well as recapture value from waste materials which would usually be sent to landfill at a cost (Fernie & Sparks, 2009), the latter being a key consideration of most RL systems(Rogers & Tibben-Lembke, 2001; Dekker, 2004; Zhou & Wang, 2008; Fernie & Sparks, 2009; Lambert, Riopel & Abdul-Kader, 2011; Das and Chowdhury, 2012). Understanding that one of the core key benefits of an RL system such as this is the potential to recapture value, it is self-evident that any supply chain model which would increase the amount of value recapture through increases in efficiency would offer greater operational resource-saving benefits. One such model is the just in time (JIT) system, created by Toyota during the third quarter of the twentieth century (Sugimori *et al.*, 1977; Lai & Cheng, 2009). Originally a production system, JITs main purpose is to eliminate all forms of waste (*muda*) within the manufacturing process, using the assumption that anything which isn't completely necessary to the manufacture of a particular item is excess and therefore an unnecessary waste (Sugimori *et al.*, 1977; Rosen & Anderson, 2000; Lai & Cheng, 2009). A number of researchers have addressed the implementation of JIT over the last two decades, notably (Ahmed, Tunc & Montagno, 1991; Prasad, 1995; Wafa & Yasin, 1998; René, 1999; Matson & Matson, 2007). One common feature of these papers is that they exclusively focus on JIT implementation within forward flow operations, without consideration of the reverse. To some extent the application of JIT and lean practices within RL is examined (Banomyong, Veerakachen & Supatn, 2007; Matson & Matson, 2007; Chan, Yin & Chan, 2010) however, Chan, Yin & Chan (*op cit*) restrict their review to academic literature alone, whereas both 2007 studies only apply lean in conjunction with agile practises, while both only consider the context of product take-back that are limited to retail returns processes.

In consideration of this gap in empirical research, as well as the possible benefits that could be derived through applying JIT and lean practices to secondary packaging recycling streams, this research sets out to assess both the feasibility of JIT application in this context as well as the consequences of such an implementation on RL process performance.

Literature

Just in Time (JIT)

As mentioned above, Toyota adopted the JIT production system against the backdrop of increasing resource pressures during the 1970's (Lai & Cheng, 2009). The reduction of this *muda* within JIT involves the development, implementation and continuous execution of a number of key practices White & Prybutok, (2001) and Lai & Cheng (2009). These practices contain many of the key elements of a successful JIT operation, however an imperative part of any such environment is the underlying operational precept of a pull production system. This can be summarised as the process of supplying or producing work in progress (WIP) goods, components, raw materials or finished products only when demand is shown by a proceeding entity (Sugimori *et al.*, 1977; Harber *et al.*, 1990; Mejabi & Wassserman, 1992; Chase, Aquilano and Jacobs, 2004; Sendil Kumar & Panneerselvam, 2007). One final aspect of the JIT philosophy is "just in time purchasing", which involves the use of small, frequent deliveries principally aimed at the reduction of inventory held by the purchasing entity (Lee & Wellan, 1993; Dong, Carter & Dresner, 2001; Giunipero *et al.*, 2005). Although this is simply an aspect of the overall JIT philosophy it has an extensive list of enabling practices which can be grouped into four categories namely operational, relational, complementary and quality (Gonzállez-Benito, 2002). These, much like the aforementioned key practices, have direct correlations with the seven '*muda'* wastes of the lean philosophy, now prevalent in Western manufacturing operations (Harrison & van Hoek, 2008; Paluch, 2009).

Implications of JIT Implementation

It is axiomatic that the focus for multiple retail organisations is increasing their financial performances across divisions, to this end Inman & Mehra, (1993); Claycomb & Germain, (1999) as well as Maiga & Jacobs, (2008), all lay down a common principle in that the implementation of JIT systems can have a direct positive effect on firms financial performance, However, this financial benefit is not directly related to, but instead achieved by less tangible benefits of JIT surrounding operational processes (Claycomb & Germain, 1999; Maiga & Jacobs, 2008). One final consideration discussed by Claycomb & Germain(1999) is that in order to gain maximum financial benefits from JIT, there is a need for a total systems strategy where a multitude of intangible benefits and JIT practices need to be present, even if not acted upon.

It is worth noting however that there are some negative implications to consider. For example Lai & Cheng (2009) outline the increased vulnerability to uncontrollable external factors such as natural disasters which could inhibit a supplier's ability to deliver products.

Success Factors

Within the extant literature reviewed there appears a relative level of consensus as to what the critical actors are for successful JIT implementation. The literature on this topic is dominated by five key texts: Lai & Cheng, 2009; Matson & Matson, 2007; René, 1999; Wafa & Yasin, 1998, and Prasad, 1995). These are referred to in Table 1, which shows sixteen key generic success factors and which authors identify them. These success factors can cover several areas of a business and thus some authors have attempted to group them to enable better analysis and give further context, two general groupings suggested are Organisational (OR)/ Operational (OP) (René, 1999) or internal (IN)/External (EX) (Ahmed, Tunc & Montagno, 1991), both examples are also categorised in Table 1.

			Cited by				
Success Factor	OP/ OR	In/Ex	Lai & Cheng, 2009	Matson & Matson, 2007	René, 1999	Wafa & Yasin, 1998	Prasad, 1995
Top management support	OR	In	✓	✓	✓	✓	✓
Quality (supplier/Production)	OP	In/Ex	✓	✓	✓	✓	✓
Employee readiness and support	OR	In	✓		✓	✓	✓
Distribution support/ Network Design	OP	In	✓		✓	✓	✓
Engineering support/ maintenance	OP	In	✓		✓		✓
Communication (intra/inter)	OP	In/Ex	✓		✓	✓	✓
JIT and Demand (Relationship)	OP	In/Ex	✓		✓		✓
JIT understanding	OR	In/Ex	✓	✓	✓		✓
Supplier Cooperation	OR	Ex	✓		✓		✓
Supplier proximity	OP	Ex	✓	✓	✓		✓
Production control system (Kanban)	OP	In	✓		✓		✓
Resources to support the project	OR	In	✓		✓		✓
Information Systems support	OP	In	✓	✓	✓		✓
Capacity	OP	In/Ex					✓
Training	OR	In	✓	✓	✓	✓	✓
Supplier Delivery timing	OP	Ex	✓	✓	✓	✓	✓

Table1: Review of Success Factors in JIT implementation

Reverse Logistics

Reverse Logistics (RL) is by no means a new phenomenon within supply chain management practise. This is evident from early research, such as that by Pohlen & Farris (1993). In its simplest form, RL involves controlling the movement of products and materials upstream from the final customer towards the point of origin (Rogers & Tibben-Lembke, 1999). However it is also possible in many circumstances that materials and products will instead be returned not to the point of origin, but to a point of recovery or indeed, several points of recovery depending upon complexity, market conditions and network development (Bernon, Rossi & Culle, 2011).

There are a number of purposes for which RL systems can be employed, those commonly cited include: Reuse, Refurbish, Re-manufacture, Material Reclamation, Recycle and as a last resort Incineration/Landfill (Rogers & Tibben-Lembke, 2001; Dekker, 2004; Lambert, Riopel & Abdul-Kader, 2011). The decision as to which of these practices should be employed is contingent on the nature of the returned materials, whether they are “product” or “packaging” (Rogers & Tibben-Lembke 2001). Moreover the quality of returns, possible demand, cost of remanufacture etc. also plays an important role as to a firms decided disposition strategy, thus the sorting and assessing of returned materials becomes imperative (Tibben-Lembke, 2002; Dekker, 2004; Xiaoming & Festus, 2008; Pokharel & Mutha, 2009; Genchev, Richey & Gabler, 2011). To this end Dekker (2004) determines that there are two main types of recovery options; direct recovery where returns are immediately resold/redistributed/reused, and process recovery, where the returns have to endure some form of processing before reuse, or where products are recycled/cannibalized/sent to landfill.

RL Performance and JIT

When addressing JIT in the context of RL it became apparent that there has been little progress in terms of research or real world application. There have in contrast been a number of attempts to provide possible routes to increasing RL performance through other means, which can be split into two main categories. Firstly network design using mathematical modelling including facility location modelling, for examples see: Pishvaee, Kianfar & Karimi (2010), El-Sayed, Afia & El-Kharbotly (2010) and Samir (2008). However none of these capture a holistic representation of RL including all recovery options and variables (Zhou & Wang, 2008). The second category explores functional capabilities and IT as performance enhancing features, for instance both Lee & Chan (2009) and Karaer & Lee (2007) discuss the benefits that implementation of radio frequency identification (RFID) tags can offer to reverse logistics, whilst Daugherty *et al*. (2005) argue that a focussed resource commitment to RL information systems can increase economic and service quality performance. There have been attempts to apply JIT and lean practices to a reverse stream, for example Banomyong, Veerakachen & Supatn (2007) suggest an agile approach to downstream collections in conjunction with lean logistics methods being used upstream of the collection point, creating a "leagile" RL flow which both handles unpredictable demand, whilst reducing costs where possible. However, it is important to note that JIT is not the focus of this research. In contrast Chan, Yin & Chan (2010) look closely at the JITRL concept through an extensive literature survey, concluding that in doing so, performance enhancements are shown to be possible, however no primary empirical evidence is presented to validate their findings further.
A common feature in research on RL performance enhancement concerns the context to which it is aimed; thus far the primary focus has been on product returns management with little consideration of RL recycling practises for secondary packaging. This issue, in conjunction with the dearth of JITRL research has led to our two principle research questions:

- *Is implementation of JIT feasible within a secondary packaging RL recycling Stream?*
- *What are the possible performance implications of such an implementation of JIT?*

<u>Method</u>
The core of these research questions require a method that will lead to an understanding of *feasibility* and require observation around *performance*. To this end, the case study research method was adopted. This method was chosen as it enables the understanding of practices present within an organisation's daily operations as well as the way in which they are viewed by the people involved (Stake, 2000; Cassell & Symon, 2004). The study presented within this research represents that of a single case design, defining the case company as 'Company G'[1] and its RL activities as the unit of analysis, however within this, two levels of analysis take place, these being the retail and logistics sub-units within company G. The main reason for employing this multi-level analysis is highlighted by Seuring (2008) who posits that when using case study research in supply chain management, the inclusion of only one stage in the chain can negatively affect the whole study's validity.

Given that the objective of the data collection was to build a representative case study which explores the RL recycling environment within company G, which could be achieved using a relatively small sample. It was decided that a purposive sampling technique should be employed (Saunders, Lewis & Thornhill, 2009). Starting at the at the retail sub-unit first, looking back up the supply chain, it was concluded that three participants would offer sufficient depth if chosen correctly. Consequently the chosen retail units were indicative of Company G's most common store profiles, ranging from convenience store to Supermarket. The chosen participants are as follows: *R1: Store manager 1500 square foot, R2: Store manager 6000 square foot, R3: Store manager 13000 Square foot*. For the logistics sub unit the decision was made to include the logistics planning department as well as the department responsible for the second stage in the recycling chain (Warehousing) as both were of

[1] Company G is one of the top 5 UK Multiple Retailers. Analysis of operations at a large, medium and small 'local' type stores was undertaken to further underpin the representativeness of the sector within this research's case study structure

critical importance to adding contextual depth to the case. The participants for this sub unit are thus: *L1: Logistics Planner, L2: Warehousing Manager.*

The construction of the case study presented in this research was facilitated through the collection of primary qualitative data of a textual nature, thus relying on the interpretation of text to reveal descriptions of particular occurrences (Auerbach & Silverstein, 2003) and the emergence of operational phenomena and their underlying constructs (Jonsen & Jehn, 2009). Our research choice was made to use only semi-structured interviews, which as explained by Yin (2003) and Silverman (2004) are an essential source of information gathering for case studies. The semi-structured approach in conjunction with a well created interview guide informed by literature on JIT success factors enabled the ability to explore relevant topics whilst not conforming to a rigid set of questions (King, 2004; Saunders, Lewis & Thornhill, 2009).

Analysis of the qualitative data collected through the above interviews was conducted using template analysis as defined by King (2004). In its simplest form this can be described as a method for analysing and organising rich textual data according to themes through the production of representative codes (King, 2004). An important aspect of this technique is the production of a comprehensive thematically informed template which was developed prior to collection of primary data. This was done through the selection of *a priori* codes informed through a review of relevant literature. As the transcripts were analysed the template was amended accordingly via the introduction of supplementary second order codes throughout the iterations of interview analysis until a point of saturation was reached and agreed upon. The end point of the template analysis, which is merely the means of effectively summarising, categorising and making sense of rich and complex textual data, is the provision of a set of key themes which are apposite and prevalent as responses to the research questions. In this case, therefore, the findings from the analysis are the key themes which represent answers to our research questions relating to the feasibility and performance of JIT in RL recycling streams.

<u>Findings</u>

Process Dynamics

The collection process outlines that of a closed loop design previously described by Guide Jr *et al* (2003), containing simultaneous product delivery and waste collection at all retail units within a particular route:

> *"the products are offloaded and the driver picks up empty cages and the waste materials, then goes to the next store on his route, and so on then he returns to the depot" (L1).*

Once arriving at the RDC the materials and RPCs/empty roll cages are collected at a central collection point; the "De-Kit" area. Here the recyclates are sorted, bailed then loaded onto trailers owned by recycling companies, whilst reusable containers typified by roll cages and crates are sorted and redistributed to support forward flow operations.

There is a clear difference of opinion between logistics and retail participants. At retail level this process is considered to be low priority; it has no relevance to performance evaluation of either the retail units or the managers. At the logistics level it is considered a key process, due to the necessity of retrieving reusable transport equipment critical to continuing store replenishment activities.

Concerns surrounding quality, quantity and integrity of materials returning to the DC are sparse; all participants explaining that there are few requirements as to quality of returns from the retail to DC level. This lack of concerns was also evident in the analysis of interactions between the DC and recycling companies, where the main issue seems to be reducing moisture penetration in card bails.

Characteristics of Returnable Materials

Accumulated packaging waste differs from unit to unit; a fully supported idea between all retail level participants is that the waste created was influenced exclusively by replenishment activities and the unit's turnover. This means that there is little or no control at the retail level in terms of deciding the amount of returned recyclable materials or RPCs. This correlation between turnover and waste accumulation does have one important benefit in terms of predictability. Due to the high level of attention paid to forward flow product demand, all participants were confident on their ability (if required) to provide forecasts for reverse flow quantities, stating present volumes of waste materials sent back were relatively stable, with no significant deviations. Finally, looking at the demand for recyclables from the receiving companies, the process was described as being relatively passive with no requirement to supply specific volumes:

"the recycling companies just take whatever we give them" (L2).

Supportive Capacity

Storage capacity at retail units was highlighted as a major issue, especially for smaller stores, it is imperative that storage space is kept clear for safety stocks, thus returnable materials must be collected regularly. Upon discussion of the De-Kit area, two themes emerged, firstly the high capacity of the bailer with ample ability to process incoming materials, the second theme however, as outlined by both L1 and L2 is the limited docking capacity available for this function, this leads to frequent queuing prior to offloading returned materials:

"in the peak times we get quite a lot of queuing for returning vehicles" (L2)

Network capacity as outlined by L1, has a high degree of slack at certain points, notably in the early mornings and evenings following pm routes which are operationally dictated by fixed schedules to comply with driver regulations. It is also explained that there is a high degree of empty running within the network. Thus capacity is greater than the demand placed upon it.

Network and Control

The delivery and collections network is an 'in house' operation; Company G having complete control over vehicles and facilities. Decisions as to the frequency of deliveries to retail units are made centrally, with little or no involvement by the retail managers themselves, this as explained by L1 is because in order to attain high levels of performance from the network, a whole systems approach must be applied, where in contrast retail managers may only consider what would be best for their unit. There are exceptions made for particular retail units as to frequency and timing of deliveries however these are infrequent and most commonly are due to access and egress restrictions imposed by local unitary authorities:

"some stores have local authority restrictions imposed on them so we can only deliver to them at certain times of the day" (L1).

Communication and Information Systems

Looking first at direct communication between the retail units and the DC, a recurring theme is that there are modes to contact particular departments such as transport and warehousing, however retail participants explain that most of the communication is directed through a customer service line, thus there is little direct communication between retail units and logistics departments. As for DC to retail communication, there is a level of communication between the transport department and retail stores when timing issues are present or dynamic changes to the delivery schedule. Assessing the level of direct information links between retail and DC it is clear that little direct support exists, with electronic information being communicated to a central hub before dissemination to the relevant parties. Currently however, this system is not used for reverse material flows in any way.

Dynamic Capability

At store level, issues emerge regarding flexibility for facilitating dynamic operations; the rigidity of staffing protocols based on a tasking system creates an environment which does not allow dynamic operations to be accommodated without affecting primary tasks. Also, issues surrounding local unitary authority access and egress restrictions and, create time constraints within certain stores ability to dictate collection criteria. At the DC operational level flexibility to support dynamic running can be seen through heavy usage of agency staff within the De-Kit area:

"we use a lot of agency workers at De-Kit for that reason"(L2)

L1 explained there is already a level of dynamic operating present where the transport department make changes to planned routes in real time. Flexibility needs to be built into the network models which are currently created on a rolling six week forecast driven by contemporary data analysis, however, if this is done, there is a suggestion that more dynamically relevant operating can be achieved:

> "*I mean we would have to know in advance that that might be done because I would have to plan an extra hour or so into the route".(L1)*

Perceived Implications of JIT

The main issue discovered after an explanation of a potential shift towards JIT surrounded the duplication of movement within the existing network and the concern by all participants pertaining to possible cost implications. There were also secondary issues surrounding the use of human resources at retail level and risk to customer service for units with no rear loading access.

Discussion

Critical Success Factor Relationships: Supplier

Inhibiting factors currently acting against implementing JIT within company G's RL function concern the suppliers of materials i.e. the retail stores. These issues directly correlate to the ability and willingness to support the process and thus overall supplier cooperation (Ahmed, Tunc & Montagno, 1991; Prasad, 1995; René, 1999; Lai & Cheng, 2009). The most prevalent issue concerns the capacity at the retail level to produce and store materials in sufficient quantities to support the JITRL processes, due to the inability to control volumes produced, especially when considering smaller retail outlets. This represents a clear capacity imbalance between operational units within the system which could affect the suitability of applying JIT philosophies (Prasad, 1995). The willingness to support the process may also be inhibited due to the focus of the retail operations towards the forward flow (Chan, Yin & Chan, 2010), giving further attention to what is seen as nothing more than a passive process of little may prove difficult for retail level management. Nevertheless, this attitudinally-driven behaviour and mind-set at the retail end could be 'low hanging fruit' in a potential business process re-engineering to remove constraints (Mabin & Balderstone, 2003). Another issue can be seen in human resource availability to support the process; the risk outlined by respondents concerns the lack of available staff resulting in forward flow activities being left to respond to the needs of the reverse, although again, this may be an attitudinal constraint rather than an operational reality.

Transport Network

A key issue concerns the ability to access stores for collection at any time of the working day due to local unitary authority restrictions imposed on some units identified by Dowlatshahi & Taham (2009). This point is only relevant to certain stores and makes assumptions around fleet type / fleet availability. However it negatively affects both the suppliers ability to cooperate with the system as well as other critical factors such as network design and supplier delivery timing (Wafa & Yasin, 1998; René, 1999; Matson & Matson, 2007; Lai & Cheng, 2009) as it creates a level of unconditional inflexibility within the existing network and fleet which would have to be managed when planning JIT collections. The main consideration when assessing JIT viability from a transport perspective is the adaptability of the network to incorporate dynamic collections (René, 1999). This would mean facilitating dynamic elements while continuing a stable forward flow of product to stores. There are some potential facilitators present within Company G's current network, first of which is the empty running and wasted capacity during evenings; this in conjunction with flexibility which can be built into proactive network plans suggests a positive correlation with the network design factor (Prasad, 1995; Wafa & Yasin, 1998; René, 1999; Lai & Cheng, 2009). Another correlation is in the close locality of the retail units to the RDC, the issue of lead times and locality of suppliers is posited as an important element in the success of JIT (Ahmed, Tunc & Montagno, 1991; Prasad, 1995; Matson & Matson, 2007).

An important aspect of company G's current RL function at the levels explored in this research is the internal nature of their system, all operations are between two units of the same organisation with a centralised level of control over logistical decisions. This control removes some issues concerning supplier delivery timing and co-operation whist also satisfying other operational success factors identified by René (1999) such as supplier partnerships driven by obligated partnering of retail units to a particular RDC and JIT transactions, thereby increasing viability of application. A potential issue with this system is that no form of supplier selection or evaluation is possible (René, 1999). This leaves the DC in a position where it must anticipate RL customer demand and react with a degree of flexibility, albeit in a closed network system. We suggest that lessons learned from tier 1 and tier 2 forwards supply chains in the automotive industry may act as useful indicators (Bennett & Klug, 2012)

Supporting Elements

Company G's current lack of direct system articulation for RL creates a significantly negative relationship to such factors as communication (Prasad, 1995; Wafa & Yasin, 1998; René, 1999; Lai & Cheng, 2009), and information systems support (1995; René, 1999; Matson & Matson, 2007; Lai and Cheng, 2009) both of which are posited as critical to successful JIT implementation. However, prerequisite IT infrastructure is present but not currently being utilised for RL purposes. When considering the opportunity to 'do more with less' current information systems may support JITRL practices, for efficiency benefits (Daugherty *et al.*, 2005) without an increase in node complexity. By simply identifying waste as stock with a zero value SKU descriptor but a variable SKU component value, it would be possible to create dynamic visibility of recyclates within the system, allowing for a stable material flow to the RDC as well as providing invaluable information, informing decision making further on in the RL supply chain, an important factor giving increasing container costs West to East.

Consequences of JIT Application

Application of JIT practices to this operational environment has one potential negative implication; two separate JIT systems utilising the same transport fleet and being routed to the same stores independently at differing times of the day. This would directly contradict two of the seven classical *muda* wastes: unnecessary movement and waiting (Harrison & van Hoek, 2008). This issue however, may not be as damning as it appears; by the removal of reverse practices from the delivery network it would be possible to significantly increase turnaround times at the RDC, thus improving forward flow productivity, possibly allowing for a reduction of fleet size and type. This increase in efficiency is not exclusive to forward operations, the use of JIT practices would allow for the collection function to be carried out at specific periods during the day giving higher resource availability. This, coupled with increased waste visibility facilitated by information system use would allow for full loads to be collected and returned to the RDC, which enables maximum output of process equipment and staff for the reverse operation. There are also potential cost savings to be found within the RDC, by running bailing and RPC maintenance activities at full capacity through JIT deliveries the machinery, staff and space essential to the process will become more efficient, saving unnecessary operational running costs such as agency staffing, as well as further increasing resources for forward flow activities, most critically space.

Conclusion

This research has sought to assess feasibility of JIT / lean practices within a multiple retailer's downstream reverse logistics network for recyclable and reusable packaging materials. Through a contextual analysis of the organisation's RL function it can be seen that there is no definitive conclusion as to a distinctly the viability of JIT to the company's RL activities in their current forms. There are, however, clear indicators as to possible feasibility given that some negative correlations to critical JIT success factors such as communication and information system support are not finite and can be overcome through systems adaptation. A number of facilitating factors are also present within company G's operational infrastructure and RL context which lend themselves favourably to JIT application, notably centralised control of both entities, network capacity excess, network flexibility, basic quality requirements, locality and predictability of material volumes produced at retail level. Notwithstanding this, negatively correlating factors create unavoidable barriers to the success of JIT, but they are by no means insurmountable.

Of most concern is the capacity imbalance between what the RDC can process and the stores can supply, given that demand for waste materials from the recycling companies is passive but constant. This factor has serious implications for a traditional JIT system where demand triggers processing which triggers material supply (Sugimori *et al.*, 1977; Harber *et al.*, 1990; Mejabi & Wassserman, 1992; Chase, Aquilano & Jacobs, 2004; Sendil Kumar & Panneerselvam, 2007). The above issue would suggest that a less holistic application of JIT, with the adoption of JITP practices to support a stand-alone RL process with limited run times would be more applicable during initial implementation and development. A system such as this offers a number of performance and cost benefits for forward and reverse processes undertaken by the RDC, notably considerable reductions in operations costs for bailing, sorting and cleaning, as well as significantly reduced turnaround times for forward operations. Managed effectively, these benefits could offset the increased cost caused through duplicate movement within the network, whilst also increasing customer service in forward flow operations and overall network efficiency, allowing the organisation to move from its accepted operational flow.

We believe that our research may allow for the development of RL systems to a point where JIT paradigms become a central notion. The research does not call for, or indicate that wholesale and manifest changes are required, but that better decisions are made utilising existing IT systems, infrastructure, fleets, management and colleague teams. The development of operational systems within the JIT paradigms is not without empirical antecedent behaviour evidenced by the development and adoption of 'Little JIT' and 'Lean Supply'. The research presented is not without its limitations, nevertheless, it can be suggested from a generalisabilty perspective that within a similar environment where reverse material flows are determanistic, and throughput levels reach a consistent level, JIT application would create positive benefits to performance and customer service. Such applications could be made to other multiple retailers, or third party logistics providersdealing with both forward and reverse operations. It is clear that this paper has opened a novel avenue of investigation up and found compelling evidence to think differently about the operational management of RL systems.

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