哈爾濱工業大學

本科毕业设计（论文）外文文献翻译

专　　业 数据科学与大数据技术

学　　生 卢兑玧

学　　号 L170300901

指导教师 范国祥

日　　期 2022.6.08

外文文献译文

人力资源和制造业绩效:世界汽车工业的组织逻辑和灵活的生产体系，劳资关系检讨

MacDuffie，J.P.，Human Resource bundles and Manufacturing Performance：Organizational Logic and Flexible Production System in the World Auto Industry，Industrial and Labor Relations Review，1995：48：2，197-221.

摘　要

作者利用 1989—1990 年对 62 家汽车装配厂进行的调查中得出的唯一国际数据集，测试了两种假设:创新的人力资源实践不是单独影响绩效，而是作为内部一致的人力资源″捆绑″或系统中的相关因素影响绩效; 以及这些人力资源束对装配工厂生产率和质量贡献最大。在灵活的生产体系″结构逻辑″下,当它们与制造业政策相融合时,其自然性就会显现出来。 调查数据的分析，测试了代表不同的人力资源和制造业实践的三种指数，支持了这两种假设。以团队为基础的工作系统、″高承诺″的人力资源实践（如意外补偿和大量培训）以及低库存和维修缓冲区的生产工厂一直优于大批量生产工厂。 捕获实践捆绑中的双向和三向交互的变量是性能更好的预测变量，支持集成假设。

尽管有人声称创新人力资源（HR）实践可以提高企业水平和国家竞争力，但很少有研究能够实证地证实这种关系，更有甚者系统地描述这种关系最强的条件。 尽管这一研究流中的一些问题是经验性的（比如，不可靠的措施和不足的控制），但更根本的障碍是概念性的。 创新的人力资源实践常常被研究为真空状态，人们更多地关注孤立个别实践的效果，而不是理解不同的人力资源实践如何相互影响，或者它们如何与业务职能和战略挂钩。 本文以 1989~1990 年 62 家汽车装配厂为对象,利用一套独特的国际数据集,测试了人力资源实践和经济绩效之间的关系。 我调查了一个假设，即″捆绑″了相互关联和内部一致的人力资源实践，而不是个别实践，是研究绩效联系的最佳分析单位，因为它们创造了支持员工激励和技能获取的相互强化多重条件。 此外，我考察了亚瑟（1992 年）和科昌（1991 年）提出的假设，即人力资源束或系统必须与核心业务职能（从而与公司总体业务战略）的互补性捆绑相结合才能有效。 我在这里指出，灵活的生产系统具有独特的″组织逻辑″，它将大量人力资源实践与制造实践结合起来，追求生产率和质量的同时提高。 灵

活的生产工厂降低了库存水平和其他"缓冲区"，增加了生产过程的相互依赖性，并突出了生产问题。 有效处理这些问题需要有干劲、技术熟练、适应性强的工人。 通过减少缓冲区与发展这些劳动力特征相结合，灵活的生产系统创造了创新人力资源实践最有可能产生有效经济绩效的条件。 这一论点与最近的工作（卡佩利和辛格 1993、科古特和桑德 1992、佩弗 1994）是一致的，认为人力资源可以成为企业可持续竞争优势的主要来源。 员工对产品、流程和社会互动模式的了解可能比容易购买的技术能力更难模仿。 专注于一个特定的行业背景，即汽车装配，为检验这一论点提供了许多优点。 关于这一课题的实证工作常常依赖于建立层次的人力资源实践的二分方法和公司层次的绩效财务指标。 这些措施可能相当不可靠，特别是在各个行业，并且分析水平也各不相同。 本研究所用的装配厂数据集包括更可靠、更符合上下文情况的在共同分析层面上衡量绩效和人力资源实践,以及可能影响制造绩效的控制变量,如技术和产品的复杂性。

过往研究

本文从两个方面对汽车工业进行了广泛的过去研究。 它比之前对比大规模和灵活生产（比如沃马克·琼斯（Womack Jones，Roos 1990）、麦克杜菲（MacDuffie）和克拉菲克（Krafcik 1992）的描述性工作更深入地探讨了人力资源在生产体系"组织逻辑"中的作用。 尽管大规模和灵活（或"精益"）生产系统在管理人力资源方面需要不同的方法，但沃马克等人并没有解释人力资源实践如何融入这些不同的生产系统，也没有测试人力资源实践与绩效之间的关系。 事实上，Womack 等人使用的"精益生产"一词恰当地抓住了缓冲区的最小化，但却忽视了在这种方法下解决问题的劳动力技能和概念知识的扩展。 这些"丰富"的人力资源能力在灵活性方面得到了更好的描述。 本文还涵盖了生产系统社会和技术方面的更多互动，而不是过去的工业关系研究（如卡茨、科赞和戈培尔 1983 年、卡茨、科赞和韦伯 1985 年、卡茨、科赞和基夫 1988 年）。 这些早期论文的作者得出结论，QWL 活动对工作组织、过程改进和技能开发几乎没有任何影响，因此对工作表现的影响很小。 但他们缺少关于生产系统的数据来验证这一假设。 1988 年的论文将调查范围扩大到团队价值，发现团队与绩效有负面的联系。 然而，只对一家公司的工厂进行研究，在这些工厂中，采用团队与生产政策的更广泛的变化没有联系。 此外，这些作者没有衡量一系列实践，而是评估了个别实践，这有可能遗漏了总体人力资源系统之间的差异。 这里强调社会制度与生产技术特征之间的关系，符合社会技术体系理论的传统（1951 年特里斯特和班福思，1976 年埃默里和索鲁德，1988 年帕斯莫尔）。 然而，我对这一关系的看法与 STS 理论大相径庭。 STS 理论的特点是,自主工作队是代替泰勒主义方式,在任何技术环境下都处于优势的工作组织。 因此，STS 组织设计试图从技术系统的约束中最大限度地提高工作组的自主性，通常通过为技术系统添加缓冲。 与此形成鲜明对比的是,本文探讨了扩大员工技能的人力资源实践与尽量减少缓冲区的生产实践相结合的问题。 例如，在沃尔

沃著名的 Uddevalla 工厂，有人预言取消移动装配线和引入整车团队装配是替代灵活生产的有吸引力的替代品（Bergren 1992）。 但正如阿德勒和科尔（1993 年）所指出的那样，尽管乌德瓦拉强调团队自主性（以及使用各种缓冲来保护这一自主性）可能有助于个人和团队学习，但它限制了组织学习和整体系统的改进。 尽管本文无法解决这一争论（Uddevalla 于 1993 年春天关闭，部分原因是担心其经济表现），但它确实验证了一个假设——即缓冲削减与创新人力资源实践如何与经济表现挂钩——这与 STS 的预测背道而驰。

灵活生产的"组织逻辑": 整合一系列实践

创新的人力资源实践只有在满足三个条件时才能促进经济绩效的改善:员工拥有管理者所缺乏的知识和技能; 员工被激励通过自由裁量行动运用这一技能和知识; 当雇员作出这些酌情努力时取得的成就（莱文和泰森 1990 年;贝利 1992 年）。 我主张,要想提高人事调动业绩,必须具备这三个条件。 技术熟练、知识渊博、没有干劲的工人不太可能做出任何自由裁量的工作。 缺乏技能或知识的有干劲的工人可以自由裁量工作，而对工作表现影响不大。 即使创新的人力资源实践造就了高技能、有干劲的工人，人力资源体系也必须与公司的生产战略相结合，以便自由裁量工作能够被适当地引导到绩效改善上来。人力资源实践的"捆绑"概念对于评估这些条件是否能够（以及如何）实现至关重要。 企业通常将人力资源实践组织成与其文化和商业战略相一致的体系（1987 年奥斯曼、布洛克、克莱纳、罗姆金和萨尔斯堡）。 而是将实践捆绑在一起而不是单独地结合在一起，形成了经理和员工之间以及员工之间的互动模式（库彻-格申菲尔德 1991）。 因此，关注个人人力资源实践对绩效的影响的研究可能会产生误导性结果，单一实践就能捕捉到整个人力资源体系（伊奇诺夫斯基、肖和普伦努西 1993）的影响。 此外，一系列相互关联、重叠的人力资源实践为工人提供了几种获得技能的方法（如脱产和在职培训、轮岗、问题解决小组）和多种激励措施，以提高激励（如基于绩效的薪酬和来自参与者的内在回报）。有决策能力及良好的工作设计)。 哈克曼（Hackman，1985）写道，表现可能是"过度确定的现象，是多个非独立因素的产物，这些因素的影响部分取决于它们冗余的事实。 " 现在，对捆绑或系统观点有充分的经验支持。2 灵活生产的"组织逻辑"将一揽子制造业实践（与缓冲区最小化相关）和一揽子人力资源实践（与劳动力技能和激励的扩大相关）联系起来。" 每个捆绑都由相互关联、内部一致甚至重叠的实践组成。 这两个捆绑是互补的，因为它们影响了一个工厂的操作，但相互强化。 因此，这里的"组织逻辑"指的是一种系统性质，它对这些捆绑内部的一致性施加了强大的拉力，并且在这些捆绑内部的一致性以及它们之间的互补性关系（捆绑内部的一致性和捆绑内部互补性的存在程度当然是一个需要实证研究的问题）。

缓冲区

在大规模生产中，生产过程（销售波动、供应中断、设备故障）的破坏阻碍了规模经济的实现。 因此,在生产系统中增加了追加库存或修理空间等缓冲材料。 这些缓冲实质上造成组织松懈，作为应对突发事件的储备。 但在灵活生产下，这些缓冲区由于几个原因而显得成本高昂。 首先，缓冲区代表的是不直接用于生产的资源承诺。 特别是库存缓冲区在存储和处理上成本很高，并且会阻碍从一个产品设计转移到另一个产品设计。 最重要的是，缓冲区可以隐藏生产问题。 库存积压较多时,可以简单地报废更换有缺陷的部分。 但是，当库存非常低时，就像及时库存系统那样，一个坏部分立即引起人们的注意，并且必须加以处理，以防止生产系统崩溃。 由于现货库存缓冲器小,批量小,因此,如果通过″下游″程序发现问题,几乎没有不良零件需要废弃。 缩小最终修复面积也会产生类似的效果，因为一旦缺陷水平升高，一小块面积就会迅速溢出。 缓冲区的最小化是一个控制或反馈功能，为生产问题提供了有价值的信息（奥诺 1988; 肖恩伯格 1982）。

人力资源能力

从历史上看，在大规模生产下，工人被雇来执行狭义的手工任务，几乎不需要技能，并且被视为可互换部件。 虽然离职率很高,但为了能让非熟练劳动者快速学习,将更换劳动者的费用降到最低。 缺勤率很高，但建立了公用事业工人的缓冲区来提供覆盖。 动机很低，但监管人员的密切监督和效率工资确保了充分的工作努力。 人们并不指望工人会考虑工作，事实上，他们对此感到灰心丧气。 批量生产经理最关心的是防止生产配额达到的干扰，他们开发了各种缓冲材料，部分是为了防止劳动力问题（岛田和麦克杜菲 1986 年）。 相反，灵活的生产使工人能够在生产体系中扮演更核心的角色。 要找出问题并解决问题，工人必须对生产过程和分析技能有概念的把握，才能找出问题的根源。 为了形成生产系统的综合概念,需要从专门检查员和工程师到车间组,通过质量检查、设备维护、职务明细、统计过程控制(SPC)等生产责任的分散化,劳动者直接遇到问题。 培养解决问题的技能需要多种多技能实践，包括广泛的脱产和在职培训、几项广泛的工作分类、允许团队内部和跨团队之间轮换工作以及″离线″小组解决问题活动（如员工参与小组或质量圈子）。 在灵活的生产条件下，工人所培养的多种技能和概念知识，除非工人有动力去贡献精神和体力，否则没有什么用处。 只有当工人们相信自己的个人利益与公司利益一致，并且公司会对他们的福利进行互惠投资时，他们才会贡献自己的自由裁量努力解决问题。 因此，灵活生产具有就业保障、部分取决于绩效的薪酬和减少管理人员和工人之间的地位壁垒等″高承诺″人力资源政策的特点。 公司对工人技能的投资也促成了这种相互承诺的″心理契约″（1979 年科尔; 1992 年）。

缓冲器和人力资源之间的联系

缓冲和人力资源政策的互补性是大规模生产与灵活生产的"组织逻辑"的关键。 在批量生产中,利用缓冲器为大量生产创造稳定的条件,在这种条件下,所有投入都可以以最大的效率进行优化,这被生产工人视为可互换部件所补充。 那些没有预料到会思考的工人，尽管他们的技能和动机很低，但他们的预期贡献却可以获得，他们完全可以与技术最优化的生产系统相匹配，这种生产系统本不应该停止，而应该将改造控制在最低限度。 为了灵活生产,缓冲最小化和人力开发之间的联系是由在日本被称为"开城"的持续改善哲学驱动的。 从开城的观点来看，问题就是改善的机会（今井 1986 年）。 正是这种理念支撑着组织愿意接受"精益"缓冲区的脆弱性和当它们变得可见时处理问题的压力——即使这意味着停止生产线，这在大规模生产中是不可想象的。 这种理念还指导了工作人员解决问题的能力的发展。 从某种意义上说，灵活的生产将应对突发事件的能力从技术体系（缓冲器提供"以防万一"的保护）转移到人力资源体系中，人力资源体系通过开发学习能力来应对突发事件（麦克达菲 1991 年、阿德勒 1992 年、西口 1993 年）。 哲学的另一个关键区别与生产系统的结果有关。 在大规模生产"逻辑"下制造的传统智慧认为生产率和质量目标之间必须权衡。 缓冲器的使用以生产率为依据是合理的，因为它可以防止大量生产的干扰，并且可以预期一定程度的质量缺陷。 相反，在灵活的生产条件下，生产率（努力最小化）和质量（缺陷最小化）被视为互补目标。 灵活生产的这一特点也与缓冲的减少和问题解决能力的培养有关。 如果没有缓冲器，任何缺陷都会使整个系统陷入停顿，因此有很强的激励将质量缺陷推向零。 如果问题可以追溯到根本原因并消除，那么停止生产线的处理可以最终提高正常运行时间和生产率。 解决问题的努力不仅限于质量问题。在灵活的生产下，工人和工程师也将他们的解决问题的能力用于随着时间的推移而提高设备性能的任务——蒙登（1983 年）认为这一过程是"给机器带来智慧"。 因此,生产技术不必自动受到衰败和贬值的影响,而是可以随着时间的推移而实际增值。 同一原则适用于所有工作规格。 虽然生产岗位的基本结构由工程师决定，但生产岗位的团队有责任开发、记录和修改岗位规范，这个过程被称为"标准化工作"。 这些规范与任何工业工程时间研究一样详细，但关键的区别在于工人而不是管理者或工程师来负责他们的修订工作。(阿德勒 1993;科尔 1992) 因此，将精益缓冲区与丰富的人力资源联系起来产生的解决问题的能力可以通过提高识别质量问题的根本原因的效率、帮助更有效地使用技术以及改进工作规范来帮助提高工作绩效。

运用组织逻辑: 测量问题

上述讨论表明，应该衡量一系列做法，以捕捉生产系统的"组织逻辑"。 这就引出了四个重要的测量问题:（1）什么是"捆绑"？（2）捆绑的实践应该如何组合？（3）捆绑的实践如何从经验上加以验证？ 及(4)如何界定不同实务范畴之间的关系?

Table 1. Innovative Human Resource Practices and Their Link to the Conditions for Economic Performance.

Innovative HR Practice	*Skill/ Knowledge*	*Motivation/ Commitment*	*Integration of HR with Production System, Strategy*
Work Systems Index			
Work Teams	X	X	X
Problem-Solving Groups (Employee Involvement or Quality Circle groups)	X	X	X
Employee Suggestions Made and Implemented	X	X	X
Job Rotation	X		X
Decentralization of Quality-Related Tasks	X		X
HRM Policies Index			
Recruitment and Hiring	X	X	
Contingent Compensation		X	X
Status Differentiation		X	
Training of New Employees	X	X	
Training of Experienced Employees	X	X	

选择包袱

研究人员为创新型人力资源实践开发了许多类型（见 1992 年贝利总结），按其对激励、技能发展或工作结构的影响分类。 但是，由于任何单一实践都可能在总体人力资源体系中扮演多方面的角色，因此没有明确的概念基础将影响激励的实践与影响技能的实践区分开来。 例如，工作团队代表工作组织的重组，将人力资源更充分地融入生产体系，但同时也发展了工人技能，影响激励和承诺。 在这项研究中，关于人力资源束的选择始于问卷的设计。 以广泛的现场调查为基础,开发出了哪些 HR 政策最明确地区分批量生产体系和灵活生产体系的问题。 大多数问题都与工厂层面的车间活动密切相关，因此排除了许多企业层面的人力资源政策。 此外,我选择了在国际样品中任何工厂中可能实施的测量方法,因此不包括与某一特定公司或国家专属相关的测量方法。 例如，衡量日本和其他国家普遍存在的团队、质量圈、工作轮换等实践，但日本特有的年薪制、国家评价制、企业工会、终身雇佣等其他实践则不然。 对于那些被测量的做法，我接着区分那些影响工作组织和执行工作任务的方式（称为工作系统）和那些反映影响各级员工的公司级人力资源政策（称为人力资源政策）。 奥斯特曼(1994)在工作组织惯例和支援人力资源管理制度方面也作了类似的区分。 表 1 显示这两类人力资源实践如何与上述三种经济表现条件中的某些或全部联系起来:工人技能和知识;工人激励;以及人力资源实践与坚定战略相结合。

将实践捆绑在一起

在″捆绑″概念中隐含的概念是捆绑内的实践是相互关联的、内部一致的，并且由于多种实践重叠和相互强化的影响，在绩效影响方面″更多更好″。 虽然一揽子实践的综合影响可以用多种方式加以规定，但两种简单的替代方案是加法法和乘法法。 在这两种方法

之间选择提出一个问题，即整个束应被视为等于或大于部分之和。 出于统计和概念上的原因，我使用加法方法来组合实践。 从统计学上讲，加法运算组合具有一个理想性质，即正态分布的可变分数之和仍然为正态分布，这对于乘积是不正确的。 从概念上讲，乘数关系意味着，如果没有单一的组织实践，"捆绑"得分（和效果）应该为零。 考虑到没有确切的理论基础来确定哪些实践意味着"组织逻辑"，这一标准过于严格。 尽管一揽子实践是相互关联的，但缺少一个特定的实践并不能根除所有其他实践的效果，反而会削弱这一揽子实践的净效果。(奥斯曼[1994]采用这种方法;参见第 176 页)

验证包

可以使用三个统计过程——每个过程都有优缺点——来验证概念上定义的"捆绑":可靠性分析、因子分析和群集分析。 可靠性分析可以评估捆绑在一起的变量之间的相互关系——如果分类实践的概念基础强，则有利;如果分类实践不强，则不利。 因子分析最适合于识别尺度中一组项目之间的相互关系，它们都是为了测量同一结构而设计的。 它不太适合评估一个"捆绑"，它不是规模，而是由一组相互关联的变量组成的指数（DeVellis 1991），每个变量代表一个不同的结构。 群集分析把在多维空间中接近给定一组变量的观测（在此情况下为植物）分组。由于不同的聚类算法会产生不同的聚类,而且所有的聚类算法都会找到某种类型的聚类,因此,测试不同的聚类解并选择在统计学上最明显的聚类解是非常重要的(Everitt 1980、Aldenderfer and Blashfield 1984、Ulrich and McKelvey 1990)。

检查捆绑之间的相互作用

束之间的相互作用也可以建模为加法关系或乘法关系。 在这里，我认为乘法假设更有意义，因为捆绑的概念化是互补的。 "组织逻辑"的观点认为，减少缓冲的政策只有在人力资源政策在劳动力中培养解决问题的能力和激励的情况下才会有效，而光靠这两套政策都是无效的。 这里将通过两种方式捕捉到三个操作包（使用缓冲区、工作系统和人力资源管理政策）之间的乘数关系——用总体生产组织指数（POI）作为三个操作包的分数之积，用双向和三向乘数交互术语。 另外,将乘法 POI 与平均 3 个指数的加法 POI 进行比较,评价关于捆绑间相互关系的假设。

方法论

样本

国际装配厂研究是由麻省理工学院的国际汽车项目（IMVP）赞助的。 作者和约

翰·克拉菲克联系了 90 家装配厂，代表 16 个国家的 24 家生产厂，约占全球装配厂总产量的 60%。 在 1989 年和 1990 年初期间,70 家工厂收到了调查答复。 这些工厂分为"体积"和"豪华"两类（后者被定义为生产 1989 年美国基本价格超过 23,000 美元的汽车工厂），其前提是这些产品类型的生产体系可能存在很大差异。 本文收录了 62 卷工厂的数据，调查比较完整。 表 2 按区域类别列出 62 株植物的分布情况。 不同地区的植物比例与全球产量比例密切相关，日本植物在日本的比例略显不足，新入境者和澳大利亚植物比例过高。选定工厂是为了实现地区、企业的均衡分配,反映各参与企业内的多种成果,最大限度地减少选择性偏向的可能性。 表 3 列出了具有描述性统计量的从属、独立和控制变量。

问卷管理及资料收集

问卷被寄给联络人,通常是工厂经理,他们向有关的部门经理或员工小组派发不同的组别。 工厂和公司被保证完全保密，作为他们的参与回报，他们收到了一份反馈报告，将他们的反应与不同地区的平均分数进行比较。 1987 年至 1990 年,其中一名研究员访问了 90 家工厂。 早期访问提供了现场观察，这成为装配厂调查问卷的基础。 其中一些工厂也被用于试运行问卷。 对于退回问卷的 70 家工厂,在收到问卷后,经常会进行访问,提供填写遗漏数据的机会,明确回答不明确或不一致的问题,并进行面谈,帮助日后对数据分析的理解。 在收到问卷之前访问时,为了提高数据准确度,还通过电话和传真进行了同样的后续处理。

Table 2. Composition of the Volume Assembly Plant Sample.

Regional Category	*n*
Japan (J/J)	8
Japanese-Parent Plants in North America (J/NA)	4
U.S.-Parent Plants in North America (US/NA)	14
Europe (All/E)	19
New Entrants, Including Korea, Taiwan, Mexico, and Brazil (All/NE)	11
Australia (All/Aus)	6
TOTAL	62

Source: International Assembly Plant Study.

措施依赖变量劳动生产率。

劳动生产率定义为在给定的装配厂制造车辆所需的实际劳动时间,通过 Krafcik(1988)所开发的方法论来调整工厂间的可比性。6 生产力方法论关注一组在调查中的所有工厂中通用的标准活动,以控制不同工厂之间的差异。垂直整合中的租赁。 大型车辆比小型车辆组装需要更多的努力,因此为了标准化车辆尺寸而进行了调整。 为了规范焊缝的数量，还

进行了调整，这些调整因设计不同而不同，因此会影响车体车间工头数量。 劳动时间也因缺勤而调整，原因有二:一、研究侧重于制造车辆所涉及的劳动努力（不包括人工总成本），不包括为弥补缺勤而雇用的额外雇员; 二、缺勤率可能受国家及社会福利政策的影响较大。控制工厂管理。 这是一项保守的调整，因为缺勤率在生产率最高（日本）的国家最低，在生产率中等的美国最低，而在生产率最差的国家（各种欧洲和新工业化国家）最高。 质量问题 这项质量指标源自 1989 年 J.D.对美国新车购买者的调查。 功率。该变量测量每 100 辆汽车的缺陷数量，并调整以只反映装配厂可能影响到的缺陷，即省略与发动机或变速器相关的缺陷，同时强调车身面板的安装和漆面质量以及电连接的完整性。 1988 年)。

Table 3. Descriptive Statistics: Dependent and Independent Variables.
(n = 62 Except for Quality, for Which n = 46)

Variable Name	*Mean*	*S.D.*	*Description*
Dependent Variables			
Productivity	33.1	12.4	Labor productivity, defined as hours of actual effort required to build a vehicle
Quality	78.4	31.2	Consumer-perceived quality, defined as defects per 100 vehicles, from J.D. Power
Independent Variables			
Production Organization Index	45.9	20	Index capturing "organizational logic" of the production system; simple average of the three component indices listed below
Use of Buffers	56.1	23.9	The degree to which production operations are buffered against potential disruptions
Work Systems	31.9	23.3	Work structures and policies that govern shop floor production activity
HRM Policies	47.3	26.0	Organization-wide HR policies that affect employee commitment and motivation
Total Automation	24.0	14.0	Overall automation stock, defined as % of direct production steps that are automated
Production Scale	904.4	639.9	Average number of vehicles built during a standard, non-overtime day
Model Mix Complexity	30.9	21.3	Mix of different platforms and models at a plant
Parts Complexity	56.5	23.5	Variation in the number of wire harnesses, exterior colors, engine/transmission combinations; number of assembly area parts; percentage of common parts across vehicles; and number of suppliers of assembly area parts
Product Design Age	4.6	3.2	Weighted average number of years since a major model introduction for each product

Source: International Assembly Plant Study.

措施无关变数

生产组织措施。 为了实现灵活和批量生产系统的"组织逻辑"的操作，我开发了三个组件索引——缓冲器的使用、工作系统、人力资源管理政策和一个总体生产组织索引。这些指数所包含的变量既反映了在装配厂问卷中应该包含哪些内容的选择，也反映了旨在提高每个指数内部可靠性的统计测试。 三个成分指数中的每一个由以下描述的多个变量组成。 所有变量都是通过转换为 z 分数来标准化，然后加法组合成索引。 指数中的每个变量都得到相同的权重，因为我觉得分配微分权重没有明确的概念基础。 为了便于解释,对各成分指数的合计 z 分数进行线性变换,使 0 是样本分数最低的植物,100 是分数最高的植物。 这些指数的有效性将在下一节中描述。

(i) 缓冲区的使用。 该指数衡量一组生产实践，这些实践表明缓冲区（如进货和现货库存）的总体生产理念，低分表示"缓冲"系统，高分表示"精益"系统。 它包括三个项目:

- 用于最终装配修理的空间（以平方英尺为单位），占总装配面积平方英寸的百分比。

- 在油漆和装配区之间在工程缓冲区的平均车辆数量，占一次轮班生产的百分比。

- 库存平均水平,以天为单位,对八个关键部分的样本,以每个部分的成本为加权值。

(ii)工作系统。 本索引从正式的工作架构和工作责任的分配,以及雇员参与与生产有关的问题解决活动的角度,均显示工作组织的方式。 该变量的分数低的话,表示"专业化"的分工较窄的工作体系,高分表示"多技能"的方向。 它包括六个项目: - 正式工作队所涉及的工作人员的百分比。

- 参与雇员参与小组的工作人口百分比-每名雇员收到与生产有关的建议数目。

- 与生产有关的建议所占百分比。

- 团队内和团队间的工作轮换范围（0=无工作轮换，1=团队内不经常轮换，2=团队内经常轮换，3=团队内和团队间经常轮换，4=团队内经常轮换，4=团队内、团队间和部门间经常轮换）。 - 生产工人执行质量任务的程度（0=负责所有质量责任的职能专家;1、2、3、4=负责下列工作之一、2、3 或 4 的生产工人:检验进口零件、在制品、成品;收集统计过程控制数据）。

(iii)人力资源政策。 该指数衡量一系列影响员工与组织之间"心理契约"的政策，从而影响员工激励和承诺。 该变量的低分表示一组"低承诺"HRM 政策，高分表示"高承诺"政策。 它包括四个项目:

- 用于选择三类雇员的雇佣标准:生产工人、一线主管和工程师（这三类雇员的各种雇佣标准的重要性的排名之和，对强调申请人现有技能和工作要求之间的匹配的标准得分较低）[「工作经验相似」]及强调开放学习及人际交往技巧的准则得分较高[「乐于学习新技能」及「与他人合作的能力」])。

- 补偿制度取决于绩效的程度(0=无意外补偿;I=取决于公司绩效的补偿;2=仅取决于厂方绩效的补偿;3=仅取决于厂方绩效或所掌握的技能;4=仅取决于生产员工;4=仅取决于厂方绩效的补偿。所有雇员均能参与工厂运作)。

- 管理者与工人之间存在地位壁垒的程度(0=没有实施打破地位壁垒的政策和 1、2、3、4=执行这些政策中的 1、2、3 或 4:共同制服、共同食堂、共同停车、禁止停车)。

- 新雇用的生产工人、主管和工程师在雇用后的头 6 个月内提供的培训水平(0=新雇用的生产工人、一线主管和工程师最多一周培训;1=所有三组新雇用的员工每周培训 1 到 2 周;2=2 到 4 周培训)所有三组新聘用的雇员;以及三组新聘用的雇员超过四星期的训练)。

- 为有经验的生产工人、主管和工程师提供的持续培训水平(每年 0=20 小时对有经验的生产工人、一线主管和工程师进行培训;所有三组每年培训 1=21-40 小时;每年培训 2=41-80 小时;每年培训 3=80 小时以上。).

(iv)生产组织指数。 如上所述，该指数既以加法形式构成，又以乘法形式构成，既以三个成分指数的简单平均值构成，又以成分指数的乘积构成。 两种形式的低 POI 分数都表示传统的批量生产系统,高 POI 分数则表示灵活的生产系统。

措施-控制变数

全面自动化 主要技术变量，即直接生产步骤的自动化百分比，既抓住了灵活的自动化程度，也抓住了固定自动化程度。 就每个功能区,如表 4 所述,制订了直接生产活动的代理措施。 然后,根据平均非自动化工厂每个功能区所需的直接人工量,计算出工厂的加权平均自动化水平。 由于该指数测定了自动化直接生产工序的全体比率,因此,预计不仅包括间接、工资时间,还包括非自动化直接生产工序所需的劳动时间,与生产性测定值有关。植物鳞片 该变量定义为根据容量利用率调整的标准非超时日平均车辆数量。 加班不包括在生产水平或工作时间之内，这可以适应产能过剩的情况。 在产能不足的情况下，我区分短期和长期产能不足。 当产能不足是短期时，我要求提供最近全产能运营期的数据。当产能不足是长期存在的时，我假设工厂能够将劳动力投入调整到这一产能水平，并将其视为工厂的有效产能。 模型混合复杂度。 这项措施是以工厂生产的不同产品和产品变体的混合为基础。 它包括不同的平台、型号、车身样式、传动系配置（前轮对后轮驱动）和出口变化（右轮对左转向）的数量，根据 Krafcik(1988)所制定的方案进行加权。 这项措施包括一个修正系数，以考虑工厂内装配线和车身车间数量。 例如,在两个平行装配线上分别产生一个模型的工厂,与用一条装配线建造一个模型的另一工厂的模型混合分数相同。 该指标的评分从 0 到 100，其中 0 代表混合复杂度最低的工厂，100 代表混合复杂度最高的工厂。 零件复杂度 这个度量是由两个子组变量组成的。 第一个子组包括三个部件或部件变动的度量标准:发动机/变速器组合的数量、线束和影响车辆排序的外部漆面颜色、所需子组件的种类以及材料和部件流经系统。 第二类包括影响物料和零件流量的物流和与供应商打交道所需的行政协调要求的三项措施,即总零件到装配区的数量、各型号通用零件的百分比和供应商的数量。 所有这些变量都是以 1-6 的比例来评分，其中 1 是最低的，6 是最高复杂度。 如上所述，它们被加成组合，得到的指数从 0 到 100。 产品设计年代。 该变数定义为,目前各工厂正在构建的各产品引进主要型号后,加权平均年限。这一措施是在最近设计的产品比旧产品更容易想到组装容易性的前提下,在组装区域内部分地代替了可制造性的措施。

Table 4. Measurement of Automated Percentage of Direct Production Steps.

Functional Area	*Proxy Measure of Automated Production Steps*
Body Welding	Percentage of spot and seam welds applied by automation
Paint: Joint Sealing	Percentage of total length of joint sealer applied by automation
Paint: Primer/Color	Percentage of total square inches of paint applied by automation
Assembly	Number of automated assembly tasks, weighted by labor content

型号规格

在回归分析中，我选择记录所有从属变量和独立变量，符合Cobb-Douglas规范用于生产函数的常规做法。 Cobb-Douglas之所以具有吸引力，是因为它能产生易于解释的系数和测试统计，并且它假定劳动力和资本的替代性（即，不同劳动力和资本的混合，但两者兼而有之，都不能达到相同的产出量）非常适合汽车装配厂的环境。 然而，这些数据并不支持使用精确的Cobb-Douglas规范，主要原因是Cobb-Douglas通常衡量劳动投入的时间是左侧生产率衡量指标的一个组成部分。 大多数Cobb-Douglas规范中的生产率指标是一个财务指标，即产出与投入的比率，而投入与产出之间的物理比率（劳动时间和车辆制造成本）。 但是，Cobb-Douglas的核心假设——生产函数最好建模为相互关联的输入之间的乘法关系——就体现在这一规范中。 还有一个先例可以包括影响资本或劳动力投入如何使用的变量。 置换（CES）模型的恒定弹性（Cobb-Douglas是其中一例）包括影响两个输入的"效率"参数。 工业关系研究者通常包括影响劳动力投入的因素（例如，工会化），但不影响资本（布朗和梅多夫1978；克拉克1980）。 生产组织指数在这里将起到这一作用。 因此，"基数"回归方程，包括所有控制变量，但不包括生产组织指数，将是:

(1) Log (Productivity) =
Log Total Automation + Log Product Design Age + Log Scale + Log Model Mix Complexity + Log Parts Complexity

and

(2) Log (Quality) =
Log Total Automation + Log Product Design Age + Log Scale + Log Model Mix Complexity + Log Parts Complexity

将逐个添加三个组件索引和整个生产组织索引的日志版本，以了解它们对解释"基本情况"变量之外的性能有何贡献。 最后，将考虑三个成分指数之间的交互作用，首先添加所有双向交互作用项，然后添加三向交互作用项。 测试交互作用项的"基格"方程将由控制变量加上所有成分指数组成。 该模型以不同的函数形式产生类似的结果，例如所有未记录变量。
最后的数据转换是保证的。 样本中有五家工厂在工作系统和人力资源管理政策指数中存在某些变量的缺失值，但所有其他变量的完整数据。 由于回归方程中要输入的变量数量较多，而且样本大小相对较小，因此保持自由度对于这些分析至关重要。 因此，在麦达拉（1977）

之后，我将这两个缺失指数（占样本的 8%）置换为样本平均值，因此它们不会被排除在回归分析之外。

实证结果:验证实践捆绑

可靠性试验

三个成分指数的可靠性测试揭示了包含的变量之间的显著相互关系。 Cronbach 的标准化 α 分数是 Use of Buffers index0.63,HRM Policies index0.70,Work Systems index0.81。这三个组件索引也具有高度相关性——对于使用缓冲区和工作系统，r=0.62;对于使用缓冲区和 HRM 策略，r=0.48;对于工作系统和 HRM 策略，r=0.62。 在生产组织指数中，克朗巴赫的标准化 α 为 0.80。

因素分析

当对构成三个成分指数的所有变量进行因子分析时,虽然出现了强因子,但每个因子都以难以解释的方式将包含缓冲区的变量与一些工作系统或 HRM 策略变量结合起来。 结果，这些因素没有被使用，因为指数在概念上更容易被论证，并且可以通过另外两种方法来验证。

群集分析

最后验证步骤涉及对从三个成分指数值生成的群集的检验。 比较各种聚类方法(这里没有报道)的分析表明,欧几里得测量聚类中心体间距离的方法和组内平均形成聚类的方法在统计上产生了最明显的聚类。 这些方法被用来导出二、三和四簇解。 这里给出了来自三簇解的方法，因为它们可以很容易地解释。 表示生产组织连续体末端点的集群 1 和集群 3 分别标注为"MassProd"和"FlexProd",集群 2 在这里标注为"Transition" 表 5 包含这三个集群中构成生产组织索引的所有变量和每个组件索引的平均值。 这些方法基于每个变量的原始非标准化比例尺，以便更容易解释。 对于单个变量和所有三个成分指数，所有平均值在群集之间都存在很大差异，并且几乎所有的 F-测试在.01 级具有统计学意义。

Table 5. Means of Production Organization Variables and Indices Across Clusters of Plants.

Variable	Sample (n = 57)	MassProd (n = 29)	Transition (n = 14)	FlexProd (n = 14)	F
Repair Area (sq. feet as % of assembly area)	10.4%	13.7%	9.1%	4.8%	15.8***
Paint-Assembly Buffer (% of 1-shift production)	23.3%	29.7%	18.7%	14.6%	3.9**
Inventory Level (days' supply for 8 parts)	2.1	2.8	2.1	0.63	18.7***
% Work Force in Teams	22.4%	5.0%	10.4%	70.2%	38.6***
% Work Force in EI, QC Groups	32.5%	16.5%	20.9%	77.4%	17.8***
Suggestions per Employee	9.2	0.24	0.33	36.5	15.3***
% Suggestions Implemented	36.3%	25.5%	23.8%	72.0%	16.8***
Job Rotation Index (0 = none; 4 = extensive)	1.8	1.2	1.9	3.0	20.8***
Quality Control at Shop Floor (0 = none; 4 = extensive)	3.1	2.6	2.9	4.5	2.8*
Hiring Criteria (Low = match past experience to job; High = interpersonal skills, willingness to learn new skills)	35.1	32.7	35.8	39.4	12.7***
Training New Hires (0 = Low; 3 = High)	1.6	1.0	1.9	2.4	13.1***
Training Experienced Employees (0 = Low; 3 = High)	1.4	0.9	1.6	2.1	7.9***
Contingent Compensation (0 = none; 4 = based on plant performance)	1.6	0.72	2.2	3.0	20.0***
Status Differentiation (0 = extensive; 4 = little)	1.9	1.1	2.0	3.4	17.7***
Use of Buffers Index	58.7	44.7	62.7	83.5	28.3***
Work Systems Index	32.0	18.8	24.3	66.7	59.4***
HRM Policies Index	47.3	26.5	55.9	81.8	73.4***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.
Source: International Assembly Plant Study.

实证结果:生产组织与制造性能

相关性

生产组织指数和性能之间的简单相关性比较高,而且相似。 对于缓冲区、工作系统和HRM 策略的使用，与生产率的相关性分别为 r=-.49、r=-.50 和 r=-.50，这三种策略的 p<.01。与质量的对应关系是 r=-.49、r=-.43 和 r=-.67，同样是 p<.01。 与性能的相关性是负的，因为测量结果的方法是每辆车低小时，而每 100 辆车低缺陷表明生产率和质量更好。 值得注意的是，这些相关性在所有情况下都高于三个指数和两个性能指标中每个单个变量之间的相关性。 这一结果证实了将个别实践组合成捆的价值。

Table 6. Production Organization Indices Regressed on Log Labor Productivity.
(Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*	*Eq. 4*	*Eq. 5*	*Eq. 6*
Log Total Automation	−0.14**	−0.15***	−0.15***	−0.14**	−0.14**	−0.14**
	(.056)	(.055)	(.054)	(.054)	(.052)	(.052)
Log Scale	−0.18**	−0.14*	−0.16**	−0.18**	−0.13*	−0.15**
	(.076)	(.078)	(.074)	(.074)	(.072)	(.072)
Log Model Mix Complexity	−0.07	−0.05	−0.07	−0.08	−0.06	−0.05
	(.053)	(.053)	(.052)	(.052)	(.049)	(.050)
Log Parts Complexity	0.18**	0.14	0.18**	0.19**	0.16*	0.16*
	(.091)	(.091)	(.088)	(.088)	(.085)	(.085)
Log Product Design Age	0.19**	0.15*	0.16**	0.15**	0.10	0.09
	(.073)	(.075)	(.072)	(.075)	(.073)	(.077)
Log Use of Buffers	—	−0.09*	—	—	—	—
		(.048)				
Log Work Systems	—	—	−0.09**	—	—	—
			(.043)			
Log HRM Policies	—	—	—	−0.08*	—	—
				(0.04)		
Log Production Organization (multiplicative)	—	—	—	—	−0.07***	—
					(.021)	
Log Production Organization (additive)	—	—	—	—	—	−0.29***
						(.096)
Adjusted R^2	0.483	0.505	0.513	0.506	0.557	0.548
F for Equation	12.4***	11.4***	11.7***	11.4***	13.3***	13.3***
F for R^2 Change from "Base Case" (Eq. 1)	—	3.5*	4.6**	3.6*	9.0***	9.0***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

集群手段

上述定义的集群的手段在生产率和质量上都有统计上的显著差异。MassProd、Transition 和 FlexProd 集群的生产率分别为每辆车 36. 6 小时、33.4 小时和 20. 9 小时。单向方差分析具有 11.2 的 F-统计量，在 99%的置信水平上具有显著性。 当使用 t 测试比较每一对集群平均值时，除了一个之外（在 MassProd 和 Transition 平均值之间）都具有统计学意义。 这些同一集群的质量分别为每 100 辆 94.1、73.9 和 49.5 个缺陷。 22.4 的 F-统计量在 99%的置信水平上具有重要意义，集群平均值的所有 t-测试也是如此。 因此，用三个成分指数定义的集群确实揭示了质量和生产率方面的巨大差异。 过渡集群的生产率平均值与 MassProd 集群几乎相同，但质量更好。 因此，对于过渡到灵活生产的倾斜，质量改进可能比生产率提高更重要。

生产率倒退

表 6 包含第一个层次回归分析。 公式 1 包含回归到对数劳动生产率上的"基本情况"变量。 除模型混合复杂度外，所有控制变量都具有统计学意义。 正如预想的那样,规模和自动化存在负面的征兆,即生产规模和自动化水平越高,每辆车的时间越短。 产品设计年龄和零部件复杂性都有积极迹象，这意味着更古老的设计和复杂性与每辆车更多的时间联系在一起。 公式 2、3、4 将生产组织指数的三个指数逐个添加到"基本情况"变量中。 这三个指

数都具有统计学意义。 此外，它们的效果大小几乎相同，标准化系数（未示出）从-.186 到-.196 不等。 在这三个方程中，调整后的 R2 都高于"基格"，并且其增加具有统计学意义。因此，每个指标与生产率——"更精益"缓冲区、更多的多技能工作系统和更"高承诺"的人力资源政策——都有假设的关系，每个指标都与每辆车的工作时间减少有关。 然后，公式 5 将全部生产组织指数（POI）以乘法形式添加到基本情况变量中。 该指数在 99%的置信水平上具有统计学意义,标准化系数为-.32(未示出),大大高于三个独立指数的系数。 R2 的增加也是统计学上重要的变化,暗示了实质性的相互作用效果。 在方程 6 中,当使用 POI 的加法形式时,结果几乎完全相同,为支持一种形式和另一种形式提供了很少的基础。 交互作用效果在表 7 中进行测试。方程 1 给出了基本情况，所有控制变量和所有三个成分指数。
方程 2 增加了双向交互项(缓冲区 x Work Sys, Buffers x HRM, Work Sys x HRM),
方程 3 增加了三向交互项(缓冲区 x Work Sys x HRM).
乘法交互项常常受到批评,因为它们与组件变量高度相关, 产生多色的问题。平铺标准误差（1979 年）。 这是一个样本体积小、自由度有限的问题。 为了解决这个问题，Jaccard、Turrisi 和 Wan（1990 年）建议采用一种称为"中心"的线性变换，即从每个分数中减去一个变量的平均值。 定心在不改变变量之间的结构关系的情况下减少多线程。 回归结果，包括对整个方程的 f 测试和渐增 R 平方变化的测试，在使用居中时不会改变。 因此，由于测量误差的减少，居中增加了识别具有统计学意义的交互效应的可能性，而无需考虑降低交互效应人工膨胀的多线程的风险（克朗巴赫 1987）。9 在方程 2 中，缓冲区 x WorkSys 交互项和 WorkSysx HRM 交互项都具有统计学意义，而缓冲区 x HRM 项则不具有统计学意义。 后一个结果的一个可能的解释是与缓冲区使用指数的高相关性（r=.72）。 个别指数的系数已不再具有统计学意义。 三个交互作用项都有预期的负号，调整后的 R2 为 0.597。 最后，R2 比公式 1 的"基底格"有统计学上的显著增加。 因此，双向交互作用项确实解释了生产率差异超过三个个体指数所捕获的差异。 三元相互作用项是生产率更好的预测指标。 在方程 3 中，在 99%置信区间，这个交互作用项（缓冲器 xWorkSysxHRM）具有统计学意义，调整后的 R2 增加到 0.649。 在三个双向交互作用项中，没有一个单独的指数具有统计学上的显著系数，只有 Buffers x HRM 具有统计学上的显著性，这是一个显著的结果，因为这个交互作用项是方程 2 中唯一没有意义的。 如表中所述，R2 从公式 1 的上升具有统计学意义。 此外，公式 2 的增量在统计学上也是有意义的，F-统计量为 8.4（p=.005）。

Table 7. Production Organization Interaction Terms Regressed on Log Labor Productivity. (Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*
Log Total Automation	–0.15*** (.053)	–0.11** (.051)	–0.11** (.048)
Log Scale	–0.29* (.173)	–0.17** (.072)	–0.11** (.070)
Log Model Mix Complexity	–0.55 (.051)	–0.07 (.049)	–0.04 (.047)
Log Parts Complexity	0.15* (.088)	0.22** (.087)	0.15* (.084)
Log Product Design Age	0.09 (.076)	0.10 (.074)	0.10 (.069)
Log Use of Buffers	–0.09* (.047)	–0.09 (.069)	–0.03 (.067)
Log Work Systems	–0.06 (.045)	–0.02 (.047)	–0.01 (.044)
Log HRM Policies	–0.08* (.045)	–0.05 (.051)	–0.03 (.056)
LBuffers × LWorkSys	—	–0.18** (.076)	–0.02 (.089)
LBuffers × LHRM Policies	—	–0.01 (.144)	–0.31* (.169)
LWorkSys × LHRM Policies	—	–0.13* (.076)	0.141 (.118)
LBuffers × LWorkSys × LHRM Policies		—	–0.64*** (.221)
Adjusted R^2	0.543	0.597	0.649
F for Equation	10.0***	9.2***	10.4***
F for R^2 change from base case (Eq. 1)	—	3.4**	5.0***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

质量回归

表 8 和表 9 显示了质量并行分析。 在表 8 中，在方程 1 中，基数为.06 的极低调整 R2，没有独立变量（或整个方程）具有统计学意义。 尤其值得注意的是，与生产率基本情况相比，自动化系数非常接近于零。 增加缓冲区使用指数的公式 2 没有什么不同，因为该指数和 R2 的变化在统计上都没有显著性。 考虑到低缓冲、及时系统与高质量水平密切相关这一点,这一结果令人惊讶。 然而，在公式（3）和公式（4）中，与生产组织有关的另外两个指数在统计上是有意义的。 公式 3 包含工作系统指数,在 95%的信赖水平上显著,R2 经调整后为.149;在公式 4 中,HRM 政策指数在 99%的信赖水平上显著,R2 经调整后上升到.24。 在这两种情况下，R2 比基底病例的增加都有统计学意义。 在这些方程中，控制变量没有显著变化。

公式 5 表明，与生产率一样，总体生产组织指数（其乘数形式）与基本情况相比，R2 的显著增加有关。 调整后的 R2 增加到.293,而-.57 的总指数(不在表中)的标准化系数比工作系统(-.33)和人力资源管理政策(-.46)的标准化系数高。 与"基础事例"相比,R2 增加的 F 统计在统计上也具有重要意义。 但是，在质量方面，使用生产组织指数的加法形式（在方程式 6 中）会导致调整后的 R2（.429）和标准化系数（.73）的增加要大得多。 这个结果令人怀疑一个假设，即成分指数之间的关系最好用乘法而不是加法来建模。 在交互作用项的测试中，质量结果与生产率结果不同。 方程 1 再次为基例提供了所有三个指数，但没有交互作用项。在包括所有双向交互项的方程 2 中,缓冲区 x 工作 Sys 具有负号意义,而缓冲区 x 工作 HRM 具有正号意义;剩余的工作 Sysx 工作 HRM 交互项不具有统计学意义,缓冲区和 HRM 策略系数均具有负号意义。试探性信号 整体调整后的 RI 为.456,从公式 1 来看,RI 的增加具有统计学意义。 方程 3 的结果非常相似，因为与生产率不同，三元交互作用项在统计学上并不显著，而其他变量的系数变化相对较小。 这些结果表明，使用缓冲区索引与质量之间的关系是复杂的。 在方程 6 和 7 中，单独的索引和 Buffers x WorkSys 交互作用项具有负系数，正如预期的那样。 但缓冲区 xHRM 相互作用项的正系数与预期相反,表明当所有其他主要效应和相互作用效应保持恒定时,这些指数的相互作用分数较高的植物每 100 个载体存在更多的缺陷。11 这些相互矛盾的关系的组合可以解释为什么这些因素对生物的相互作用系数的影响。缓冲器索引的使用对质量没有影响，它单独用公式 2 中的控制变量输入。

Table 8. Production Organization Indices Regressed on Log Quality.
(Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*	*Eq. 4*	*Eq. 5*	*Eq. 6*
Log Total Automation	0.01 (.095)	−0.02 (.099)	0.01 (.091)	0.03 (.086)	0.01 (.084)	0.02 (.075)
Log Scale	−0.14 (.120)	−0.10 (.126)	−0.11 (.116)	−0.16 (.108)	−0.07 (.106)	−0.06 (.095)
Log Model Mix Complexity	0.05 (.085)	0.09 (.089)	0.06 (.081)	0.04 (.077)	0.09 (.074)	0.11 (.067)
Log Parts Complexity	0.02 (.151)	0.06 (.154)	0.03 (.144)	0.02 (.136)	0.08 (.132)	0.08 (.119)
Log Product Design Age	0.18 (.130)	0.08 (.151)	0.12 (.126)	0.06 (.122)	−0.04 (.127)	−0.10 (.115)
Log Use of Buffers	—	−0.11 (.094)	—	—	—	—
Log Work Systems	—	—	−0.15** (.065)	—	—	—
Log HRM Policies	—	—	—	−0.20*** (.062)	—	—
Log Production Organization (multiplicative)	—	—	—	—	−0.12*** (.032)	—
Log Production Organization (additive)	—	—	—	—	—	−0.65*** (.125)
Adjusted R^2	0.064	0.075	0.149	0.241	0.293	0.429
F for Equation	1.6	1.6	2.3**	3.4***	4.1***	6.6***
F for R^2 change from "base case" (Eq. 1)	—	1.5	5.0**	10.3***	14.0***	26.6***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

Table 9. Production Organization Interaction Terms Regressed on Log Quality. (Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*
Log Total Automation	–0.11 (.087)	–0.04 (.079)	–0.05 (.079)
Log Scale	–0.19 (.255)	–0.14 (.099)	–0.17 (.104)
Log Model Mix Complexity	0.81 (.078)	0.03 (.069)	0.01 (.073)
Log Parts Complexity	–0.07 (.135)	0.17 (.134)	0.20 (.141)
Log Product Design Age	–0.07 (.140)	–0.22 (.132)	–0.23 (.133)
Log Use of Buffers	–0.14 (.087)	–0.48*** (.138)	–0.51*** (.141)
Log Work Systems	–0.06 (.065)	0.07 (.073)	0.06 (.074)
Log HRM Policies	–0.19* (.065)	–0.20*** (.071)	–0.24*** (.084)
LBuffers × LWorkSys	—	–0.49*** (.137)	–0.56*** (.158)
LBuffers × LHRM Policies	—	0.36* (.197)	0.49* (.253)
LWorkSys × LHRM Policies	—	–0.07 (.108)	–0.18 (.174)
LBuffers × LWorkSys × LHRM Policies		—	0.27 (.321)
Adjusted R^2	0.288	0.456	0.452
F for Equation	3.3***	4.4***	4.1***
F for R^2 change from "base case" (Eq. 1)	—	4.8***	3.8***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

「日本效应」?

为了测试可能的’日本效应’，我在回归方程中分别添加了日本位置和日本管理的假变量。[12] 这些假变量在大多数生产率回归中具有统计学意义。 当加到表 6 的公式 2-5 中时，三个成分指数以及整个生产组织指数的系数不再具有统计学意义。 这一结果部分可能是因为这些指数与日本假币之间的相关性很高——从.36 到.73。 但这也表明在生产率方面可能存在某种"日本效应"。 但是,对于表 7 的方程式 2 和 3 来说,如果加上与日本相关的模型,相互作用效果的统计学意义不会改变。 例如，在方程 3 中，日本变量的统计学意义重大，但三元交互项和缓冲区 xHRM 项也同样重要。 因此，即使日本工厂受到控制，三个生产组织之间的相互作用也是生产率的有力预测因素。 此外，几乎没有证据表明对质量有任何"日本效应"。

日本伪变量在任何质量回归中都没有统计学意义。 与原始结果相比的唯一变化是，工作系统指数在原始质量回归中具有统计学意义，当添加日本模型时不再具有显著性，但伪变量在统计学上也没有显著性。 这可能是因为日本傀儡和工作系统指数之间的多重一致性。 和生产力一样，当加入日本堆时，交互作用项的系数基本上是不变的。 最后，我使用非参数的 Spearman 相关系数，考察生产组织指数和交互作用项是否有助于解释 13 个日本管理工厂组内的性能差异。13 几乎所有的 8 个变量（三个组件指数、一个总体生产组织指数和四个 i）。交互作用术语)与生产率和质量有统计学上的显著关系。 只有 HRM 政策与生产率没有显著的关系，只有工作系统与质量没有显著的关系。'4 这些结果强化了构成灵活生产的一系列实践确实考虑了观察到的性能差异的情况。

结论

过去关于创新人力资源实践和经济绩效之间的关系的研究常常没有认识到总体人力资源体系中实践之间的相互关系; 在公司层面的分析中使用了总绩效指标，这与许多人力资源实践的实现相去甚远;由于缺乏有关公司生产系统及业务策略的技术方面的数据,未能评估人力资源系统对业绩的相对贡献。 另外,对汽车组装工厂性能的研究中,大部分没有充分探讨两个系统的相互作用和如何影响性能,而是过分强调技术系统或 HR 系统。 在这篇论文中，我研究出了两种尚未解决的假设:创新的人力资源实践不是单独影响绩效，而是作为内部一致的人力资源"捆绑"或系统中的相互关联的要素影响绩效; 而当它们与工厂的生产效率和质量结合在一起时，这些人力资源束对组装工厂的性能和质量贡献最大。在灵活的生产体系"结构逻辑"下的制造业政策。 我开发了三个指数（使用缓冲器、工作系统和人力资源管理政策），以捕捉大规模生产与灵活生产之间的组织逻辑差异。 我发现这些指数在捆绑式操作之间的相互关系方面,每个指数都有很高的内部一致性。 每个指数与其他两个指数也具有很高的相关性，这表明高度集成。 最后，集群分析区分了三组植物——大规模生产、过渡和柔性生产，这些植物平均值和它们所捆绑的实践存在显著差异。 利用阶层回归分析,探索了革新人事惯例对经济成果的贡献度,在包含控制变量的"基本事例"方程式中依次增加了生产组织指数。 三个生产组织指数,以及结合它们的总体指数,除了对质量不大的缓冲区使用外,都是对生产率和质量的统计重要预测指标。 此外，该结果还有力地支持了假设的指数之间的双向和双向交互作用效应。 回归分析中解释的差异在生产率方面比质量方面高得多。 这种差异部分可能是因为质量回归的样本体积较小。 但控制变量在"基例"生产率方程中占方差 48%，而在"基例"质量方程中只占 6%。 这种差异表明，生产组织指数对质量的相对贡献大于对生产率的贡献。 这种解释与植物过渡簇的质量比植物大量生产簇的质量要好，但大致等同于生产力的事实是一致的。 但是,也有可能在质量回归中错误地指定了控制变量。 总体而言，

证据有力地支持这样一种假设，即使用灵活的生产系统组装工厂，将人力资源实践与生产/商业战略相结合，在生产率和质量方面都优于使用更传统的大量生产系统的工厂。 这些结果为创新的人力资源实践和经济绩效之间建立积极关系提供了最强有力的统计证据,特别是考虑到全面的国际样本、强大的控制变量存在、特定于情境的绩效措施和人力资源实践的高可靠性。, 以及在一个小样本中发现具有统计学意义的相互作用效应。 这项研究有几个局限性。 这些数据是截面数据，因此不能确定因果关系。 装配厂的研究结果——既有资本密集型操作，也有劳动力密集型操作——可能无法很好地推广到其他环境中。 自动化措施不能捕捉到生产过程的所有资本投入，因此对资本来说是不完美的代理。 此外，数据并不包括可能影响装配厂性能的所有变量。 这项研究还面临着如何衡量创新型人力资源实践的一些长期困境。 例如，调查数据无法识别团队运作的细微差别。 一些团队可能因为工人抵制强加于他们的"团队概念"而很少进行轮岗和交叉培训。 其他团队可能会专注于人员安排，但很少解决生产问题。 因此，越来越多的组装工厂案例研究是这些调查数据的重要补充（比如布朗和里奇 1989、阿德勒 1992、赫胥黎、罗伯逊和雷纳哈特 1991、鲁本斯坦、科昌和贝内特 1993）。 这些数据也无法解决关于灵活生产是否代表"压力管理"的争论。 批评者认为，灵活的生产工厂通过更快的工作速度、标准化的工作岗位、同龄人压力控制社会、无缓冲的生产系统和强调减少劳动力投入的"开城"（Parker and Slaughter）努力来"榨取"工人的生产率优势。 1988 年;富西尼和富西尼 1990 年;格雷厄姆 1993 年）。 由于本文分析的数据没有明确地衡量工作速度，因此我无法评价灵活的生产必然导致"加速"的说法，也无法评价它要求"更聪明"而不是更努力工作。 这项研究确实揭示了人力资源战略与商业战略的"合宜"问题(阿瑟 1992)。 "适合"假说预测,在人力资源和生产战略之间具有良好契合性的批量生产工厂或柔性生产工厂都会取得好成绩。 相反，这些结果表明，至少对于汽车装配厂来说，灵活的生产方法总是能够带来比批量生产方法更好的性能。 如果灵活的生产确实构成了汽车装配的优越策略，那么它应该比其他生产系统更快地扩散开来——随着这项研究继续从同一个国际样本中收集纵向数据，这个问题将会得到探讨。

外文文献译文

人力资源和制造业绩效:世界汽车工业的组织逻辑和灵活的生产体系，劳资关系检讨

MacDuffie，J.P.， Human Resource bundles and Manufacturing Performance：Organizational Logic and Flexible Production System in the World Auto Industry，Industrial and Labor Relations Review，1995：48：2，197-221.

Abstract

Using a unique international data set from a 1989-90 survey of 62 automotive assembly plants, the author tests two hypotheses: that innovative HR practices affect performance not individually but as interrelated elements in an internally consistent HR "bundle" or system; and that these HR bundles contribute most to assembly plant productivity and quality when they are integrated with manufacturing policies under the "organizational logic" of a flexible production system. Analysis of the survey data, which tests three indices representing distinct bundles of human resource and manufacturing practices, supports both hypotheses. Flexible production plants with team-based work systems, "high-commitment" HR practices (such as contingent compensation and extensive training), and low inventory and repair buffers consistently outperformed mass production plants. Variables capturing twoway and three-way interactions among the bundles of practices are even better predictors of performance, supporting the integration hypothesis.

Despite claims that innovative human resource (HR) practices can boost firm-level performance and national competitiveness, few studies have been able to confirm this relationship empirically, and still fewer have systematically described the conditions under which it will be strongest. Although some of the problems in this research stream have been empirical (for example, unreliable measures and inadequate controls), the more fundamental barriers have been conceptual. Innovative HR practices are often studied in a vacuum, with more attention paid to isolating the standing how different HR practices interact to reinforce one another, or how they are linked to business functions and strategies. In this paper I test the relationship between HR practices and economic performance using a unique international data set based on surveys distributed to 62 automotive assembly plants in 1989-90. I investigate the hypothesis that "bundles" of interrelated and internally consistent HR practices, rather than individual practices, are the appropriate unit of analysis for studying the link to performance, because they create the multiple, mutually reinforcing conditions that support employee motivationtand skill acquisition. Furthermore, I examine the hypothesis advanced in Arthur (1992) and Kochan, CutcherGershenfeld, and MacDuffie (1991) that an HR bundle or system must be integrated with complementary bundles of practices from core business functions (and thereby with the firm's overall business strategy) to be effective. I argue here that flexible production systems have a distinct "organizational logic" that integrates bundles of human resource practices with manufacturing practices in pursuit of simultaneous improvements in productivity and quality. A flexible production plant reduces inventory levels and other "buffers," increasing interdependence in the production process and highlighting production problems. Dealing effectively with these problems requires motivated, skilled, and adaptable workers. By combining the reduction of buffers with the development of these work force characteristics, flexible production systems create the conditions under which innovative HR practices are most likely to yield effective economic performance. This line of argument is consistent with recent work (Cappelli and Singh 1993; Kogut and Zander 1992; Pfeffer 1994) asserting that human resources can be a primary source of sustainable competitive advantage for a firm. Employee knowledge about products, processes, and customers that is embedded in routines and social interaction patterns can create organizational capabilities more difficult to imitate than readily purchased technological capabilities. Focusing on one specific industry context, automotive assembly, provides many advantages for testing this argument. Empirical work on this topic has often relied on dichotomous measures of HR practices at the establishment level and financial measures of performance at the corporate level. These measures can be quite unreliable, particularly across industries, and are at different levels of analysis. The assembly plant data set used in this study includes more reliable, context-specific measures of performance and HR practices at a common level of analysis, as well as control variables, such as technology and product complexity, that could affect manufacturing performance.

Previous Research

This paper builds on an extensive body of past research on the auto industry in two ways. It explores the role of human resources in the "organizational logic" of a production system more deeply than previous descriptive work that contrasts mass and flexible production (for example, WomackJones, and Roos 1990; MacDuffie and Krafcik 1992). Although mass and flexible (or "lean") production systems implicitly require different approaches to managing human resources, Womack et al. did not explain how HR practices are integrated into these different production systems, nor did they test the relationship between HR practices and performance. Indeed, the term "lean production" used by Womack et al. appropriately captures the minimization of buffers but neglects the expansion of work force skill and conceptual knowledge required for problemsolving under this approach. These "enriched" human resource capabilities are better described in terms of flexibility. This paper also encompasses more of the interaction between social and technical aspects of the production system than past industrial relations research (such as Katz, Kochan, and Gobeille 1983; Katz, Kochan, and Weber 1985; Katz, Kochan, and Keefe 1988). The authors of these earlier papers concluded that Quality-of-Work-Life (QWL) activities had little impact on performance because QWL had virtually no effect on work organization, process improvement, or skill development. But they lacked data about the production system to test this hypothesis. The 1988 paper extended the inquiry to the value of teams, finding that teams were negatively associated with performance. However, only plants from a single company were studied, at which the adoption of teams was not linked to broader changes in production policies. Also, these authors did not measure bundles of practices but assessed individual practices, potentially missing differences between overall HR systems. The emphasis here on the relationship between the social system and technical features of production is consistent with the tradition of socio-technical systems (STS) theory (Trist and Bamforth 1951; Emery and Thorsrud 1976; Pasmore 1988). My view of this relationship, however, differs considerably from that of STS theory. STS theory characterizes autonomous work teams as an alternative to Taylorist approaches to work organization that is superior in any technical setting. STS organizational designs thus seek to maximize the autonomy of work teams from the constraints of the technical system, often by adding buffers to the technical system. In contrast, this paper explores the integration of HR practices that seek to expand employee skill and involvement with production practices that minimize buffers. For example, at Volvo's celebrated Uddevalla plant, the elimination of the moving assembly line and the introduction of team assembly of an entire vehicle were heralded by some as an appealing alternative to flexible production (Berggren 1992). But as Adler and Cole (1993) have argued, although Uddevalla's emphasis on team autonomy (and the use of buffers of various kinds to protect this autonomy) may have facilitated individual and team learning, it constrained organizational learning and overall system improvement. Although this paper cannot resolve this debate (Uddevalla was closed in the spring of 1993, in part due to concerns about its economic performance), it does test a hypothesis-about how buffer reduction coupled with innovative HR practices is linked to economic performance-that is counter to STS predictions.

The "Organizational Logic" of Flexible Production: Integrating Bundles of Practices

Innovative human resource practices are likely to contribute to improved economic performance only when three conditions are met: when employees possess knowledge and skills that managers lack; when employees are motivated to apply this skill and knowledge through discretionary effort; and when the firm's business or production strategy can only be achieved when employees contribute such discretionary effort (Levine and Tyson 1990; Bailey 1992). I will argue that all three conditions must be met for HR practices to contribute to performance. Skilled and knowledgeable workers who are not motivated are unlikely to contribute any discretionary effort. Motivated workers who lack skills or knowledge may contribute discretionary effort with little impact on performance. Even if innovative HR practices generate skilled and motivated workers, the HR system must be integrated with the firm's production strategy for discretionary effort to be appropriately channeled toward performance improvement. The concept of "bundles" of HR practices is important in evaluating whether (and how) these conditions can be met. Firms generally organize human resource practices into systems that are consistent with their culture and business strategy (Osterman 1987; Block, Kleiner, Roomkin, and Salsburg 1987). It is the combination of practices in a bundle, rather than individual practices, that shapes the pattern of interactions between and among managers and employees (Cutcher-Gershenfeld 1991). Thus, research that focuses on the impact of individual HR practices on performance may produce misleading results, with a single practice capturing the effect of the entire HR system (Ichniowski, Shaw, and Prennushi 1993). Furthermore, a bundle of interrelated, overlapping HR practices provides several ways for workers to acquire skills (for example, off-the job and on-the job training, job rotation, problem-solving groups) and multiple incentives to boost motivation (for example, extrinsic rewards such as performance-based pay and intrinsic rewards from participating in decision-making and good job design). As Hackman (1985) wrote, performance may be "an overdetermined phenomenon, the product of multiple nonindependent factors whose influence depends in part on the fact that they are redundant." There is now ample empirical support for the bundling or systems view.2 The "organizational logic" of flexible production links together a bundle of manufacturing practices (related to the minimization of buffers) with a bundle of human resource practices (related to the expansion of work force skills and motivation).' Each of these bundles is made up of interrelated, internally consistent, and even overlapping practices. The two bundles are complementary in that they affect separate aspects of a plant's operations and yet mutually reinforce each other. Thus, "organizational logic" here refers to a systemic property that exerts a powerful pull toward internal consistency within these bundles and a complementary relationship between them. (The degree to which internal consistency within bundles and complementarities across bundles exists is, of course, a matter for empirical investigation.)

Buffers

Under mass production, disruptions to the production process (sales fluctuations, supply interruptions, equipment breakdowns) prevent the realization of economies of scale. Accordingly, buffers such as extra inventories or repair space are added to the production system. These buffers essentially create organizational slack as a reserve against unforeseen contingencies. But under flexible production, such buffers are seen as costly for several reasons. First, the buffers represent a commitment of resources not directly devoted to production. Inventory buffers in particular are costly to store and handle, and can hinder the move from one product design to another. Most important, buffers can hide production problems. When inventory stocks are high, a defective part can simply be scrapped and replaced. But when inventories are very low, as with a Just-in Time inventory system, a bad part draws immediate attention, and must be dealt with, to prevent the production system from grinding to a halt. Buffers of in-process inventories are kept low and lot sizes are small, so if a problem is discovered by a "downstream" process, there are few defective parts that must be discarded. Shrinking the size of the final repair area has a similar effect, since a small area will overflow quickly if defect levels rise. The minimization of buffers serves a cybernetic or feedback function, providing valuable information about production problems (Ono 1988; Schonberger 1982).

Human Resource Capabilities

Historically, under mass production, workers were hired to perform narrowly defined manual tasks requiring little skill, and were viewed as interchangeable parts. Turnover was high, but jobs were set up so any unskilled worker could learn them quickly, minimizing the costs of replacing workers. Absenteeism was high, but buffers of utility workers were established to provide coverage. Motivation was low, but close monitoring by supervisors and efficiency wages ensured adequate work effort. Workers were not expected to think on the job, and were in fact discouraged from doing so. The main concern of mass production managers was to prevent any disruption to the achievement of production quotas, and they developed buffers of various kinds, in part, as a safeguard against labor troubles (Shimada and MacDuffie 1986). In contrast, flexible production gives workers a much more central role in the production system. To identify and resolve problems as they appear on the line, workers must have both a conceptual grasp of the production process and the analytical skills to identify the root cause of problems. Developing an integrated conception of the production system requires that workers directly encounter problems, through the decentralization of production responsibilities such as quality inspection, equipment maintenance, job specification, and statistical process control (SPC) from specialized inspectors and engineers to shopfloor teams. Developing the skills for this problem-solving requires a variety of multiskilling practices, including extensive off- and on-the-job training, a few broad job classifications, allowing job rotation within and across teams, and "off-line" group problem-solving activities (for example, employee involvement groups or quality circles). The multiple skills and conceptual knowledge developed by the work force under flexible production are of little use unless workers are motivated to contribute mental as well as physical effort. Workers will only contribute their discretionary effort problem-solving if they believe that their individual interests are aligned with those of the company, and that the company will make a reciprocal investment in their wellbeing. Thus, flexible production is characterized by such "high commitment" human resource policies as employment security, compensation that is partially contingent on performance, and a reduction of status barriers between managers and workers. The company investment in building worker skills also contributes to this "psychological contract" of reciprocal commitment (Cole 1979; Dore 1992).

The Link Between Buffers and Human Resources

The complementarity of policies on buffers and human resources is critical to the "organizational logic" of mass versus flexible production.4 Under mass production, the use of buffers to create stable conditions for high-volume production, under which all inputs can be optimized for great est efficiency, is complemented by the view of production workers as interchangeable parts. Workers who were not expected to think and whose expected contribution of effort could be obtained despite their low skill and motivation were a perfect match for a technically optimized production system that was not supposed to stop and in which modifications were to be kept to a minimum. For flexible production, the link between the minimization of buffers and the development of human capabilities is driven by the philosophy of continuous improvement, known in Japan as "kaizen." From the perspective of kaizen, problems are opportunities for improvement (Imai 1986). It is this philosophy that sustains the organization's willingness to accept the vulnerability of "lean" buffers and the pressure to deal with problems as they become visible-even if this means stopping the production line, unthinkable under mass production. This philosophy also guides the development of problem-solving skills in the work force. In a sense, flexible production transfers the ability to cope with contingencies from the technical system, where buffers provide mass production systems with 'just in case" protection, into the human resource system, which deals with the unexpected by developing a capability for learning (MacDuffie 1991; Adler 1992; Nishiguchi 1993). Another critical difference in philosophy relates to production system outcomes. The conventional wisdom of manufacturing under a mass production "logic" assumes a necessary tradeoff between the goals of productivity and quality. The use of buffers is justified on productivity grounds, because it protects against disruptions to high-volume production, and because a certain level of quality defects is expected. By contrast, under flexible production, productivity (minimization of effort) and quality (minimization of defects) are regarded as complementary goals. This characteristic of flexible production is also linked to the reduction of buffers and the development of problem-solving capabilities. With no buffers present, any defect can bring the entire system to a standstill, so there is a strong incentive to drive quality defects toward zero. Stopping the line to deal with a quality problem can ultimately boost uptime and productivity if the problem can be traced back to its root cause and eliminated.

Problem-solving efforts are not limited to quality matters. Under flexible production, workers and engineers also apply their problem-solving abilities to the task of improving equipment performance over time-a process identified by Monden (1983) as "giving wisdom to the machine." As a result, production technology need not be automatically subject to decay and depreciation but can actually appreciate in value over time. The same principle applies to all job specifications. Although the basic structure of production jobs is determined by engineers, teams of production workers have responsibility for developing, recording, and modifying job specifications-a process known as "standardized work." These specifications are as detailed as any industrial engineering time study, but with the crucial difference that workers, rather than managers or engineers, take charge of their revision. (Adler 1993; Cole 1992.) Thus the problem-solving capabilities that arise from linking lean buffers with enriched human resources can help boost performance by improving the efficiency with which the root causes of quality problems are identified, by helping technology to be used more effectively, and by refining job specifications.

Operationalizing the Organizational Logic: Measurement Issues

The discussion above suggests that bundles of practices should be measured to capture the "organizational logic" of a production system. This raises four important measurement questions: (1) What constitutes a "bundle"? (2) How should practices in a bundle be combined? (3) How can a bundle be empirically validated? and (4) How should the relationship between different bundles of practices be specified?

Table 1. Innovative Human Resource Practices and Their Link to the Conditions for Economic Performance.

Innovative HR Practice	*Skill/ Knowledge*	*Motivation/ Commitment*	*Integration of HR with Production System, Strategy*
Work Systems Index			
Work Teams	X	X	X
Problem-Solving Groups (Employee Involvement or Quality Circle groups)	X	X	X
Employee Suggestions Made and Implemented	X	X	X
Job Rotation	X		X
Decentralization of Quality-Related Tasks	X		X
HRM Policies Index			
Recruitment and Hiring	X	X	
Contingent Compensation		X	X
Status Differentiation		X	
Training of New Employees	X	X	
Training of Experienced Employees	X	X	

Choosing a Bundle

Researchers have developed many typologies for innovative HR practices (see a summary in Bailey 1992), categorized in terms of their impact on, for example, motivation or skill development or work structures. But given that any single practice may play a multifaceted role in the overall human resource system, there is no clear conceptual basis for separating practices affecting motivation from those affecting skill. For example, work teams represent a restructuring of work organization that integrates human resources more fully into the production system, but they also develop worker skills and influence motivation and commitment. In this study, the choices about the

HR bundle began with the design of the questionnaire. I developed questions based on extensive field work that revealed which HR policies differentiated mass and flexible production systems most clearly. Most questions were closely tied to shop floor activities at the plant level, and therefore excluded many human resource policies at the corporate level. Furthermore, I selected for measurement only practices that could potentially be implemented in any plant in the international sample, thus excluding practices that are exclusively associated with one particular company or country. For example, practices such as teams, quality circles, and job rotation that are commonly found both in japan and in other countries are measured, but other practices such as the nenko wage system, satei evaluation system, enterprise unions, or lifetime employment-considered more uniquely Japanese-are not. For those practices that were measured, I then distinguish between those that affect the organization of work and the way work tasks are carried out (called Work Systems) and those that reflect firm-level human resource policies affecting employees at all levels (called HRM Policies). Osterman (1994) made a similar distinction between work organization practices and supporting HRM practices. Table 1 indicates how the human resource practices in these two categories can be linked to some or all of the three conditions identified above as essential for economic performance: worker skill and knowledge; worker motivation; and the integration of human resource practices with firm strategy.

Combining Practices in a Bundle

Implicit in the notion of a "bundle" is the idea that practices within bundles are interrelated and internally consistent, and that "more is better" with respect to the impact on performance, because of the overlapping and mutually reinforcing effect of multiple practices. While the combined impact of practices in a bundle could be specified in a variety of ways, two simple alternatives are an additive approach and a multiplicative approach. Choosing between these two approaches poses the question of whether the bundle as a whole should be viewed as equal to or greater than the sum of the parts. For both statistical and conceptual reasons, I use the additive approach to combining practices. Statistically, the additive combination of practices has the desirable property that the sum of normally distributed variable scores is still normally distributed, which is not true for the multiplicative product. Conceptually, a multiplicative relationship implies that if any single organizational practice is not present, the "bundle" score (and effect) should be zero. This is too rigid a criterion for a bundle, given that there is no precise theoretical basis for specifying which practices signify the "organizational logic." Although practices in a bundle are expected to be interrelated, the absence of a particular practice will not eradicate the effect of all other practices, but will weaken the net effect of the bundle. (Osterman [1994] takes this approach; see p. 176.)

Validating a Bundle

Three statistical procedures-each with advantages and disadvantages-can be used to validate a conceptually defined "bundle": reliability analysis, factor analysis, and cluster analysis. Reliability analysis can evaluate the intercorrelations among variables grouped together in a bundle-an advantage if the conceptual basis for categorizing practices is strong, and a disadvantage if it is not. Factor analysis is best suited to identifying the interrelationships among a set of items in a scale, all designed to mea sure the same construct. It is less appropriate for assessing a "bundle," which is not a scale but an index (DeVellis 1991) consisting of a set of interrelated variables, each of which represents a different construct. Cluster analysis groups observations (in this case plants) that lie in close proximity in multidimensional space for a given set of variables. Since different clustering algorithms produce different clusters and all clustering algorithms will find clusters of some kind, it is important to test different cluster solutions and choose those that are most statistically distinct (Everitt 1980; Aldenderfer and Blashfield 1984; Ulrich and McKelvey 1990).

Examining the Interaction

Between Bundles

The interaction between bundles can also be modeled as either an additive or multiplicative relationship. Here, I argue that the multiplicative assumption makes more sense, because the bundles are conceptualized as complementary. The "organizational logic" argument claims that policies to reduce buffers will only be effective in the presence of HR policies that develop problem-solving skills and motivation in the work force, and that either set of policies alone will be ineffective. A multiplicative relationship among the three bundles of practices (Use of Buffers, Work Systems, and HRM Policies) will be captured in two ways here-with an overall Production Organization Index (POI) that is the product of scores for the three bundles, and with two-way and three-way multiplicative interaction terms. In addition, I will compare the multiplicative POI with an additive POI that averages the three indices to assess the assumption about interrelationships among bundles.

Methodology

Sample

The International Assembly Plant Study was sponsored by the International Motor Vehicle Program (IMVP) at M.I.T.5 The author and John Krafcik contacted ninety assembly plants, representing 24 producers in 16 countries, and approximately 60% of total assembly plant capacity worldwide. Survey responses were received from 70 plants during 1989 and early 1990. These plants were divided into "volume" and "luxury" categories (the latter defined as plants producing automobiles with a 1989 U.S. base price of over $23,000), on the assumption that the production systems for these product types might differ substantially. This paper includes data from the 62 volume plants, whose surveys were more complete. Table 2 lists the distribution of the 62 volume plants by regional category. The proportion of plants in different regions corresponds closely to the proportion of worldwide production volume associated with those regions, with a slight underrepresentation of Japanese plants in Japan and overrepresentation of New Entrant and Australian plants, whose volume is low. Plants were chosen to achieve a balanced distribution across regions and companies, and to reflect a range of performance within each participating company, minimizing the potential for selectivity bias. Table 3 lists the dependent, independent, and control variables, with descriptive statistics.

Questionnaire Administration and Data Collection

Questionnaires were sent to a contact person, often the plant manager, who distributed different sections to the appropriate departmental manager or staff group. Plants and companies were guaranteed complete confidentiality and, in return for their participation, received a feedback report comparing their responses with mean scores for different regions. All 90 plants that were contacted were visited by one of the researchers between 1987 and 1990. Early visits provided the field observations that became the foundation of the assembly plant questionnaire. Some of these plants were used to pilot the questionnaire as well. For the 70 plants that returned a questionnaire, the visit often followed receipt of the questionnaire, providing an opportunity to fill in missing data, clarify responses that were unclear or not internally consistent, and carry out interviews to aid the later interpretation of data analyses. When the visit preceded receipt of a questionnaire, this same follow-up process to improve data accuracy was carried out via telephone and fax.

Table 2. Composition of the Volume Assembly Plant Sample.

Regional Category	*n*
Japan (J/J)	8
Japanese-Parent Plants in North America (J/NA)	4
U.S.-Parent Plants in North America (US/NA)	14
Europe (All/E)	19
New Entrants, Including Korea, Taiwan, Mexico, and Brazil (All/NE)	11
Australia (All/Aus)	6
TOTAL	62

Source: International Assembly Plant Study.

Measures-Dependent Variables

Labor productivity. Labor productivity is defined as the hours of actual working effort required to build a vehicle at a given assembly plant, adjusted for comparability across plants by a methodology developed by Krafcik (1988) .6 The productivity methodology focuses on a set of standard activities that are common across all plants in the survey, to control for differences in vertical integration. Since a large vehicle requires more effort to assemble than a small vehicle, adjustments are made to standardize for vehicle size. Adjustments are also made to standardize for the number of welds, which differs across designs and therefore affects headcount in the body shop. Labor hours are also adjusted for absenteeism, for two reasons: (1) the study focuses on the labor effort involved in building vehicles (not total labor costs) and does not include the additional employees hired to cover absenteeism; and (2) absenteeism rates may be influenced significantly by national and social welfare policies that are not under the control of plant management. This is a conservative adjustment, given that absenteeism is lowest in the country with plants having the highest productivity (Japan), moderate in the United States, where productivity is intermediate, and highest in countries whose productivity is worst in the sample (various European and newly industrialized countries). Quality. The quality measure is derived from the 1989 survey of new car buyers in the United States, carried out by J. D. Power. The variable measures the number of defects per 100 vehicles, and is adjusted to reflect only those defects that an assembly plant can affect, that is, omitting defects related to the engine or transmission, while emphasizing defects related to the fit and finish of body panels, paint quality, and the integrity of electrical connections (Krafcik 1988).

Table 3. Descriptive Statistics: Dependent and Independent Variables.
(n = 62 Except for Quality, for Which n = 46)

Variable Name	*Mean*	*S.D.*	*Description*
Dependent Variables			
Productivity	33.1	12.4	Labor productivity, defined as hours of actual effort required to build a vehicle
Quality	78.4	31.2	Consumer-perceived quality, defined as defects per 100 vehicles, from J.D. Power
Independent Variables			
Production Organization Index	45.9	20	Index capturing "organizational logic" of the production system; simple average of the three component indices listed below
Use of Buffers	56.1	23.9	The degree to which production operations are buffered against potential disruptions
Work Systems	31.9	23.3	Work structures and policies that govern shop floor production activity
HRM Policies	47.3	26.0	Organization-wide HR policies that affect employee commitment and motivation
Total Automation	24.0	14.0	Overall automation stock, defined as % of direct production steps that are automated
Production Scale	904.4	639.9	Average number of vehicles built during a standard, non-overtime day
Model Mix Complexity	30.9	21.3	Mix of different platforms and models at a plant
Parts Complexity	56.5	23.5	Variation in the number of wire harnesses, exterior colors, engine/transmission combinations; number of assembly area parts; percentage of common parts across vehicles; and number of suppliers of assembly area parts
Product Design Age	4.6	3.2	Weighted average number of years since a major model introduction for each product

Source: International Assembly Plant Study.

Measures-Independent Variables

Production organization measures. To operationalize the "organizational logic" of flexible and mass production systems, I developed three component indices-Use of Buffers, Work Systems, HRM Policiesand an overall Production Organization Index. The variables included in these indices reflect both choices about what to include in the assembly plant questionnaire and statistical tests aimed at boosting the internal reliability of each index. Each of the three component indices is composed of multiple variables, described below. All variables are standardized by conversion to z-scores before being additively combined to form indices. Each variable in an index receives equal weight, because I felt that there was no clear conceptual basis for assigning differential weights. For ease of interpretation, I apply a linear transformation to the summed z scores for each component index, such that 0 is the plant with the lowest score in the sample and 100 is the plant with the highest score. The validation of these indices is described in the next section.

(i) Use of Buffers. This index measures a set of production practices that are indicative of overall production philosophy with respect to buffers (for example, incoming and work-in-process inventory), with a low score signifying a "buffered" system and a high score signifying a "lean" system. It consists of three items:

- the space (in square feet) dedicated to final assembly repair, as a percentage of total assembly area square footage.
- the average number of vehicles held in the work-in-process buffer between the paint and assembly areas, as a percentage of one shift production.
- the average level of inventory stocks, in days for a sample of eight key parts, weighted by the cost of each part.

(ii) Work Systems. This index captures how work is organized, in terms of both formal work structures and the allocation of work responsibilities, and the participation of employees in production-related problem-solving activity. A low score for this variable indicates a work system with a narrow division of labor that is "specializing" in orientation, and a high score indicates a "multiskilling" orientation. It consists of six items:

- the percentage of the work force involved in formal work teams.
- the percentage of the work force involved in employee involvement groups.
- the number of production-related suggestions received per employee.
- the percentage of production-related suggestions implemented.
- the extent of job rotation within and across teams (O = no job rotation, 1 = infrequent rotation within teams, 2 = frequent rotation within teams, 3 = frequent rotation within teams and across teams of the same department, 4 = frequent rotation within teams, across teams, and across departments).
- the degree to which production workers carry out quality tasks (O = functional specialists responsible for all quality responsibilities; 1, 2, 3, 4 = production workers responsible for 1, 2, 3, or 4 of the following tasks: inspection of incoming parts, work-in-process, finished products; gathering Statistical Process Control data).

(iii) HRM Policies. This index measures a set of policies that affects the "psychological contract" between the employee and the organization, and hence employee motivation and commitment. A low score for this variable indicates a "low commitment" set of HRM policies and a high score indicates "high commitment" policies. It consists of four items:

- the hiring criteria used to select employees in three categories: production workers, first line supervisors, and engineers (the sum of rankings of the importance of various hiring criteria for these three groups of employees, with low scores for criteria that emphasize the fit between an applicant's existing skills and job requirements ["previous experience in a similar job"] and high scores for criteria that emphasize openness to learning and interpersonal skills ["a willingness to learn new skills" and "ability to work with others"]).
- the extent to which the compensation system is contingent on performance (0 = no contingent compensation; I = compensation contingent on corporate performance; 2= compensation contingent on plant performance, for managers only; 3 = compensation contingent on plant performance or skills acquired, production employees only; and 4 = compensation contingent on plant performance, all employees).
- the extent to which status barriers between managers and workers are present (0 = no implementation of policies that break down status barriers and 1, 2, 3, 4 = implementation of 1, 2, 3, or 4 of these policies: common uniform, common cafeteria, common parking, no ties).
- the level of training provided to newly hired production workers, supervisors, and engineers in the first six months of employment (0 = up to one week of training for newly hired production workers, first line supervisors, and engineers; 1 = one to two weeks of training for newly hired employees in all three groups; 2 = two to four weeks of training for newly hired employees in all three groups; and 3 = over four weeks of training for newly hired employees in all three groups).
- the level of ongoing training provided to experienced production workers, supervisors, and engineers (0 = 0-20 hours of training for experienced production workers, first line supervisors, and engineers per year; 1= 21-40 hours of training per year for all 3 groups; 2 = 41-80 hours of training per year; and 3 = over 80 hours of training per year).

(iv) Production Organization Index (POI). This index is constructed, as described above, in both an additive form, as a simple average of the three component indices, and a multiplicative form, as the product of component indices. For both forms, a low POI score indicates a traditional mass production system and a high POI score indicates a flexible production system.

Measures-Control Variables

Total automation. The main technology variable, the automated percentage of direct production steps, captures the level of both flexible and fixed automation.7 For each functional area, a proxy measure for direct production activities was developed, as described in Table 4. Then a weighted average level of automation for the plant was calculated, based on the amount of direct labor each functional area requires in an average unautomated plant. Since the index measures the percentage of total direct production steps that are automated, it is expected to correlate with the productivity measure, which includes the labor hours required for non-automated direct production steps as well as indirect and salaried hours. Plant scale. This variable is defined as the average number of vehicles built during a standard, non-overtime day, adjusted for capacity utilization. Overtime is not included in either production levels or hours worked, which adjusts for overcapacity situations. In undercapacity situations, I distinguished between short-term and longterm undercapacity. When undercapacity was short-term, I asked for data from the most recent period of full capacity operation. When undercapacity was long-term, I assumed that plants would have been able to adjust labor inputs to that capacity level and regarded it as the effective capacity of the plant. Model mix complexity. This measure is based on the mix of different products and product variants produced in the plant. It includes the number of distinct platforms, models, body styles, drive train configurations (front-wheel versus rear-wheel drive), and export variations (right-hand versus left-hand steering), weighted according to a scheme developed by Krafcik (1988). The measure includes a correction factor to account for the number of assembly lines and body shops in the plant. For instance, a plant with two parallel assembly lines producing a single model on each is given the same model mix score as that of another plant that builds one model with one assembly line. The measure is scaled to yield a score from 0 to 100, where 0 represents the plant with the least model mix complexity and 100 the plant with the most model mix complexity. Parts complexity. This measure is compiled from two subgroups of variables. The first subgroup includes three measures of parts or component variation-the number of engine/transmission combinations, wire harnesses, and exterior paint colorsthat affect the sequencing of vehicles, the variety of required sub-assemblies, and material and parts flow through the system. The second subgroup includes three measures-the number of total parts to the assembly area, the percentage of common parts across models, and the number of suppliers to the assembly area-that affect both the logistics of material and parts flow and the administrative/coordination requirements for dealing with suppliers. All these variables are scored on a 1-6 scale, where 1 is the lowest and 6 the highest complexity level. They are additively combined and the resulting index is rescaled from 0 to 100, as above. Product design age. This variable is defined as the weighted average number of years since a major model change introduction for each of the products currently being built at each plant. This measure is a partial proxy for manufacturability in the assembly area, under the assumption that products designed more recently are more likely than older products to have been conceived with ease of assembly in mind.

Table 4. Measurement of Automated Percentage of Direct Production Steps.

Functional Area	*Proxy Measure of Automated Production Steps*
Body Welding	Percentage of spot and seam welds applied by automation
Paint: Joint Sealing	Percentage of total length of joint sealer applied by automation
Paint: Primer/Color	Percentage of total square inches of paint applied by automation
Assembly	Number of automated assembly tasks, weighted by labor content

Model Specification

For the regression analyses, I chose to log all dependent and independent variables, conforming to the common practice of using a Cobb-Douglas specification for the production function. Cobb-Douglas is attractive because it generates coefficients and test statistics that are easy to interpret and its assumption of the substitutability of labor and capital (that is, that different mixes of labor and capital, but neither factor exclusively, can achieve the same output quantity) is a good fit to the auto assembly plant context. These data do not support the use of the precise Cobb-Douglas specification, however, primarily because labor hours, the usual measure of labor inputs in CobbDouglas, is an integral part of the left-handside productivity measure. The productivity measure in most Cobb-Douglas specifications is a financial metric-the ratio of outputs to inputs where both are expressed in dollars-whereas here productivity is the physical ratio of inputs to outputs (hours of effort and vehicles built). But the central assumption of Cobb-Douglas-that the production function is best modeled as a multiplicative relationship among interrelated inputs-is embodied in this specification. There is also precedent for including a variable that affects how capital or labor inputs are utilized. The constant elasticity of substitution (CES) model (of which Cobb-Douglas is a specific case) includes an "efficiency" parameter that affects both inputs. Industrial relations researchers commonly include factors that affect labor inputs (for example, unionization) but not capital (Brown and Medoff 1978; Clark 1980). The production organization indices will play this role here. Thus the "base case" regression equations, including all control variables but not the production organization indices, will be:

(1) Log (Productivity) =
Log Total Automation + Log Product
Design Age + Log Scale + Log Model
Mix Complexity + Log Parts Complexity

and

(2) Log (Quality) =
Log Total Automation + Log Product
Design Age + Log Scale + Log Model
Mix Complexity + Log Parts Complexity

Logged versions of the three component indices and the overall Production Organization index will be added, one at a time, to see what they contribute to explaining performance beyond the "base case" variables. Finally, interaction effects among the three component indices will be considered, first by adding all two-way interaction terms, then by adding the three-way interaction term. The "base case" equation for testing the interaction terms will consist of the control variables plus all the component indices. The model produces similar results with different functional forms, such as all unlogged variables.

One final data transformation is warranted. Five plants in the sample have missing values for some variables in the Work Systems and HRM Policies indices, but have complete data for all other variables. Preserving degrees of freedom is crucial for these analyses, given the high number of variables to be entered in the regression equation and the relatively small sample size. Therefore, following Maddala (1977), I substitute the sample mean for the two missing indices for these plants (8% of the sample) so they are not excluded from the regression analyses.

Table 5. Means of Production Organization Variables and Indices Across Clusters of Plants.

Variable	*Sample* (*n* = *57*)	*MassProd* (*n* = *29*)	*Transition* (*n* = *14*)	*FlexProd* (*n* = *14*)	*F*
Repair Area (sq. feet as % of assembly area)	10.4%	13.7%	9.1%	4.8%	15.8***
Paint-Assembly Buffer (% of 1-shift production)	23.3%	29.7%	18.7%	14.6%	3.9**
Inventory Level (days' supply for 8 parts)	2.1	2.8	2.1	0.63	18.7***
% Work Force in Teams	22.4%	5.0%	10.4%	70.2%	38.6***
% Work Force in EI, QC Groups	32.5%	16.5%	20.9%	77.4%	17.8***
Suggestions per Employee	9.2	0.24	0.33	36.5	15.3***
% Suggestions Implemented	36.3%	25.5%	23.8%	72.0%	16.8***
Job Rotation Index (0 = none; 4 = extensive)	1.8	1.2	1.9	3.0	20.8***
Quality Control at Shop Floor (0 = none; 4 = extensive)	3.1	2.6	2.9	4.5	2.8*
Hiring Criteria (Low = match past experience to job; High = interpersonal skills, willingness to learn new skills)	35.1	32.7	35.8	39.4	12.7***
Training New Hires (0 = Low; 3 = High)	1.6	1.0	1.9	2.4	13.1***
Training Experienced Employees (0 = Low; 3 = High)	1.4	0.9	1.6	2.1	7.9***
Contingent Compensation (0 = none; 4 = based on plant performance)	1.6	0.72	2.2	3.0	20.0***
Status Differentiation (0 = extensive; 4 = little)	1.9	1.1	2.0	3.4	17.7***
Use of Buffers Index	58.7	44.7	62.7	83.5	28.3***
Work Systems Index	32.0	18.8	24.3	66.7	59.4***
HRM Policies Index	47.3	26.5	55.9	81.8	73.4***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.
Source: International Assembly Plant Study.

Empirical Results: Validating the Bundling of Practices

Reliability Tests

Reliability tests for the three component indices reveal a significant intercorrelation among the included variables. The Cronbach's standardized alpha score is 0.63 for the Use of Buffers index, 0.70 for the HRM Policies index, and 0.81 for the Work Systems index. The three component indices are also highly intercorrelated-for Use of Buffers and Work Systems, r = 0.62; for the Use of Buffers and HRM Policies, r = 0.48; and for Work Systems and HRM Policies, r = 0.62. For the Production Organization Index, the Cronbach's standardized alpha is 0.80.

Factor Analysis

When all variables making up the three component indices were factor analyzed, strong factors did emerge, but each factor combined variables involving Buffers with some Work Systems or HRM Policy variables in ways that were not readily interpretable. As a result, these factors were not used, since the indices can be more readily justified conceptually and are validated by the other two methods.

Cluster Analysis

The final validation step involved the examination of clusters generated from values of the three component indices. Analyses comparing various clustering methods (not reported here) showed that the Euclidean measure for distance between cluster centroids and the Within Group Average method of forming clusters produced the most statistically distinct clusters. These methods were used to derive two-, three-, and four-cluster solutions. Means from the three-cluster solution are presented here, since they can be readily interpreted. Clusters 1 and 3, which represent the endpoints of the production organization continuum, are labeled "MassProd" and "FlexProd," respectively, and Cluster 2 is regarded as an intermediate group, here labeled "Transition." Table 5 contains means across these three clusters for all of the variables making up the Production Organization Index and then for each component index. These means are based on the original, unstandardized scale for each variable, for easier interpretability. All means differ substantially across clusters, for both the individual variables and all three component indices, and nearly all the F-tests are statistically significant at the .01 level.

Empirical Results: Production Organization and Manufacturing Performance

Correlations

The simple correlations between the production organization indices and performance are relatively high, and similar. For Use of Buffers, Work Systems, and HRM Policies, the correlations with productivity are, respectively, $r = -.49$, $r =-.50$, and $r = -.50$, with $p < .01$ for all three. The corresponding correlations with quality are $r = - .49$, $r = -.43$, and $r = -.67$, again with $p < .01$. The correlation swith performance are negative because of the way outcomes are measured lower hours per vehicle and lower defects per 100 vehicles indicate better productivity and better quality. It is important to note that these correlations are in all cases higher than the correlations between each individual variable in the three indices and the two performance measures. This result confirms the value of combining individual practices into bundles.

Table 6. Production Organization Indices Regressed on Log Labor Productivity. (Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*	*Eq. 4*	*Eq. 5*	*Eq. 6*
Log Total Automation	−0.14** (.056)	−0.15*** (.055)	−0.15*** (.054)	−0.14** (.054)	−0.14** (.052)	−0.14** (.052)
Log Scale	−0.18** (.076)	−0.14* (.078)	−0.16** (.074)	−0.18** (.074)	−0.13* (.072)	−0.15** (.072)
Log Model Mix Complexity	−0.07 (.053)	−0.05 (.053)	−0.07 (.052)	−0.08 (.052)	−0.06 (.049)	−0.05 (.050)
Log Parts Complexity	0.18** (.091)	0.14 (.091)	0.18** (.088)	0.19** (.088)	0.16* (.085)	0.16* (.085)
Log Product Design Age	0.19** (.073)	0.15* (.075)	0.16** (.072)	0.15** (.075)	0.10 (.073)	0.09 (.077)
Log Use of Buffers	—	−0.09* (.048)	—	—	—	—
Log Work Systems	—	—	−0.09** (.043)	—	—	—
Log HRM Policies	—	—	—	−0.08* (0.04)	—	—
Log Production Organization (multiplicative)	—	—	—	—	−0.07*** (.021)	—
Log Production Organization (additive)	—	—	—	—	—	−0.29*** (.096)
Adjusted R^2	0.483	0.505	0.513	0.506	0.557	0.548
F for Equation	12.4***	11.4***	11.7***	11.4***	13.3***	13.3***
F for R^2 Change from "Base Case" (Eq. 1)	—	3.5*	4.6**	3.6*	9.0***	9.0***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

Cluster Means

Means of the clusters defined above show statistically significant differences for both productivity and quality. Productivity figures for the MassProd, Transition, and FlexProd clusters are, respectively, 36.6, 33.4, and 20.9 hours per vehicle. The oneway analysis of variance has an F-statistic of 11.2 and is significant at the 99% confidence level. When using t-tests to compare each pair of cluster means, all but one (between the MassProd and Transition means) are statistically significant. Quality for these same clusters is 94.1, 73.9, and 49.5 defects per 100 vehicles, respectively. The F-statistic of 22.4 is significant at the 99% confidence level, as are all t-tests for cluster means. Thus, clusters defined in terms of the three component indices do reveal large differentials in both productivity and quality between the MassProd and FlexProd clusters. The Transition cluster has nearly the same productivity mean as the MassProd cluster but substantially better quality. It therefore appears that quality improvement may precede productivity improvement for lants making a transition to flexible production.

Productivity Regressions

Table 6 contains the first hierarchical regression analysis. Equation 1 contains the "base case" variables regressed on log labor productivity. All of the control variables are statistically significant except for model mix complexity. As expected, scale and automation have negative signs, that is, the higher the scale of production and level of automation, the lower the hours per vehicle. Product design age and parts complexity have positive signs, signifying that an older design and more complexity are linked to more hours per vehicle. Equations 2, 3, and 4 add the three indices of the production organization index, one at a time, to the "base case" variables. All three indices are statistically significant. Furthermore, they all have approximately the same effect size, with standardized coefficients (not shown) ranging from -.186 to -.196. In all three equations, the adjusted R2 is higher than the "base case" and the increase is statistically significant. Thus each index has the hypothesized relationship to productivity-"leaner" buffers, more multiskilling work systems, and more "high commitment" HR policies are each associated with fewer hours per vehicle. Equation 5 then adds the full Production Organization Index (POI), in its multiplicative form, to the base case variables. The index is statistically significant at the 99% confidence level, with a standardized coefficient of -.32 (not shown), substantially higher than coefficients for the three separate indices. The increase in R2 is also a statistically significant change, suggesting substantial interaction effects. Results when using the additive form of the POI, in equation 6, are virtually identical, providing little basis for supporting one form over the other. Interaction effects are tested in Table 7. Equation 1 provides the base case, with all control variables and all three component indices. Equation 2 adds the two-way interaction terms (Buffers x WorkSys; Buffers x HRM; WorkSys x HRM), and equation 3 adds the three-way interaction term (Buffers x WorkSys x HRM). Multiplicative interaction terms are often criticized because they are so highly correlated with the component variables, creating problems of multicollinearity that can inflate standard errors (Blalock 1979). This is a particular problem with a small sample size and limited degrees of freedom. To deal with this problem, Jaccard, Turrisi, and Wan (1990) recommended a linear transformation known as "centering," in which the mean value for a variable is subtracted from each score. Centering reduces multicollinearity without chang-ing the structural relationship among the variables. Regression results, including ftests for the overall equation and for incremental R-squared changes, are unchanged when centering is used. Thus centering increases the likelihood that a statistically significant interaction effect can be identified, because of the reduction in measurement error, without the risk associated with other procedures for reducing multicollinearity that interaction effects will be artificially inflated (Cronbach 1987).9 In equation 2, the Buffers x WorkSys interaction term and the WorkSys x HRM interaction term are both statistically significant, while the Buffers x HRM term is not. One possible explanation for this latter result is the high correlation (r = .72) with the Use of Buffers index. Coefficients for the individual indices are no longer statistically significant. All three interaction terms have the expected negative sign, and the adjusted R2 is .597. Finally, there is a statistically significant increase in R2 from the "base case" of equation 1. Thus the twoway interaction terms do explain variance in productivity beyond that captured by the three individual indices. The three-way interaction term is an even better predictor of productivity. In equation 3, this interaction term (Buffers x WorkSys x HRM) is statistically significant at the 99% confidence interval, and the adjusted R2 increases to .649. None of the individual indices have statistically significant coefficients, and of the three two-way interaction terms, only Buffers x HRM is statistically significant-a striking finding, since this interaction term was the only one that was not significant in equation 2. The increase in R2 from equation 1 is statistically significant, as noted in the table. Furthermore, the increase from equation 2 is also statistically significant, with an F-statistic of 8.4 (p = .005).

Table 7. Production Organization Interaction Terms Regressed on Log Labor Productivity. (Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*
Log Total Automation	–0.15*** (.053)	–0.11** (.051)	–0.11** (.048)
Log Scale	–0.29* (.173)	–0.17** (.072)	–0.11** (.070)
Log Model Mix Complexity	–0.55 (.051)	–0.07 (.049)	–0.04 (.047)
Log Parts Complexity	0.15* (.088)	0.22** (.087)	0.15* (.084)
Log Product Design Age	0.09 (.076)	0.10 (.074)	0.10 (.069)
Log Use of Buffers	–0.09* (.047)	–0.09 (.069)	–0.03 (.067)
Log Work Systems	–0.06 (.045)	–0.02 (.047)	–0.01 (.044)
Log HRM Policies	–0.08* (.045)	–0.05 (.051)	–0.03 (.056)
LBuffers × LWorkSys	—	–0.18** (.076)	–0.02 (.089)
LBuffers × LHRM Policies	—	–0.01 (.144)	–0.31* (.169)
LWorkSys × LHRM Policies	—	–0.13* (.076)	0.141 (.118)
LBuffers × LWorkSys × LHRM Policies		—	–0.64*** (.221)
Adjusted R^2	0.543	0.597	0.649
F for Equation	10.0***	9.2***	10.4***
F for R^2 change from base case (Eq. 1)	—	3.4**	5.0***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

Quality Regressions

Tables 8 and 9 show the parallel analyses for quality. In Table 8, the base case, in equation 1, has a very low adjusted R2 of .06, and none of the independent variables (or the equation overall) is statistically significant. Particularly noteworthy, in comparison with the productivity base case, is that the automation coefficient is very close to zero. Equation 2, which adds the Use of Buffers index, is little different, since neither the index nor the change in R2 is statistically significant. This result is surprising, given the expectation that low buffer, Just-in-Time systems are strongly associated with high quality levels. In equations (3) and (4), however, the two other indices related to production organization are statistically significant. Equation 3 contains the Work Systems index, significant at the 95% confidence level, with an adjusted R2 of .149, and in equation 4 the HRM Policies index is significant at the 99% confidence level and the adjusted R2 rises to .24. In both cases, the increase in R2 over the base case is statistically significant. The control variables do not change appreciably in any of these equations. Equation 5 reveals that, as with productivity, the overall Production Organization Index (in its multiplicative form) is associated with a more substantial increase in R2 over the base case than the individual component indices. The adjusted R2 increases to .293, and the standardized coefficient for the overall index (not in the table) of -.57 is higher than that for Work Systems(-.33) and HRM Policies (-.46). The Fstatistic for the increase in R2, compared to the "base case," is also statistically significant. For quality, however, using the additive form of the Production Organization Index (in equation 6) results in a much larger increase in adjusted R2 (.429) and a much larger standardized coefficient (.73). This result calls into question the assumption that the relationship among the component indices is best modeled as multiplicative rather than additive. In tests of interaction terms (Table 9), the results for quality differ from those for productivity. Equation 1 again provides the base case with all three indices but no interaction terms. In equation 2, which includes all the two-way interaction terms, Buffers x WorkSys is significant with a negative sign, while Buffers x HRM is significant with a positive sign; the remaining WorkSys x HRM interaction term is not statistically indices, both Use of Buffers and HRM Policies coefficients are statistically significant, both with a negative sign. The overall adjusted RI is .456, and the increase in RI from equation 1 is statistically significant. Equation 3 shows very similar results because, unlike for productivity, the threeway interaction term is not statistically significant, and the coefficients for the other variables change relatively little. These results suggest that the relationship of the Use of Buffers index to quality is complex. In equations 6 and 7, the index alone and the Buffers x WorkSys interaction term are significant with negative coefficients, as expected. But the positive coefficient for the Buffers x HRM interaction term is counter to expectations, indicating that when all other main effects and interaction effects are held constant, plants with a high interaction score for these indices have more defects per 100 vehicles.11 The combination of these contradictory relationships may explain why the Use of Buffers index, entered alone with the control variables in equation 2, has no impact on quality.

Table 8. Production Organization Indices Regressed on Log Quality. (Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*	*Eq. 4*	*Eq. 5*	*Eq. 6*
Log Total Automation	0.01 (.095)	−0.02 (.099)	0.01 (.091)	0.03 (.086)	0.01 (.084)	0.02 (.075)
Log Scale	−0.14 (.120)	−0.10 (.126)	−0.11 (.116)	−0.16 (.108)	−0.07 (.106)	−0.06 (.095)
Log Model Mix Complexity	0.05 (.085)	0.09 (.089)	0.06 (.081)	0.04 (.077)	0.09 (.074)	0.11 (.067)
Log Parts Complexity	0.02 (.151)	0.06 (.154)	0.03 (.144)	0.02 (.136)	0.08 (.132)	0.08 (.119)
Log Product Design Age	0.18 (.130)	0.08 (.151)	0.12 (.126)	0.06 (.122)	−0.04 (.127)	−0.10 (.115)
Log Use of Buffers	—	−0.11 (.094)	—	—	—	—
Log Work Systems	—	—	−0.15** (.065)	—	—	—
Log HRM Policies	—	—	—	−0.20*** (.062)	—	—
Log Production Organization (multiplicative)	—	—	—	—	−0.12*** (.032)	—
Log Production Organization (additive)	—	—	—	—	—	−0.65*** (.125)
Adjusted R^2	0.064	0.075	0.149	0.241	0.293	0.429
F for Equation	1.6	1.6	2.3**	3.4***	4.1***	6.6***
F for R^2 change from "base case" (Eq. 1)	—	1.5	5.0**	10.3***	14.0***	26.6***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

Table 9. Production Organization Interaction Terms Regressed on Log Quality. (Standard Errors in Parentheses)

Variable	*Eq. 1*	*Eq. 2*	*Eq. 3*
Log Total Automation	−0.11 (.087)	−0.04 (.079)	−0.05 (.079)
Log Scale	−0.19 (.255)	−0.14 (.099)	−0.17 (.104)
Log Model Mix Complexity	0.81 (.078)	0.03 (.069)	0.01 (.073)
Log Parts Complexity	−0.07 (.135)	0.17 (.134)	0.20 (.141)
Log Product Design Age	−0.07 (.140)	−0.22 (.132)	−0.23 (.133)
Log Use of Buffers	−0.14 (.087)	−0.48*** (.138)	−0.51*** (.141)
Log Work Systems	−0.06 (.065)	0.07 (.073)	0.06 (.074)
Log HRM Policies	−0.19* (.065)	−0.20*** (.071)	−0.24*** (.084)
LBuffers × LWorkSys	—	−0.49*** (.137)	−0.56*** (.158)
LBuffers × LHRM Policies	—	0.36* (.197)	0.49* (.253)
LWorkSys × LHRM Policies	—	−0.07 (.108)	−0.18 (.174)
LBuffers × LWorkSys × LHRM Policies		—	0.27 (.321)
Adjusted R^2	0.288	0.456	0.452
F for Equation	3.3***	4.4***	4.1***
F for R^2 change from "base case" (Eq. 1)	—	4.8***	3.8***

*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level.

A "Japan Effect"?

To test for a possible 'Japan effect," I added dummy variables for Japanese location andjapanese management, separately, to the regression equations.12 These dummy variables were statistically significant in most of the productivity regressions. When added to equations 2-5 in Table 6, the coefficients for the three component indices, as well as the overall Production Organization index, ceased to be statistically significant. This result may be partially due to the high correlations-ranging from .36 to .73- between these indices and the Japanese dummies. But it also suggests that there may be some 'Japan effect" with respect to productivity. However, for equations 2 and 3 in Table 7, the statistical significance of the interaction effects is unchanged when the Japan-related dummies are added. In equation 3, for example, the Japan dummies are statistically significant, but so is the three-way interaction term and the Buffers x HRM term. Thus, even when Japanese plants are controlled for, the interaction among the three production organization bundles is a powerful predictor of productivity. Also, there is little evidence of any 'Japan effect" for quality. The Japanese dummy variables are not statistically significant in any of the quality regressions. The only change from the original results is that the Work Systems index, statistically significant in the original quality regressions, ceases to be significant when the Japan dummies are added, but the dummy variables are also not statistically significant. This may be due to multicollinearity between the Japan dummies and the Work Systems index. As with productivity, the coefficients for the interaction terms are essentially unchanged when the Japanese dummies are added. As a final test, I examine whether the production organization indices and interaction terms help explain performance differences within the group of 13 Japanesemanaged plants, using non-parametric Spearman correlation coefficients.13 Nearly all of the eight variables (three component indices, one overall Production Organization index, and four interaction terms) have statistically significant correlations with productivity and quality. Only HRM Policies does not have a significant correlation with productivity, and only Work Systems is not significantly correlated with quality.'4 These results strengthen the case that the bundles of practices that make up flexible production do account for observed performance differences.

Conclusions

Past research on the relationship between innovative human resource practices and economic performance has often failed to recognize the interrelationships among practices in the overall HR system; has used aggregate performance measures at a corporate level of analysis, far removed from the settings in which many HR practices are implemented; or has lacked adequate data about technical aspects of a firm's production system and business strategy to assess the relative contribution of the HR system to performance. In addition, much of the research on the performance of automotive assembly plants has overemphasized either the technical system or the HR system without fully exploring the interaction of the two systems and how it can affect performance. In this paper I have investigated two hypotheses left unresolved by this research stream: that innovative HR practices affect performance not individually but as interrelated elements in an internally consistent HR "bundle" or system; and that these HR bundles contribute most to assembly plant productivity and quality when they are integrated with manufacturing policies under the "organizational logic" of a flexible production system. I developed three indices (Use of Buffers, Work Systems, and HRM Policies) to capture systemic differences in organizational logic between mass production and flexible production. I found that each of these indices had high internal consistency, in terms of intercorrelations among the bundled practices. Each was also highly correlated with the other two indices, suggesting a high degree of integration. Finally, cluster analysis distinguished three groups of plants-Mass Production, Transition, and Flexible Production-that differed significantly in mean values for these indices and the practices bundled within them. I explored the contribution of innovative HR practices to economic performance using hierarchical regression analysis, adding production organization indices successively to a "base case" equation containing control variables. The three production organization indices, as well as the overall index combining them, were all found to be statistically significant predictors of productivity and quality, with the exception of Use of Buffers, which was not significant for quality. Furthermore, the results strongly support the hypothesized two-way and three-way interaction effects among the indices. The variance explained in the regression analyses was much higher for productivity than for quality. This difference may partly be due to the smaller sample size for the quality regressions. But the control variables account for 48% of the variance in the "base case" productivity equation, and only 6% in the "base case" quality equation. This difference suggests that the relative contribution of the production organization indices is greater for quality than for productivity. This interpretation is consistent with the fact that the Transition cluster of plants has better quality than the Mass Production cluster of plants, but roughly equivalent productivity. However, it also raises the possibility that the control variables are incorrectly specified in the quality regressions. Overall, the evidence strongly supports the hypothesis that assembly plants using flexible production systems, which bundle human resource practices into a system that is integrated with production/business strategy, outperform plants using more traditional mass production systems in both productivity and quality. These results provide the strongest statistical evidence to date of a positive relationship between innovative human resource practices and economic performance, particularly given the comprehensive international sample, the presence of strong control variables, the high reliability of the context-specific measures of performance and HR practices, and the discovery of statistically significant interaction effects in a small sample. There are several limitations to this study. The data are cross-sectional, so causality cannot be definitively determined. Findings from assembly plants, which have both capital-intensive and labor-intensive operations, may not generalize well to other settings. The automation measures do not capture all capital inputs to the production process and are thus imperfect proxies for capital. In addition, the data do not include all the variables that could affect assembly plant performance. This study also faces some of the perennial dilemmas of how to measure innovative HR practices. For example, survey data cannot identify the nuances of team functioning. Some teams may engage in little job rotation and cross-training because of workers' resistance to having a "team concept" forced on them. Other teams may focus on personnel and schedule matters but do little production problem-solving. Thus the growing body of assembly plant case studies is an essential complement to these survey data (for example, Brown and Reich 1989; Adler 1992; Huxley, Robertson, and Rinehart 1991; Rubenstein, Kochan, and Bennett 1993). These data also cannot address the debate about whether flexible production represents "management by stress." Critics argue that flexible production plants achieve much of their productivity advantage by "sweating" workers through a faster work pace, standardized jobs, social control via peer pressure, and stress from a bufferless production system and "kaizen" (continuous improvement) efforts that emphasize reductions of labor input (Parker and Slaughter 1988; Fucini and Fucini 1990; Graham 1993). Because the data analyzed here do not measure work pace explicitly, I cannot evaluate the claim that flexible production leads inevitably to "speedup"-or the counterclaim that it requires "working smarter" more than working harder. This study does shed light on the issue of "fit" between HR strategy and business strategy (Arthur 1992). A "fit" hypothesis predicts that either mass or flexible production plants with a good fit between their HR and production strategies will perform well. In contrast, these results suggest that, at least for auto assembly plants, the flexible production approach consistently leads to better performance than the mass production approach. If flexible production does constitute a superior strategy for automotive assembly, then it should diffuse more rapidly than other production systems-an issue that will be explored as this research continues with the collection of longitudinal data from the same international sample.

REFERENCES

Adler, Paul S. 1992. "The 'Learning Bureaucracy': New United Motor Manufacturing, Inc." In Barry M. Staw and Larry L. Cummings, eds., *Research in Organizational Behavior.* Greenwich, Conn.: JAI Press.

____. 1993. "Time-and-Motion Regained." *Harvard Business Review* (Jan.–Feb.), pp. 97–108.

Adler, Paul S., and Robert E. Cole. 1993. "Designed to Learn: A Tale of Two Auto Plants." *Sloan Management Review* (Spring), pp. 33–45.

Aldenderfer, Mark S., and Roger K. Blashfield. 1984. *Cluster Analysis.* Beverly Hills: Sage.

Arthur, Jeffrey B. 1992. "The Link Between Business Strategy and Industrial Relations Systems in American Steel Minimills." *Industrial and Labor Relations Review,* Vol. 45, No. 3 (April), pp. 488–506.

Bailey, Thomas. 1992. "Discretionary Effort and the Organization of Work: Employee Participation and Work Reform Since Hawthorne." Paper written for the Sloan Foundation, Columbia University.

Berggren, Christian. 1992. *Alternatives to Lean Production: Work Organization in the Swedish Auto Industry.* Ithaca, N.Y.: ILR Press.

Biggart, Nicole Woolsey. 1991. "Explaining Asian Economic Organization: Toward a Weberian Institutional Perspective." *Theory and Society,* Vol. 20, pp. 199–232.

Blalock, H. M. 1979. *Social Statistics.* New York: McGraw-Hill.

Block, Richard, Morris Kleiner, Myron Roomkin, and Sidney Salsburg. 1987. "Industrial Relations and the Performance of the Firm: An Overview." In Morris M. Kleiner et al., eds., *Human Resources and the Performance of the Firm.* Madison, Wis.: Industrial Relations Research Association Series.

Brown, Charles, and James Medoff. 1978. "Trade Unions in the Production Process." *Journal of Political Economy,* Vol. 86, No. 3 (June), pp. 335–78.

Brown, Claire, and Michael Reich. 1989. "When Does Union-Management Cooperation Work? A Look at NUMMI and GM-Van Nuys." *California Management Review,* Vol. 31, No. 4 (Summer), pp. 26–44.

Cappelli, Peter, and Harbir Singh. 1992. "Integrating Strategic Human Resources and Strategic Management." In Peter Sherer, David Lewin, and Olivia Mitchell, eds., *Research Frontiers in Industrial Relations,* pp. 165–92. Madison, Wis.: Industrial Relations Research Association series.

Carper, W. B., and W. E. Snizek. 1980. "The Nature and Type of Organizational Typologies: An Overview." *Academy of Management Review,* Vol. 5, pp. 65–75.

Clark, Kim. 1980. "The Impact of Unionization on Productivity: A Case Study." *Industrial and Labor Relations Review,* Vol. 34, No. 4 (July), pp. 466–87.

Clark, Kim, and Takahiro Fujimoto. 1991. *Product Development Performance.* Cambridge, Mass.: Harvard Business School Press.

Cole, Robert E. 1979. *Work, Mobility, and Participation: A Comparative Study of Japanese and American Industry.* Berkeley: University of California Press.

____. 1992. "Issues in Skill Formation and Training in Japanese Approaches to Automation." In Paul S. Adler, ed., *Technology and the Future of Work,* pp. 187–209. New York: Oxford University Press.

Cronbach, Lee. 1987. "Statistical Tests for Moderator Variables." *Psychological Bulletin,* Vol. 102, No. 3, pp. 414–17.

Cusumano, Michael. 1985. *The Japanese Auto Industry: Technology and Management at Toyota and Nissan.* Cambridge, Mass.: Harvard University Press.

Cutcher-Gershenfeld, Joel. 1991. "The Impact on Economic Performance of a Transformation in Workplace Relations." *Industrial and Labor Relations Review,* Vol. 44, No. 2 (January), pp. 241–60.

DeVellis, Robert F. 1991. *Scale Development: Theory and Applications.* Newbury Park, Calif.: Sage.

Dore, Ronald P. 1992. "Japan's Version of Managerial Capitalism." In Thomas A. Kochan and Michael Useem, eds., *Transforming Organizations.* New York: Oxford University Press, pp. 17–27.

Ebrahimpour, Maling, and Sang Lee. 1988. "Quality Management Practices of American and Japanese Electronic Firms in the U.S." *Production and Inventory Management Journal* (4th qtr.), pp. 28–31.

Emery, Fred, and Einar Thorsrud. 1976. *Democracy at Work.* Leiden, Netherlands: Martinus Nijhoff.

Everitt, Brian. 1980. *Cluster Analysis,* 2nd Edition. London: Heineman.

Florida, Richard, and Martin Kenney. 1991. "Transplanted Organizations: The Transfer of Japanese Industrial Organization to the U.S." *American Sociological Review,* Vol. 56 (June), pp. 381–98.

Fucini, J., and J. Fucini. 1990. *Working for the Japanese: Inside Mazda's American Auto Plant.* New York: Free Press.

Graham, Laurie. 1993. "Inside a Japanese Transplant: A Critical Perspective." *Work and Occupations,* Vol. 20, No. 2, pp. 147–73.

Hackman, J. Richard. 1985. "Doing Research That Makes a Difference." In Edward E. Lawler III et al., eds., *Doing Research That Is Useful for Theory and Practice.* San Francisco: Jossey-Bass.

Hayes, Robert, and Kim Clark. 1985. "Exploring the Sources of Productivity Differences at the Factory Level." In Kim Clark et al., eds., *The Uneasy Alliance.* Boston, Mass.: Harvard Business School Press.

Helper, Susan. 1991. "Strategy and Irreversibility in Supplier Relations: The Case of the U.S. Automobile Industry." *Business History Review,* Vol. 65, pp. 781–824.

Huselid, Mark. 1993. "Human Resource Management Practices and Firm Performance." Unpublished paper, Rutgers University.

Huxley, Christopher, David Robertson, and Jim Rinehart. 1991. "Team Concept: A Case Study of Japanese Management in a Unionized Canadian Auto Plant." Unpublished paper, Canadian Auto Workers Research Group.

Ichniowski, Casey. 1991. "Human Resource Management Systems and the Performance of U.S. Manufacturing Businesses." *NBER Working Paper Series #3449.* Cambridge, Mass.: National Bureau of Economic Research.

Ichniowski, Casey, Kathryn Shaw, and Giovanni Prennushi. 1993. "The Effect of Human Resource Management Practices on Productivity." Unpublished paper, Columbia University.

Imai, Kenichi. 1986. *Kaizen.* New York: Free Press.

Jaccard, James, Robert Turrisi, and Choi K. Wan. 1990. *Interaction Effects in Multiple Regression.* Newbury Park, Calif.: Sage.

Katz, Harry, and Jeffrey Keefe. 1992. "Collective Bargaining and Industrial Relations Outcomes: The Causes and Consequences of Diversity." In Peter Sherer, David Lewin, and Olivia Mitchell, eds., *Research Frontiers in Industrial Relations,* pp. 43–76. Madison, Wis.: Industrial Relations Research Association series.

Katz, Harry, Thomas A. Kochan, and Kenneth Gobeille. 1983. "Industrial Relations Performance, Economic Performance, and QWL Programs: An Interplant Analysis." *Industrial and Labor Relations Review,* Vol. 37, No. 1 (October), pp. 3–17.

Katz, Harry, Thomas A. Kochan, and Jeffrey Keefe. 1988. "Industrial Relations and Productivity in the U.S. Automobile Industry." *Brookings Papers on Economic Activity,* Vol. 3, pp. 685–715.

Katz, Harry, Thomas A. Kochan, and Mark Weber. 1985. "Assessing the Effects of Industrial Relations and Quality of Working Life on Organizational Performance." *Academy of Management Journal,* Vol. 28, No. 3 (September), pp. 509–27.

Kochan, Thomas A., Joel Cutcher-Gershenfeld, and John Paul MacDuffie. 1991. "Employee Participation, Work Redesign, and New Technology: Implications for Manufacturing and Engineering Practice." In Gavriel Salvendy, ed., *Handbook of Industrial Engineering,* 2nd Edition. New York: John Wiley, pp. 798–814.

Kogut, Bruce, and Udo Zander. 1992. "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology." *Organization Science,* Vol. 3, No. 3 (August), pp. 383–97.

Krafcik, John F. 1988. "Comparative Analysis of Performance Indicators at World Auto Assembly Plants." M.S. Thesis, Sloan School of Management, M.I.T.

Lawler, Edward E., III, Susan Mohrman, and Gerald E. Ledford, Jr. 1992. *Employee Involvement and TQM: Practice and Results in Fortune 1000 Companies.* San Francisco: Jossey-Bass.

Levine, David, and Laura D'Andrea Tyson. 1990. "Participation, Productivity, and the Firm's Environment." In Alan S. Blinder, ed., *Paying for Productivity.* Washington, D.C.: Brookings Institute, pp. 183–244.

MacDuffie, John Paul. 1991. "Beyond Mass Production: Flexible Production Systems and Manufacturing Performance in the World Auto Industry." Diss., Sloan School of Management, M.I.T.

MacDuffie, John Paul, and John F. Krafcik. 1992. "Integrating Technology and Human Resources for High Performance Manufacturing: Evidence from the International Auto Industry." In Thomas A. Kochan and Michael Useem, eds., *Transforming Organizations.* New York: Oxford University Press, pp. 209–26.

Maddala, G. S. 1977. *Econometrics.* New York: McGraw-Hill.

Meyer, Alan D., Anne S. Tsui, and C.R. Hinings. 1993. "Configurational Approaches to Organizational Analysis." *Academy of Management Journal,* Vol. 36, No. 6 (December), pp. 1175–95.

Milgrom, Paul, and John Roberts. 1993. "Complementarities and Fit: Strategy, Structure, and Organizational Change." Unpublished manuscript, Stanford University.

Miller, Danny, and Peter Friesen. 1980. "Momentum and Revolution in Organizational Adaptation." *Academy of Management Journal,* Vol. 23, pp. 591–614.

Mitchell, Daniel J.B., David Lewin, and Edward E. Lawler III. 1990. "Alternative Pay Systems, Firm Performance, and Productivity." In Alan S. Blinder, ed., *Paying for Productivity.* Washington, D.C.: Brookings Institution, pp. 15–94.

Monden, Yasuhiro. 1983. *Toyota Production System.* Norcross, Ga.: Institute of Industrial Engineers.

Nishiguchi, Toshihiro. 1993. *Strategic Industrial Sourcing: The Japanese Advantage.* New York: Oxford University Press.

Ono, Taiichi. 1988. *Workplace Management.* Cambridge, Mass.: Productivity Press.

Osterman, Paul. 1987. "Choices Among Alternative Internal Labor Market Systems." *Industrial Relations,* Vol. 27, No. 1 (February), pp. 46–67.

____. 1994. "How Common Is Workplace Transformation and Who Adopts It?" *Industrial and Labor Relations Review,* Vol. 47, No. 2 (January), pp. 173–88.

Parker, Mike, and Jane Slaughter. 1988. *Choosing Sides: Unions and the Team Concept.* Boston: South End Press.

Pasmore, William. 1988. *Designing Effective Organizations: The Socio-Technical Systems Perspective.* New York: John Wiley.

Pfeffer, Jeffrey. 1994. *Competitive Advantage Through People.* Boston, Mass.: Harvard Business School Press.

Rubenstein, Saul, Thomas A. Kochan, and Michael Bennett. 1993. "The Saturn Partnership: Co-Management and the Reinvention of the Local Union." In Bruce Kaufman and Morris Kleiner, eds., *Employee Representation: Alternatives and Future Directions.* Madison, Wis.: Industrial Relations Research Association series.

Schonberger, Richard. 1982. *Japanese Manufacturing Techniques.* New York: Free Press.

Shimada, Haruo, and John Paul MacDuffie. 1986. "Industrial Relations and 'Humanware': Japanese Investments in Automobile Manufacturing in the United States." Working Paper, Sloan School of Management, M.I.T.

Snell, Scott A., and James W. Dean, Jr. 1992. "Integrated Manufacturing and Human Resource Management: A Human Capital Perspective." *Academy of Management Journal,* Vol. 35, No. 3 (August),

pp. 467–504.
Trist, Eric, and Kenneth Bamforth. 1951. "Some Social and Psychological Consequences of the Longwall Method of Coal-Getting." *Human Relations*, Vol. 4, pp. 6–38.
Ulrich, Dave, and Bill McKelvey. 1990. "General Organizational Classification: An Empirical Test Using the United States and Japanese Electronics Industries." *Organizational Science*, Vol. 1, No. 1 (February), pp. 99–118.
Useem, Michael. 1993. *Executive Defense: Shareholder Power and Corporate Reorganization.* Cambridge, Mass.: Harvard University Press.
Weitzman, Martin, and Douglas Kruse. 1990. "Profit Sharing and Productivity." In Alan S. Blinder, ed., *Paying for Productivity.* Washington, D.C.: Brookings Institute, pp. 95–142.
Womack, James, Daniel Jones, and Daniel Roos. 1990. *The Machine That Changed the World.* New York: Rawson-MacMillan.