The traditional logistics performance measures include ‘hard’and ‘soft’metrics. The first one treats quantitative measures such as order cycle time, fill rates and costs; the second deals with qualitative measures like manager’s perceptions of customer satisfaction and loyalty (Chow, Heaver, and Henriksson 1994; Fugate, Mentzer, and Stank 2010). The ‘hard’ metrics are easily computable with some simple mathematical expressions while the soft metrics require more sophisticated tools of measurement (e.g. Regression analysis, fuzzy logic, Data Envelopment Analysis, etc.). In this paper, we will refer to the ‘hard’ metrics as direct indicators and the soft ones as indirect indicators.

传统的物流绩效指标包括“硬”和“软”指标。 第一个处理定量度量，例如订单周期时间，完成率和成本； 第二个涉及定性指标，例如经理对客户满意度和忠诚度的看法（Chow，Heaver和Henriksson，1994； Fugate，Mentzer和Stank，2010）。 “硬”指标可以使用一些简单的数学表达式轻松计算，而软指标则需要更复杂的测量工具（例如回归分析，模糊逻辑，数据包络分析等）。 在本文中，我们将“硬”指标称为直接指标，将“软”指标称为间接指标

All direct indicators extracted from papers are classified according to four performance evaluation dimensions, commonly used in industries. Each indicator can be only assigned to a single dimension at time. These are: time (Chan and Qi 2003; Frazelle 2001; Gallmann and Belvedere 2011; Gunasekaran and Kobu 2007; Mentzer and Konrad 1991; Neely, Gregory, and Platts 1995; Spencer 1993), quality (Frazelle 2001; Gallmann and Belvedere 2011; Neely, Gregory, and Platts 1995; Stainer 1997), cost (Beamon 1999; Cai et al. 2009; Chan and Qi 2003; Keebler and Plank 2009; Mentzer and Konrad 1991; Neely, Gregory, and Platts 1995) and productivity (Chan and Qi 2003; Frazelle 2001; Gallmann and Belvedere 2011; Keebler and Plank 2009; Stainer 1997). We note that some works prefer to use flexibility instead of productivity as the fourth dimension (Beamon 1999; Gunasekaran and Kobu 2007; Neely, Gregory, and Platts 1995; Stainer 1997), defining it as the ‘ability to respond to a changing environment’ (Beamon 1999). However, flexibility may be intangible and difficult to measure (Gunasekaran and Kobu 2007) in some cases. We present in Section 4.2 that flexibility is preferably measured indirectly rather than directly. Consequently, in this section, productivity will be used as a dimension for direct warehouse performance indicators.

从论文中提取的所有直接指标均根据行业常用的四个绩效评估维度进行分类。每个指标一次只能分配给一个维度。这些是：时间（时间（Chan和Qi 2003; Frazelle 2001; Gallmann和Belvedere 2011; Gunasekaran和Kobu 2007; Mentzer和Konrad 1991; Neely，Gregory和Platts 1995; Spencer 1993）），质量（Frazelle 2001; Gallmann和Belvedere 2011; Neely，Gregory和Platts 1995; Stainer 1997），成本（Beamon 1999; Cai等2009; Chan和Qi 2003; Keebler和Plank 2009; Mentzer和Konrad 1991; Neely，Gregory和Platts 1995）和生产率（Chan Qi； 2003年； Frazelle，2001年； Gallmann和Belvedere，2011年； Keebler和Plank，2009年； Stainer，1997年）。我们注意到，有些作品更喜欢使用灵活性而不是生产力作为第四维度（Beamon 1999； Gunasekaran和Kobu 2007； Ne​​ely，Gregory和Platts 1995； Stainer 1997），将其定义为“对不断变化的环境做出反应的能力”。 （Beamon 1999）。但是，在某些情况下，灵活性可能是无形的且难以衡量（Gunasekaran和Kobu 2007）。我们在第4.2节中指出，柔韧性最好是间接而非直接衡量。因此，在本节中，生产力将用作直接仓库绩效指标的一个维度。

The following procedure is used for the classification. Initially, all the direct indicators found in the selected papers are listed. Once the list is completed, two types of aggregations are made: (i) similar indicators are regrouped; (ii) very specific metrics are included in more generic ones. One example of this second group is the work by Manikas and Terry (2010) mentioning the indicator ‘time of quality control in receiving’. This can be considered as a portion of the ‘receiving operation time’. Therefore, we include this indicator together with the class of indicators called the ‘receiving time’. Finally, the indicators are organised according to what they measure (time, quality, cost or productivity). We note that, for the sake of uniformity throughout this literature review, the classifications presented in this article are based on our interpretation, instead of the original category proposed by the selected papers. For example, Banaszewska et al. (2012) consider the ‘number of consignment processed per warehouse employee’ as a productivity indicator. Indeed, the measure is a productivity indicator. In this review, we propose a sub-category, called the labour productivity and Banaszewska et al. (2012) appears in this category (see Table A2). Another example is the article by Saetta et al. (2012), where the authors measure the customer satisfaction as ‘the percentage of orders on time’ and we classify the article under a broader indicator which is the ‘on time delivery’ (see Table A2). The results from this analysis are given in Table 5, which demonstrates all performance indicators comprised in a dimension. The third column of Table 5 shows the number of publications containing each specific indicator. The discussions about the results of Table 5 are presented in the next sections. Throughout the classification process, we have observed several problems: it is neither easy to draw straightforward frontiers for the indicators, nor the measurements are clearly defined. For example, we found two indicators with different names but measured the same way. Conversely, some metrics have the same name but they are measured differently. Moreover, whereas in some papers, the measurements are explicit; in some others, only the indicator’s names are given.

以下过程用于分类。最初，列出了在所选论文中找到的所有直接指标。列表完成后，将进行两种类型的汇总：（i）重新组合类似的指标； （ii）比较笼统的指标中包含非常具体的指标。第二组的一个例子是Manikas和Terry（2010）的工作，其中提到了指标“接收中的质量控制时间”。这可以视为“接收操作时间”的一部分。因此，我们将此指标与称为“接收时间”的指标类别一起包括在内。最后，指标根据它们衡量的内容（时间，质量，成本或生产率）进行组织。我们注意到，为了使整个文献综述一致，本文提供的分类是基于我们的解释，而不是所选论文提出的原始类别。例如，Banaszewska等。 （2012）将“每位仓库员工处理的托运货物数量”视为生产力指标。实际上，该度量是生产率指标。在本文中，我们提出了一个子类别，称为劳动生产率和Banaszewska等人。 （2012）出现在此类别中（请参阅表A2）。另一个例子是Saetta等人的文章。 （2012），作者将客户满意度衡量为“按时订购的百分比”，我们根据“按时交货”这一更广泛的指标对文章进行分类（参见表A2）。此分析的结果在表5中给出，该表演示了维度中包含的所有性能指标。表5的第三列显示了包含每个特定指标的出版物数量。关于表5的结果的讨论将在下一部分中介绍。在整个分类过程中，我们发现了几个问题：既不容易为指标绘制简单的边界，也很难清楚地定义度量。例如，我们发现了两个名称不同但测量方式相同的指标。相反，某些度量具有相同的名称，但是度量却不同。而且，在某些论文中，测量是明确的。在另一些情况下，仅给出指标的名称。

To address these issues, the next sections present indicator definitions in Tables 6–9. The definitions come initially from paper database. In the case where several definitions are found for a given indicator, we show both in the table (e.g. order lead time in Table 6). In the case where no definitions are given, we look for these definitions in Warehouse Education and Research Council (WERC 2008) database (available at www.werc.org) (e.g. picking accuracy in Table 7). Finally, when the definition is neither in the papers nor in WERC database, we defined the indicators based on the best common sense that we could infer from the literature and we refer to the authors that have used these measures in their papers. For example, in Table 7, cargo damage rate is used by Lu and Yang (2010) but the indicator is not explicitly defined by the authors. Thus, for the purpose of this work, we provide an indicator definition according to the described procedure, identified by ∗ symbol in the tables.

为了解决这些问题，下一节将在表6–9中介绍指标定义。这些定义最初来自纸质数据库。在为给定指标找到多个定义的情况下，我们在表中都显示了这两个定义（例如，表6中的订单提前期）。在未给出定义的情况下，我们在仓库教育与研究理事会（WERC 2008）数据库（可从www.werc.org获得）中查找这些定义（例如，表7中的拣选准确性）。最后，当定义既不在论文中也不在WERC数据库中时，我们根据可以从文献中推断出的最佳常识来定义指标，并请参考在其论文中使用这些度量的作者。例如，在表7中，Lu和Yang（2010）使用了货物损坏率，但是该指标并未由作者明确定义。因此，出于这项工作的目的，我们根据所描述的过程提供了一个指标定义，在表中以\*符号标识。

Analysis of the direct performance indicators In order to provide well-defined boundaries for the warehouse indicators, the result of indicators in Table 5 and their respective definitions (Tables 6 up to 9) are further analysed using an activity-based framework. Consequently, the indicators that are classified in Section 4.1, according to quality, cost, time and productivity dimensions, are now also classified in terms of warehouse activities described in Section 3.2. The result of this new classification is illustrated by Table 11. In order to classify the direct indicators with respect to the warehouse activities, we defined three types of direct indicators: • Specific Indicators: are defined specifically for an activity. • Transversal Indicators: are defined for a process rather than a unique activity. Therefore, their boundaries are also defined for a group of activities. • Resource related Indicators: Some direct indicators are related to the resources used in the warehouses. We divide them into two distinct categories: Labour and Equipment/Building

直接绩效指标的分析为了为仓库指标提供明确的界限，使用基于活动的框架对表5中的指标结果及其各自的定义（表6至9）进行了进一步分析。因此，根据质量，成本，时间和生产率维度在第4.1节中分类的指标现在也按照第3.2节中所述的仓库活动进行分类。表11说明了这种新分类的结果。为了对与仓库活动有关的直接指标进行分类，我们定义了三种直接指标：•特定指标：专门为一项活动定义。 •横向指标：是为流程而不是唯一活动定义的。因此，还为一组活动定义了它们的边界。 •与资源有关的指标：一些直接指标与仓库中使用的资源有关。我们将它们分为两个不同的类别：人工和设备/建筑

In Table 11, we propose a mapping for both the specific (on the upper half of the table) and transversal indicators (on the lower half) on the warehouse activities. The activities are given on the columns. Although inventory is not a warehouse activity, we choose to include inventory as an activity in Table 11 due to its importance in warehouse management. Gallmann and Belvedere (2011) state that companies consider inventory management as a key to achieve excellent service levels. We also observe numerous metrics treating the subject (see Section 4.1). On the rows of Table 11, the reader can observe the previous dimensions of classification (time, quality, cost and productivity). Each direct indicator is then placed in the related cell in the table. For example, ‘order picking time’ is a time indicator which is specific to the picking activity.

在表11中，我们建议针对仓库活动的特定指标（在表的上半部分）和横向指标（在下半部）进行映射。 这些活动在各列中给出。 尽管库存不是仓库活动，但由于其在仓库管理中的重要性，我们选择将库存作为表11中的活动。 Gallmann和Belvedere（2011）指出，公司将库存管理视为实现出色服务水平的关键。 我们还观察到治疗该受试者的众多指标（请参阅第4.1节）。 在表11的行上，读者可以观察到以前的分类维度（时间，质量，成本和生产率）。 然后，将每个直接指示器放置在表中的相关单元格中。 例如，“订单领料时间”是特定于领料活动的时间指示器。

In the lower half of Table 11, we illustrate the direct transversal indicators. Chan and Qi (2003) have defined that the inbound logistics concern both the materials transportation and the storage; while outbound logistics involve the outbound warehousing tasks, transportation and distribution. Based on this idea, the inbound process covers both receiving and storage activities, and are named as ‘Inbound Processes’ in Table 11 while picking, shipping and delivery activities are regrouped under ‘Outbound Processes’. Inventory is considered as an internal process in this case linking inbound to outbound processes. The indicators are then placed according to the extent of their boundaries. For example, the transversal indicator ‘Dock to stock time’ is classified as an inbound indicator encompassing receiving and storage activities. ‘Order lead time’ is an outbound indicator, covering picking, shipping and delivery activities. Here, we classify the ‘queuing time’ as global to all warehouse activities since it can be measured either for any type of activity or for all activities.

在表11的下半部分，我们说明了直接横向指标。 Chan and Qi（2003）定义了入库物流既涉及物料运输又涉及仓储。出库物流涉及出库任务，运输和分配。基于此思想，入站流程涵盖了接收和存储活动，并在表11中被称为“入站流程”，而提货，运输和交付活动则被重新组合到“出站流程”下。在这种情况下，库存被视为内部流程，将入库流程链接到出库流程。然后根据指示器的边界范围放置指示器。例如，横向指标“停靠到库存时间”被归类为包含接收和存储活动的入站指标。 “订单提前期”是一个出站指标，涵盖了提货，运输和交付活动。在这里，我们将“排队时间”归类为所有仓库活动的全局时间，因为它可以针对任何类型的活动或所有活动进行度量。

In the lower half of Table 11, we illustrate the direct transversal indicators. Chan and Qi (2003) have defined that the inbound logistics concern both the materials transportation and the storage; while outbound logistics involve the outbound warehousing tasks, transportation and distribution. Based on this idea, the inbound process covers both receiving and storage activities, and are named as ‘Inbound Processes’ in Table 11 while picking, shipping and delivery activities are regrouped under ‘Outbound Processes’. Inventory is considered as an internal process in this case linking inbound to outbound processes. The indicators are then placed according to the extent of their boundaries. For example, the transversal indicator ‘Dock to stock time’ is classified as an inbound indicator encompassing receiving and storage activities. ‘Order lead time’ is an outbound indicator, covering picking, shipping and delivery activities. Here, we classify the ‘queuing time’ as global to all warehouse activities since it can be measured either for any type of activity or for all activities.

We note that the boundaries of indicators as described in Table 11 depend on warehouse production processes. Table 11 is created following a make-to-stock environment. A warehouse which operates on a no storage strategy (e.g. crossdocking) could define the boundaries of the indicators differently. The operating strategies impact mainly the transversal indicators. One example is the order lead time. If a make-to-order system is considered, the customer order would start upstream (in the supply process) and not at the picking activity.

我们注意到，表11中描述的指标范围取决于仓库的生产过程。 表11是在按库存生产环境后创建的。 采用无存储策略（例如交叉对接）的仓库可以不同地定义指标的边界。 操作策略主要影响横向指标。 一个例子是订单提前期。 如果考虑按订单生产系统，则客户订单将在上游（在供应过程中）而不是在拣配活动处开始。