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THE IMPACT OF COLLABORATION PLANNING FORECASTING AND REPLENISHMENT (CPFR) ON THE PERFORMANCE OF FIRMS IN A SUPPLY CHAIN

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Cette thèse intitulée:

THE IMPACT OF COLLABORATION PLANNING FORECASTING AND REPLENISHMENT (CPFR) ON THE PERFORMANCE OF FIRMS IN A SUPPLY CHAIN

présentée par: CASSIVI Luc

en vue de l'obtention du diplôme de: Philosophiae Doctor

a été dûment acceptée par le jury d'examen constitué de :

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ABSTRACT

In today's digital economy, firms increasingly rely on their business partners to add value to their products and services. Electronically driven collaboration initiatives are emerging in a good number of supply chains where critical information must be visible and available for both upstream and downstream partners. In these technology-driven supply chain relationships, improved performance is the ultimate goal. However, in order to obtain a high level of performance, efforts must be made and methods are required to plan collaborative actions between supply chain partners.

This study analyzes the impact of collaboration planning on the performance of a supply chain. The first elements of collaborative planning, forecasting and replenishment (CPFR), namely developing a front-end agreement and creating a joint business plan, are used to assess the effect of collaboration planning on the supply chain's performance. This study also has the objectives of analyzing the impact of collaboration planning on a firm's innovativeness and, of evaluating the mediating effect of process and relational innovations on the relationship between collaboration planning and supply chain performance.

In order to achieve these specific objectives, the study was carried out in two phases. First, a field research, which focuses on one large telecommunications equipment manufacturer and a few strategic first-tier suppliers, provides the basis to fully understand the collaboration methods and the various issues and concerns of the different members of the telecommunication equipment supply chain. The impact of collaboration methods

on the dynamics of supply chain relationships was clearly an issue for the companies involved in the field research. For system integrators, different roles may be attributed to collaboration tools in the constant evolution of the supply chain: (i) facilitate access to information, which affects knowledge creation capabilities, and (ii) assist in the design of flexible supply chains. The field study also demonstrated that process and relational innovations are enhanced by the development of electronic collaboration activities within the telecommunications equipment supply chain. Supply chain collaboration initiatives such as CPFR change the way firms do business with partners (process innovation) and transform the way they interact (relational innovation).

An electronic survey conducted with 53 firms worldwide acting in the same supply chain constitutes the second phase of the study. The research model is established on two important issues: (i) reaching firms positioned at different levels of one supply chain and (ii) analyzing the supply chain from both the upstream and downstream perspectives. The results indicate that collaboration planning has a significant effect on process and relational innovations and on supply chain performance in terms of output, resource and flexibility measures. The findings also reveal a partial mediation effect of innovativeness on the relationship between collaboration planning and supply chain performance.

Finally, using cluster analysis, an attempt is made to develop a typology of collaboration among firms within a supply chain environment. The telecommunications equipment supply chain seems to be adequately represented by three groups, representing stages from minimal concern with supply chain collaboration to in-depth involvement.

CONDENSÉ EN FRANÇAIS

Les entreprises manufacturières oeuvrant dans des domaines de haute technologie sont aujourd'hui confrontées à de multiples impératifs, tels la globalisation des marchés et l'impartition de certaines de leurs activités. Ces impératifs incitent les entreprises à collaborer avec des partenaires pour l'ensemble des leurs activités (recherche et développement, fabrication, ventes, etc.). Cette collaboration a comme objectif d'améliorer la performance de l'entreprise mais également d'améliorer le rendement global de la chaîne d'approvisionnement (aussi connu sous les appellations chaîne logistique et *supply chain*).

Les méthodes de gestion de chaîne d'approvisionnement et les outils de collaboration sont de plus en plus utilisés et permettent aux entreprises de progresser dans un contexte manufacturier. La performance est souvent liée de près au niveau d'intégration d'une chaîne d'approvisionnement (Armistead et Mapes, 1993; Evans et al., 1993; Kwan, 1999). Cette intégration, aussi connue sous le nom d'entreprise-réseau ou d'entreprise virtuelle, est une forme de collaboration inter-organisationnelle (Browne et Zhang, 1999; Martinez et al., 2001; Weisenfeld et al., 2001; Buchel et Raub, 2002). Porter (1985) affirme que les interactions de plusieurs entreprises créent un système à valeur ajoutée qui permet à un membre, grâce aux activités à valeur ajoutée de ses partenaires, d'améliorer son avantage compétitif. Plusieurs autres auteurs perçoivent également le réseautage et le partenariat comme étant une manière de générer un avantage compétitif (Lamming, 1996; Bovet et Martha, 2000b).

Très peu d'études empiriques portant sur la collaboration des entreprises d'un réseau évaluent les impacts des nouvelles technologies de collaboration, tel le CPFR (*collaborative planning forecasting and replenishment*). Un bon nombre d'études ont été conduites dans les domaines de la gestion des relations clients-fournisseurs ou de la gestion de la chaîne d'approvisionnement, mais la plupart de celles-ci sont de nature conceptuelle ou basées sur des études de cas (Shin et al., 2000). De plus, la gestion de la chaîne d'approvisionnement a été analysée dans plusieurs secteurs mais la performance de la chaîne d'approvisionnement a quant à elle rarement été étudiée de façon empirique (Miller, 2001).

1. Problématique

L'arrivée de nouvelles technologies de l'information a permis le développement de partenariats au sein des chaînes d'approvisionnement, plus précisément entre les différents tiers fournisseurs. Ces technologies se font cependant rares étant donné le niveau excessif de ressources qu'elles requièrent dans un cadre de développement. Ainsi, dans les secteurs manufacturiers, la collaboration est souvent associée à un nombre réduit de fournisseurs importants (Bakos et Brynjolfsson, 1993). Pour la majorité des entreprises, l'impartition de la production est désormais quasi incontournable afin d'assurer une certaine compétitivité. Aussi, l'impartition devient un choix stratégique (Collins et Bechler, 1999). Dans le cas d'une entreprise qui travaille avec un seul fournisseur, les activités de conception conjointe et d'échange de plans de production créent une synergie et une complémentarité intéressantes pour les deux partenaires (Spina et Zotteri, 2000).

Les systèmes d'information de gestion (MIS) jouent un rôle important lors de la planification des activités de la chaîne d'approvisionnement, tant au niveau intra-organisationnel qu'inter-organisationnel (Rutner et al., 2001). Tout d'abord, l'échange et la diffusion de l'information au niveau interne sont assurés par les systèmes d'information (par exemple, les systèmes ERP – *Enterprise Resource Planning*). Ayant établi des processus sur le modèle des meilleures pratiques d'affaires, les activités opérationnelles (planification, achat, production) sont souvent pré-programmées au sein même de ces systèmes. Par contre, avant même l'implantation de ces systèmes, les rôles des différents départements dans le processus de planification de la collaboration doivent être établis par l'équipe de gestion, ce qui exige souvent la mise en place d'outils, de règlements et de processus spécifiques pour faciliter les relations intra-entreprises.

Au niveau inter-organisationnel, les systèmes ont la capacité de lier les entreprises avec leurs partenaires d'affaires, quoique certaines entreprises oeuvrant dans un environnement très compétitif préfèrent ne pas se lancer dans la collaboration pour des raisons de sécurité et de confidentialité. L'impartition des activités de production ne cesse de croître et les donneurs d'ordres se concentrent sur leurs activités clés (R&D, marketing ou logistique, par exemple). Ces derniers utilisent des technologies de gestion de chaîne d'approvisionnement afin de superviser les fournisseurs de services spécialisés qui se chargent de la conception et de la fabrication, activités autrefois réalisées au sein même des grandes entreprises à gestion verticale. Les gains en terme de volume produit, de « time-to-market » et de profits poussent généralement les entreprises à impartir les activités manufacturières.

Ces changements importants au sein de l'entreprise ont pour effet de transformer la chaîne d'approvisionnement, qui nécessite de nouvelles formes de relations inter-organisationnelles. Les fournisseurs ne sont plus perçus comme d'éventuels compétiteurs mais plutôt comme des partenaires (Christopher, 1992; Laseter, 1998; Horvath, 2001). Les thèmes de recherche issus des relations inter-organisationnelles, tels le partenariat dans la chaîne d'approvisionnement et les relations clients-fournisseurs, sont également à l'avant-poste des recherches en commerce électronique (B-to-B) (Sheth, 1996). Cela démontre que la durée et la complexité des relations des membres d'une chaîne d'approvisionnement peuvent être très déterminantes dans le succès des activités de commerce électronique. Plusieurs auteurs confirment l'impact des relations de longue durée sur le succès d'un produit ou d'un service (Kalwani et Narayandas, 1995; Ittner et Larcker, 1997). D'autres témoignent de l'importance de la collaboration, de l'efficacité des échanges et de la flexibilité de la chaîne d'approvisionnement pour les entreprises voulant réussir et se démarquer dans leur secteur d'activité (Landeros et Monczka, 1989; Vickery et al., 1999 ; Mentzer et al., 2000).

Ainsi, la responsabilité et la réalisation d'un produit ou d'un service se retrouvent davantage sur les épaules des membres de la chaîne d'approvisionnement, d'où l'importance de la sélection de partenaires d'affaires compétents, des relations inter-organisationnelles qui en découlent et de la bonne performance de tous les membres de la chaîne d'approvisionnement.

2. Objectifs visés

Lors de cette recherche, une revue de la littérature relative aux études empiriques dans le domaine de la gestion de la chaîne d'approvisionnement a permis d'identifier les lacunes et les avenues de recherche suivantes:

1. La planification est aussi importante que l'exécution des activités de la chaîne d'approvisionnement: cette planification est l'un des points forts de la méthode CPFR lorsqu'elle est utilisée avec des fournisseurs.

2. Le contexte des recherches en matière de chaîne d'approvisionnement doit être bien précis et délimité. Le niveau d'impartition qui ne cesse de croître dans le secteur des équipements de télécommunication en fait un secteur particulièrement intéressant, et ce, plus précisément dans le contexte d'une chaîne d'approvisionnement d'un donneur d'ordres.

3. Dans un contexte de chaîne d'approvisionnement, les mesures de performance doivent être alignées avec les processus innovateurs et les nouvelles formes de relations générées par ces processus. Les méthodes utilisées par les partenaires d'une chaîne d'approvisionnement pour échanger de l'information sur les opérations (inventaire, plan de production, etc.) ont été transformées par le commerce électronique, et plus particulièrement par les outils électroniques de collaboration. Le développement de ces outils amène de nouvelles avenues de recherche qui ont comme

objectif d'évaluer l'impact des innovations (de types processus ou relationnelles) sur la chaîne d'approvisionnement.

4. L'impact de la collaboration sur la chaîne d'approvisionnement doit être analysé tant pour les activités en amont que celles en aval : la méthode de collecte de données doit être conçue pour rejoindre à la fois ceux qui échangent avec les fournisseurs que ceux qui sont en contact avec les clients.

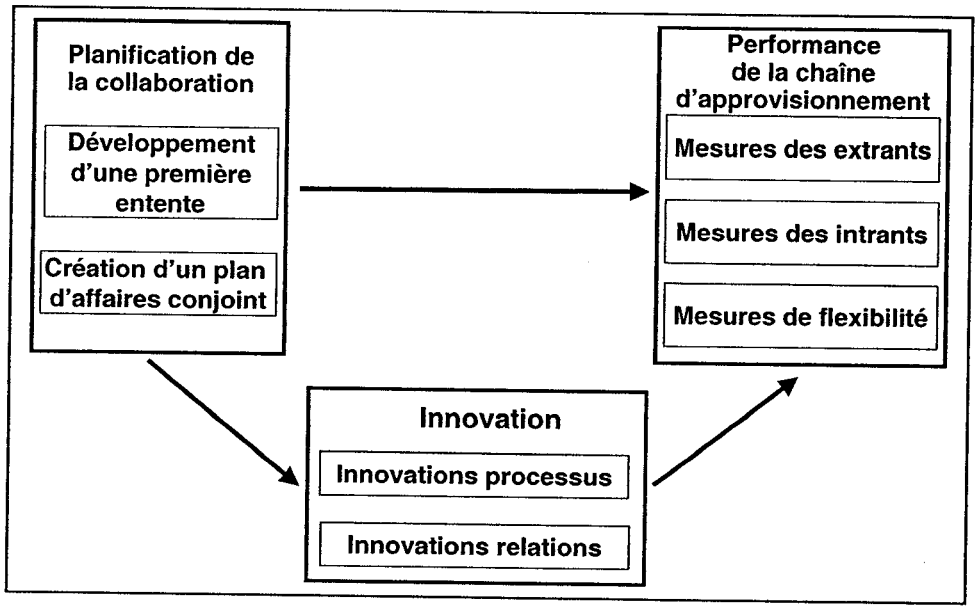
Les quatre points ci-dessus identifient certains aspects importants qui guideront les recherches et les analyses des impacts des outils de collaboration, et surtout de la planification conjointe de la collaboration. Des questions principales découlent des activités de planification conjointe:

(i) La planification conjointe mènera-t-elle à certaines innovations (sous forme produit, processus ou relation) qui faciliteront la collaboration au sein de la chaîne d'approvisionnement?

(ii) La planification conjointe aura-t-elle un impact sur la performance des entreprises oeuvrant dans la chaîne?

3. Cadre de recherche

Trois groupes de variables ont été identifiés pour répondre à la problématique et aux objectifs de recherche. Le tableau suivant présente ces variables et les différentes propositions de recherche.



3.1 Planification de la collaboration (CPFR) – variables indépendantes

La méthode CPFR permet aux entreprises de collaborer dans un contexte de chaîne d'approvisionnement. Elle est particulièrement axée sur les activités de planification et de prévision de la demande, et aide les entreprises à développer des plans de production et de distribution qui répondent à la fois aux demandes actuelles (commandes des clients) et futures (VICS 1998). La méthode CPFR trouve ses origines dans les programmes d'optimisation d'inventaire, notamment le VMI (*vendor-managed inventory*) et le CRP (*continuous replenishment programs*), qui ont été conçus pour rapprocher les partenaires d'une chaîne d'approvisionnement. La lacune principale des ces méthodes, le manque d'échange d'information, est comblée par la méthode CPFR qui ajoute certains mécanismes de collaboration afin de faciliter l'échange d'information à travers les divers niveaux de fournisseurs de la chaîne d'approvisionnement.

Développé par l'association VICS (*Voluntary Interindustry Commerce Standards*), CPFR est divisé en plusieurs phases. La première phase, dite de «planification», comporte deux étapes importantes : le développement d'une première entente et la création d'un plan d'affaires conjoint. La deuxième phase comporte deux étapes qui se concentrent sur l'aspect prévisionnel (*sales-forecast collaboration* et *order-forecast collaboration*). La troisième et dernière phase du CPFR, le réapprovisionnement, comprend une seule étape: la production de la commande. Cette étude analyse l'impact de la planification de la collaboration et se concentre sur la première phase du CPFR, soit les étapes de développement d'une première entente et de création d'un plan d'affaires conjoint.

Étape de développement d'une première entente : Une première entente ferme entre partenaires est souvent requise afin d'éviter des complications dans les relations d'affaires qui ne cessent d'évoluer. Cette étape du CPFR inclut dix actions qui ont été regroupées pour des fins d'analyses statistiques et forment les trois construits suivants:

(i) l'entente de collaboration : regroupe des sujets tels les objectifs communs de collaboration, la confidentialité, les compétences, les opportunités et les impacts de mesures conjointes de performance.

(ii) la modélisation (*mapping*) du processus de collaboration : aborde des points bien précis de la conception du processus de collaboration tels l'identification des systèmes et des fonctionnalités, l'identification des points de collaboration, l'information à être échangée, le niveau d'engagement (service, personnel, temps) du processus de collaboration et les ressources requises.

(iii) l'amélioration continue : s'intéresse aux activités d'évaluation et d'étalonnage (*benchmark*) des relations, la formulation des règlements et l'échange des documents officiels d'entente.

Étape de création d'un plan d'affaires conjoint : Cette étape provoque un engagement à long terme entre les partenaires d'affaires qui doivent s'entendre sur les méthodes d'échange d'information et sur une vision commune des activités de collaboration. Cette étape du CPFR inclut six actions qui ont été regroupées en deux construits:

(i) Actions stratégiques de collaboration : regroupe quelques notions qui permettent aux partenaires de bien cerner les stratégies de chacun, tels le développement d'une stratégie acceptée par tous, l'échange d'information stratégique et la comparaison de plan d'affaires pour la création d'un plan conjoint.

(ii) Actions tactiques de collaboration: aborde les sujets reliés aux produits plutôt que ceux reliés à l'entreprise (comme c'est le cas pour les actions stratégiques), tels le rôle et les objectifs de catégories spécifiques de produit et le développement de plans individuels basés sur des informations échangées antérieurement.

Un troisième construit, qui n'est pas relié à la méthode CPFR, complète l'étape de la création d'un plan d'affaires conjoint : l'efficacité des outils électroniques de collaboration utilisés dans la chaîne d'approvisionnement.

3.2 Innovation

Les partenaires qui collaborent dans le développement d'outils de commerce électronique et de stratégie de chaîne d'approvisionnement doivent innover afin de rester compétitif dans leur secteur (Mason-Jones et Towill, 1999). Ces innovations, qui sont souvent exigées par un client important, voire un fournisseur, peuvent prendre plusieurs formes, parmi lesquelles l'innovation processus, l'innovation relationnelle et l'innovation produit.

Les innovations processus influencent la manière dont les produits et services sont conçus et fabriqués. Davenport (1993) définit ainsi un processus: "*a structured and measured set of activities designed to produce a specific output for a particular customer or market*". Dans cette étude, les innovations produits sont scindées en trois construits. Deux items forment le premier construit, soit la génération de processus et l'ajustement des processus face aux besoins du client. Le deuxième construit s'attarde aux améliorations des processus logistiques, à la flexibilité des activités de distribution et à la réactivité de la chaîne de distribution. Le dernier des trois construits réunit les items reliés à la production, soit la conception de nouveaux procédés de production et la flexibilité manufacturière.

Les innovations relationnelles dans une chaîne d'approvisionnement regroupent les nouvelles méthodes (ou améliorations de celles-ci) qui guide les interactions entre acheteurs et fournisseurs. La confiance, la loyauté, l'engagement et la segmentation de marché sont quelques-uns des aspects formant dans les innovations relationnelles d'une chaîne d'approvisionnement. Plusieurs études ont démontré que la confiance et

l'engagement sont des éléments critiques en matière de relations acheteurs-fournisseurs et de formation d'alliances (Anderson et Narus, 1990 ; Ring et Van de Ven, 1994 ; Handy, 1995 ; Moore, 1998 ; Zaheer et al., 1998). Les innovations relationnelles sont représentées par deux construits, le développement de partenariat et l'amélioration des relations. Le premier construit inclut l'identification de nouveaux partenaires et le prolongement des relations avec les partenaires actuels tandis que le deuxième construit aborde la confiance, la loyauté et la qualité des relations entre partenaires.

3.3 Performance de la chaîne d'approvisionnement

L'auteur de cette étude s'est appuyé sur les recherches de Beamon (1999) portant sur la performance d'une chaîne d'approvisionnement. Ainsi, trois construits ont été développés selon le cadre établi par Beamon : mesures des extrants, mesures des intrants et mesure de flexibilité. Neuf items ont été utilisés pour former le construit des mesures des extrants (entre autres le nombre d'items, le temps de production, la qualité du produit, la satisfaction du client, etc.). Les mesures des extrants incluent cinq items (inventaire, argent, main-d'œuvre, équipement et énergie) requis pour mener à bien une chaîne d'approvisionnement tandis que les mesures de flexibilité, qui sont utilisées pour répondre aux impératifs technologiques et de marché, ont été formées à partir de quatre items, soit la flexibilité en terme de volume de production, de variété de produit, d'agilité logistique et de développement de produit.

Ainsi, cinq propositions sont émises afin d'évaluer les relations entre chaque groupe de variables :

P1: La planification de la collaboration a une influence positive sur l'innovation

P2: La planification de la collaboration a une influence positive sur la performance de la chaîne d'approvisionnement.

P3: L'innovation a une influence positive sur la performance de la chaîne d'approvisionnement

P4: Les relations énumérées dans P1, P2, P3 sont influencées par des variables comme le niveau de demande et de personnalisation d'un produit et la position d'un fournisseur au sein de la chaîne d'approvisionnement.

P5: L'innovation a un effet de médiation sur la relation entre la planification de la collaboration et la performance de la chaîne d'approvisionnement

4. Méthodologie de la recherche

La chaîne d'approvisionnement du secteur équipementier des télécommunications a été sélectionnée parce que l'utilisation d'outils électroniques de collaboration et la croissance du niveau d'impartition, surtout pour les activités manufacturières, sont importantes dans cette industrie. Par ailleurs, un récent sondage sur la collaboration à l'occasion d'échanges d'information et d'intégration de systèmes, effectué par une firme spécialisée dans l'intégration de systèmes a identifié l'industrie des télécommunications comme l'un des secteurs avec le plus haut niveau de collaboration entre les partenaires d'une chaîne (NerveWire, 2002). On y trouve en outre, selon ce sondage, des niveaux importants d'intégration interne. Notre étude se concentre sur une chaîne d'approvisionnement

rattachée à une grande entreprise dans ce secteur de pointe qui comprend ses fournisseurs (de tous les niveaux) et ses clients.

La stratégie de collecte de données est composée de deux phases :

(i) Une étude de terrain, qui a été menée dans le cadre d'une étude internationale (pilotée par l'OCDE dans huit pays) sur les initiatives reliées au commerce électronique. Cette première étape se concentre sur un important fabricant d'équipement de télécommunications et quelques-uns de ses fournisseurs stratégiques. L'objectif de cette étape est de bien cerner les méthodes, d'identifier les intérêts et de comprendre le questionnement des différents membres de la chaîne d'approvisionnement en ce qui a trait à la collaboration dans la chaîne. Quatre entreprises (cinq unités d'affaires) ont participé à cette première étape. Lors de l'étude de terrain, des entrevues semi-structurées (face-à-face) ont été utilisées comme méthode de collecte de données. Le guide de l'entrevue a été fourni par l'OCDE et plusieurs questions y ont été ajoutées par l'auteur. Des observations directes (sur les sites d'intervention) et de la documentation sur le sujet (communiqués de presse, rapports, articles de journaux, sites web) ont également été utilisées en complément.

(ii) Un questionnaire électronique, qui sollicitait la participation d'entreprises oeuvrant dans la chaîne d'approvisionnement d'un important équipementier du secteur des télécommunications. En se basant sur les résultats obtenus dans la première phase, ce questionnaire électronique a été développé pour recueillir de l'information sur les activités, à la fois en amont de la chaîne (fonctions reliées aux fournisseurs, par exemple

les achats et la conception), et en aval (fonctions reliées aux clients, par exemple les ventes et le marketing). Cent trente entreprises ont été appelées à participer au questionnaire électronique, la majorité étant des fournisseurs importants de l'équipementier. Le taux de réponse (40,8%) au questionnaire a été jugé très satisfaisant.

5. Résultats et analyses

Cette section synthétise les principaux résultats de l'étude de terrain et du questionnaire électronique.

5.1 Résultats de l'étude de terrain

L'impact des outils de collaboration sur la dynamique des relations au sein de la chaîne d'approvisionnement était important aux yeux des entreprises participantes. Les techniques de fabrication «allégée» (*lean*) et la stratégie « menée par la demande » (*demand-driven*) (Lummus et Vokurka, 1999; Vollmann et al., 2000; Frohlich et Westbrook, 2002) sont les concepts-clés derrière le développement de ces outils. Cette stratégie « *demand-driven* » implique une étroite collaboration entre les partenaires (Tan et al. 1999; Christopher et Towill, 2000; Simatupang et Sridharan, 2002). La planification de la collaboration est un élément important des processus de la chaîne d'approvisionnement et les premières phases de la méthode CPFR semblent bien correspondre à l'approche privilégiée par les joueurs de la chaîne d'approvisionnement du secteur. Entre autres, avec la présence d'une structure de pouvoir au sein de la chaîne,

les activités de collaboration doivent être préparées adéquatement en développant conjointement des ententes et des plans d'affaires.

L'étude de terrain démontre également que les innovations processus et relationnelles sont enrichies par le développement des activités de collaboration électronique au sein de la chaîne. Les initiatives de collaboration, tel le CPFR, modifient la manière dont les entreprises s'y prennent pour interagir avec leurs partenaires (innovations processus) et transforment leurs comportements lorsqu'elles interagissent entre elles (innovations relationnelles). Par contre, la planification de la collaboration, et voire même la collaboration au sein de la chaîne d'approvisionnement, ne semble pas influencer les innovations produits, c'est-à-dire la conceptions de produits, la personnalisation et la différentiation de produits.

5.2 Résultats du questionnaire électronique

Les analyses statistiques réalisées sur les données recueillies par le questionnaire électronique ont mené à des résultats intéressants :

(i) Les innovations processus et relationnelles sont influencées positivement par le développement d'une première entente et par la création d'un plan d'affaires conjoint. Ces propositions sont appuyées tant pour les activités en amont que celles en aval de la chaîne.

(ii) Généralement, la performance de la chaîne d'approvisionnement est positivement et partiellement reliée au développement d'une première entente ainsi qu'à la création

d'un plan d'affaires conjoint. De plus, le développement d'une première entente influence positivement les mesures de flexibilité pour les activités en amont tandis que la création d'un plan d'affaires conjoint influence positivement ces mêmes mesures pour les activités en aval.

(iii) La performance de la chaîne d'approvisionnement est également positivement corrélée aux innovations processus et relationnelles. Les effets de l'innovation sur les mesures des extrants et de flexibilité sont significatifs, mais n'affectent pas les mesures des intrants.

(iv) L'influence des variables de contrôle sur les propositions P1, P2 et P3 ne sont pas très significatifs. Ces variables ont tendance à influencer légèrement davantage les relations en amont que celles en aval.

(v) L'effet de médiation sur la relation entre le développement d'une première entente et la performance de la chaîne d'approvisionnement est relativement semblable pour les innovations processus et relationnelles. Les propositions reliées à la médiation sont partiellement supportées pour les relations entre les deux premières étapes du développement d'une première entente (entente de collaboration et modélisation du processus de collaboration) et la performance de la chaîne d'approvisionnement. Par contre, pour les relations impliquant l'amélioration continue (troisième étape du développement d'une première entente) et la performance de la chaîne d'approvisionnement, un effet de médiation des innovations processus est perçu lors des activités en aval, mais pas pour celles en amont. On peut également déceler un effet de médiation partielle sur ces mêmes

relations (à la fois pour les activités en amont et en aval) en utilisant les innovations relationnelles comme variables médiatrices.

(vi) En général, les innovations processus, et particulièrement les innovations relationnelles, fournissent des effets de médiation partielle sur les relations entre la création d'un plan d'affaires conjoint et la performance de la chaîne d'approvisionnement. Par contre, aucun effet de médiation (innovations processus et relationnelles) est décelé pour les relations entre les actions stratégiques de collaboration et la performance de la chaîne d'approvisionnement lors des activités en amont.

(vii) À l'aide d'une méthode de regroupement (classification hiérarchique ascendante - *cluster analysis*), nous avons tenté de créer des configurations de collaboration. Trois groupes distincts comportant des niveaux et types de planification de la collaboration différents ont été identifiés : 42,5% des entreprises sont positionnées dans le groupe de planification de collaboration minimal; 17,5% dans le groupe de planification de collaboration à sens unique; et 40% dans le groupe de planification de la collaboration à double sens. Ces groupes représentent bien la chaîne d'approvisionnement de l'industrie des équipements de télécommunication où les entreprises sont, soit très impliquées dans la collaboration avec leurs partenaires de la chaîne, soit très rarement concernées par la collaboration.

6. Portée de la thèse

Pour cette étude, l'auteur a choisi une méthodologie qui présente à la fois certaines forces et certaines faiblesses. En utilisant deux méthodes complémentaires de collection de données, les activités d'une seule chaîne d'approvisionnement (équipement de télécommunication) sont particulièrement bien identifiées, et l'analyse reflète bien les rôles et tâches de chaque membre de la chaîne.

En se concentrant sur les initiatives reliées à la collaboration d'une chaîne spécifique, l'étude était limitée à un certain nombre d'entreprises réalisant des activités de planification de la collaboration. L'application de méthodes de collaboration, comme le CPFR, est récente dans l'industrie des équipements de télécommunication, ce qui limite le nombre de compagnies utilisant celles-ci dans un contexte de commerce électronique. Ces méthodes n'ont pas encore atteint un niveau de maturité dans l'industrie, ce qui peut partiellement expliquer le nombre restreint de répondants. Par contre, l'adoption progressive de ces pratiques de collaboration rend cette étude exploratoire des plus intéressantes. Le double sens du questionnaire, auquel les gestionnaires en amont et en aval doivent répondre, augmente sa complexité. Par contre, l'étude qui en découle tire son originalité du fait qu'une analyse des activités reliées à chacune des perspectives (client et fournisseur) est réalisable et par conséquent fort intéressante. Le manque de généralisation des résultats de cette étude à d'autres chaînes d'approvisionnement est également une limite, mais elle est rapidement estompée par la qualité de l'information

obtenue par une étude approfondie. À partir de ces arguments, on reconnaît la pertinence de l'analyse d'une seule chaîne d'approvisionnement.

Le but ultime d'une entreprise qui adopte des processus de collaboration est d'intégrer les activités internes à celles en amont et en aval de l'entreprise. Ainsi, la complexité reliée à l'analyse de ces deux perspectives (amont et aval) renforce cette étude car les activités peuvent être évaluées et comparées selon des critères identiques. Par contre, en observant ces deux perspectives, l'auteur renonce à un certain niveau de détail qui aurait pu être atteint en analysant une seule des perspectives. Très peu d'entreprises sont engagées dans une collaboration qui couvre la totalité de la chaîne d'approvisionnement (Akkermans et al., 1999; Whippel et al., 1999; Harps et Hansen, 2000). Cette étude est l'une des seules dans le domaine qui s'attarde à évaluer les deux perspectives. Certaines études, par exemple celle de Fawcett et Magnan (2002), analysent les deux perspectives mais se concentrent sur un seul niveau d'une chaîne. Le contexte de chaîne d'approvisionnement à multiples niveaux et l'évaluation des perspectives clients et fournisseurs contribuent à l'originalité de notre étude.

L'évaluation de la performance d'une chaîne d'approvisionnement n'est pas une tâche facile, puisqu'elle consiste à comprendre les liens qui unissent les activités de chaque membre de la chaîne. Suivre le cheminement d'un produit à travers la chaîne et mesurer sa performance à chaque niveau s'avère un mode d'évaluation intéressant mais ardu. Cette méthode demande la participation de chaque membre de la chaîne, ce qui n'est pas simple étant donné que les entreprises du secteur des télécommunications n'ont pas

l'habitude de fournir de l'information sur leurs produits innovateurs et à cycles de vie très courts. Ainsi, l'auteur a choisi une autre approche où les liens entre les membres de la chaîne trouvent leurs fondements dans les outils de collaboration facilitant l'échange et le partage de l'information. Certaines activités de planification de la collaboration ont facilité la conception et l'utilisation de ces outils, et ce dans un contexte d'une chaîne « *demand-driven* ». Cette approche permet d'évaluer l'impact de la planification de la collaboration sur la performance des activités reliées à la chaîne telle qu'elle est perçue par les entreprises participantes.

La validité interne de l'étude est conséquemment difficile à établir puisque les mesures de performance sont celles perçues par chaque membre de la chaîne, et que ces mesures sont surtout orientées vers le domaine manufacturier. Par exemple, la performance financière de l'entreprise n'est pas analysée par le modèle conceptuel, ce qui s'explique par le fait que les mesures de performance à caractère financier ne sont pas directement liées au développement et à l'utilisation des outils de collaboration (comme c'est le cas pour des mesures de performances opérationnelles).

7. Principales conclusions, applications et recommandations

Cette étude explore un thème important qui influencera l'avenir de certaines industries. Les processus d'affaires, qui étaient auparavant surtout réalisés à l'interne, s'étendent de plus en plus aux partenaires de la chaîne d'approvisionnement par le biais des activités

communes, d'un niveau important d'impartition ou tout simplement par l'échange d'information critique entre partenaires.

Il existe plusieurs définitions d'une chaîne d'approvisionnement qui varient selon le sujet (logistique, gestion des connaissances, etc.). Ainsi, aucune définition générale a pu être identifiée car certains aspects sont spécifiques au sujet de recherche. Un des objectifs de cette étude était d'éclaircir certains sujets issus de ce domaine de recherche. Plusieurs auteurs ont émis certains concepts reliés au domaine des chaînes d'approvisionnement mais peu d'entre eux ont conduit des recherches quantitatives. Les deux phases (étude de terrain et questionnaire électronique) de cette étude améliorent notre compréhension de la collaboration au sein d'une chaîne d'approvisionnement et le rôle de la planification de la collaboration sur la performance d'une chaîne.

La planification de la collaboration et l'utilisation de méthodes, tel le CPFR, dans un contexte de chaîne d'approvisionnement ne sont qu'à leurs premiers balbutiements. Les recherches reliées au commerce électronique et à la chaîne d'approvisionnement se sont concentrées sur les technologies et les compétences requises à la réalisation de projets de collaboration au sein d'une chaîne. Très peu d'études (voire aucune) se sont intéressées en particulier aux étapes de préparation à la collaboration électronique. Afin de bien comprendre la collaboration au sein d'une chaîne, cette étude tente d'identifier le rôle de certaines actions (planification de la collaboration) sur la performance d'une chaîne spécifique (secteurs des télécommunications) utilisant des outils de collaboration, ce qui permettra éventuellement une analyse de différentes chaînes de divers secteurs.

Les entreprises qui collaborent au sein d'une chaîne d'approvisionnement ne peuvent se contenter d'un simple accès à des outils de collaboration électroniques. Elles doivent transformer les méthodes d'échanges d'information, et ce au niveau des processus d'affaires et des relations dans la chaîne. Le modèle conceptuel proposé dans cette étude tente de définir la structuration des actions reliées à la planification de la collaboration qui permettra à des membres d'une chaîne d'obtenir une performance optimale. Ce modèle peut guider des chercheurs de différents domaines (i.e. gestion de la technologie, génie industriel et gestion des opérations) à mieux cerner les enjeux d'une planification de la collaboration lors de l'utilisation d'outils électroniques. De plus, ce modèle tente d'analyser tous les niveaux de la chaîne en utilisant les perspectives fournisseurs et clients, ce qui, jusqu'à présent, n'a pas été fait dans le contexte d'une chaîne d'approvisionnement.

L'accroissement de l'impartition des activités de conception et de fabrication implique la participation accrue des entreprises spécialisées, ce qui occasionne certaines complications reliées à la confidentialité et à la sécurité de l'information échangée. Une évolution constante de la technologie doit accompagner le développement des processus et les relations de la chaîne d'approvisionnement. Ainsi, les vendeurs de logiciels, entre autres ceux dans les domaines du commerce électronique et de la gestion d'entreprise peuvent être intéressés par certains résultats de cette étude :

(i) CPFR : L'étude peut aider les entreprises à comprendre le rôle du CPFR dans la gestion de la chaîne d'approvisionnement et plus particulièrement le rôle de la

planification de la collaboration (deux premières étapes du CPFR) dans le développement de leurs réseaux.

(ii) Implantation : L'étude identifie certaines variables (tactiques et stratégiques) de collaboration et indique leur importance dans le succès des implantations d'outils *supply chain.*

(iii) Indicateurs de performance : L'étude permet d'estimer certaines mesures de performance en relation avec de futures actions et stratégies de collaboration mises en place par des gestionnaires.

(iv) Bénéfices : L'étude fournit quelques pistes intéressantes reliées au développement des activités de collaboration dans la chaîne et identifie des bénéfices potentiels aux initiatives de collaboration dans un contexte de chaîne d'approvisionnement. De plus, pour les vendeurs de logiciels qui souhaitent démontrer les nombreux avantages des outils de *supply chain*, ils pourront, avec cette étude, démontrer les bénéfices de l'application d'outils de collaboration dans un contexte de chaîne d'approvisionnement et également y ajouter de nouvelles fonctions complémentaires.

Les initiatives de recherche sur les impacts de la collaboration sur les chaînes d'approvisionnement commencent à se manifester dans la littérature. Cette étude exploratoire nous a permis d'identifier quelques avenues de recherche. En identifiant des mesures de performances pertinentes, elle représente une des premières étapes vers

l'évaluation d'une chaîne d'approvisionnement en utilisant un ensemble complet de mesures. Selon Lambert et Pohlen (2001), il n'existe pas encore de mesures de performance adaptées à l'évaluation de la chaîne complète et chaque chaîne doit développer les mesures selon les caractéristiques de son environnement. Ainsi, une étude de terrain à plus grande échelle fondée sur l'utilisation de mesures spécifiques à un contexte s'avère intéressante pour l'avancement des connaissances reliées aux mesures d'une chaîne d'approvisionnement.

Selon Hoover et al. (2001), plus l'étendue de la collaboration au sein de la chaîne est importante, plus les bénéfices associés à la planification de la collaboration sont importants. Comme cette étude se concentre sur les premières étapes du CPFR, il serait intéressant de la compléter en y intégrant les autres étapes du CPFR, soit les étapes de prévisions et de réapprovisionnement, ce qui permettrait d'évaluer l'impact d'un cycle complet de la méthode CPFR sur une chaîne d'approvisionnement.

De plus, les résultats démontrent que la planification de la collaboration a tendance à améliorer la performance sous une forme intangible (mesures de flexibilité) plutôt que sous une forme tangible (mesures des extrants et des intrants). Une analyse plus poussée du rôle des bénéfices intangibles au sein d'une chaîne d'approvisionnement efficace, plutôt qu'une étude utilisant des mesures plus traditionnelles (coûts, inventaire, etc.), pourrait intéresser un bon nombre d'entreprises.

Finalement, à la suite de cette étude d'une chaîne d'approvisionnement dans le secteur manufacturier des équipements de télécommunications, il serait intéressant d'identifier

des chaînes d'approvisionnement similaires pour des fins de comparaison. Une industrie, où les cycles de vie de produit et les délais de fabrication sont courts (par exemple le secteur de l'informatique), et où les partenaires sont engagés dans la planification de la collaboration, pourrait être mesurée au secteur des équipements de télécommunications.

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INTRODUCTION

Communications technologies and media, such as the Internet, are, becoming ever faster, cheaper, more accessible and easier to use. These characteristics, along with evolving market imperatives (globalization, outsourcing, etc.), have driven companies, particularly those involved in networks or supply chains of high-tech industries, to collaborate at every level within the firm (R&D, manufacturing, sales, etc.). The purpose of these collaborative initiatives is not only to improve the firm's performance but also to enhance the performance of the supply chain as a whole.

The telecommunications equipment industry has had to address all of these issues. One of its main players has developed several tools and methods for collaborating with its suppliers. This highly collaborative environment, which includes a number of suppliers using electronic collaboration tools, served as the "ground" to this research.

To be efficient, these collaborative initiatives require some planning between business partners. This efficiency may be defined by a number of performance measures such as reductions in costs, inventories, time and staff, or increases in sales and products manufactured. Given that companies wish to benefit from the intra-enterprise integration generated by their enterprise resource planning (ERP) systems, the implementation of inter-enterprise applications, such as customer relationship management (CRM), supply chain management (SCM) or electronic commerce (e-commerce), is an initiative that may yield interesting results. However, inter-enterprise applications involve the participation

of all stakeholders in a collaborative process, particularly during the planning phases of the process.

During the two research phases of this study, namely the field study and the electronic survey, three objectives were pursued. First, a number of collaboration tools are in use in the telecommunications equipment industry. We assess the impact of these tools on the various layers of the supply chain. Second, several methods of planning the use of these collaborative tools may be employed. We examine the effect of collaboration planning on the performance of the supply chain. Finally, collaboration planning activities may spur firms on to innovate. We evaluate the influence of these innovations on the performance of the supply chain, more specifically by analyzing the mediating effect of innovativeness on the relationship between collaborative planning and supply chain performance.

In the first chapter, the theoretical background related to supply chain environments, collaborative methods such as Collaborative planning, forecasting and replenishment (CPFR) and electronic commerce are presented and analyzed.

The conceptual model developed during the research design phase is presented in the second chapter, which also includes the justification of the research variables used during both the field study and the electronic survey. The research propositions are presented in this section.

The third chapter describes the methodology applied for both the field study and the electronic survey. It also clarifies the context in which the study was carried out by

presenting the structure of the telecommunications equipment industry and the different imperatives governing this high-tech industry.

The results of the field study are presented in the fourth chapter. The main technological and market trends are summarized, but the chapter is centered on the impact of the collaboration tools.

The fifth chapter presents the results of the electronic survey sent to the suppliers of a large OEM in the telecommunications equipment industry. A brief overview of the characteristics of the responding firms precedes the reliability tests executed on the research variables. The third and most important part of this chapter is devoted to the verification of the research propositions by means of a set of statistical analyses.

Finally, the last chapter summarizes the most important results and examines the limitations of the study. The theoretical and practical contributions are also discussed, leading to the elaboration of future research initiatives.

CHAPTER 1 - THEORETICAL BACKGROUND

This chapter concentrates on the performance of individual firms in an electronic supply chain. In the first section, key issues, such as value network and collaboration initiatives, which shape the supply chain are described. Section 1.2 defines the new supply chain environments in which manufacturing companies must operate. Electronic commerce (e-commerce) and its role in supporting these new supply chain environments are the focus of section 1.3, while section 1.4 discusses the need to develop supply chain strategies in line with technological capabilities to ensure supply chain efficiency. Finally, section 1.5 reviews the most important research initiatives related to supply chain performance.

1.1 Performance, supply chain and value network

More and more manufacturing firms are making use of supply chain management and collaboration tools to improve their performance. This performance is often closely linked to the level of integration within the supply chain (Armistead and Mapes, 1993; Evans et al., 1993; Kwan, 1999). Integrated supply chains, which are a form of inter-organizational collaboration, are referred to as value networks, networked enterprises or virtual enterprises by some authors (Browne and Zhang, 1999; Martinez et al., 2001; Weisenfeld et al., 2001; Buchel and Raub, 2002).

In fact, Porter (1985) asserts that the interaction of separate companies creates a value system that enables a member to gain a competitive advantage from the value-added

activities created by its partners. Other authors also see partnerships and networking as means to create a competitive advantage (Lamming, 1996; Bovet and Martha, 2000a).

A value network, which is a multi-enterprise network of relationships, focuses on the integration of information flows to exploit information and knowledge in the network (Timmers, 1999). For Bovet and Martha (2000b), a value network refers to a dynamic, high-performance network of customer/supplier partnerships and information flows while Parolini (1999) defines it as sets of activities that are jointly involved in the creation of value. Consequently, each member of the network is forced to rethink the way it handles relationships with business partners (especially customers and suppliers) and its approach to collaborative product development (Andrews and Hahn, 1999). The information made available by customers and the information flows coming from the supplier base are critical for conducting an effective supply chain. With the use of new methods and tools, activities such as planning, forecasting and replenishment are now very tightly managed, thereby facilitating the sharing and distribution of information throughout the supply chain. Moreover, with several companies participating in the creation of a product, a manufacturing environment is especially susceptible to events, such as component shortages or production line interruptions that may affect the production, distribution and sale of its products.

Collaboration between participants in the supply chain undoubtedly shapes and influences the type and volume of information being shared. Collaboration must be planned and sustained in order to be effective. A manufacturer/supplier's dynamic

environment is filled with potential collaboration points. The outsourcing of different activities to suppliers creates numerous possibilities for collaboration throughout the product life cycle (from R&D to recycling). A manufacturer may decide to design a product and ask its suppliers to provide important insights into different characteristics of the product, such as manufacturing capabilities and material quality. It will also ask its customer to clearly state its requirements. Hence, the effectiveness and speed of product completion not only depend on the activities of each tier of the supply chain but on the information flows throughout the supply chain. However, the impact of new technologies on supply chain performance has not yet been evaluated. As Shin puts it: "Considerable research has been conducted on buyer-supplier relationship management or supply chain management, but most of these studies are conceptual in nature or based on a few case studies" (Shin et al., 2000: 318). Supply chain management has received a great deal of attention in certain sectors but very few empirical studies on supply chain performance are available (Miller, 2001).

1.2 New supply chain environments

The environment in which firms operate has changed drastically with the advent of value networks, the potential for outsourcing and the growth of collaboration between business partners and even competitors. These new supply chain environments raise important challenges that companies are now forced to deal with in order to stay in business. First, the reorganization of the supply chain is almost inevitable in most industries where the reduction of inventories is a key issue. Second, this reorganization transforms

relationships between supply chain partners, since stronger value-added partnerships are critical to the success of the supply chain. One other challenge to overcome is the management of the supply chain, which can be complex given that many different supply chain activities must be planned and executed. Information systems, which are shared with partners to support supply chain activities, are not always an extension of internal information exchanges. The challenge of externalizing information systems is tackled with sophisticated e-commerce and collaboration tools. The use of information systems to exchange critical information with business partners affects short- and long-term supply chain activities. Another challenge for supply chain members is to select technologies that meet the particular needs of partners along the chain. Short-term supply chain execution has been emphasized. However, some of the biggest barriers to creating an efficient supply chain relate to long-term planning methods such as Collaborative planning, forecasting and replenishment (CPFR). Each of these challenges is described in turn below.

1.2.1 Reorganizing the supply chain

Although the new supply chain environments raise many financial and non-financial challenges, the reorganization of the supply chain represents one of the most formidable ones:

> The challenge in supply chain performance is to improve customer delivery service and reduce inventories simultaneously. A large company (in electronics) believes that poor order fulfillment costs a million dollars a day. In sales, you need to meet quotas, in production, you must match the plan
>
> (Johnson and Davis, 1998: 3)

Furthermore, the number of partners in a supply chain often makes it difficult for stakeholders to formulate an effective supply chain strategy. "Matching the plan" is not always what companies are aiming for, since there is not always a plan to follow. Supply chain management requires a major investment in planning, which is quite different from the techniques applied in the 1980s and 1990s. In recent decades, engineers and managers have focused on reactive operational techniques such as Total Quality Management (TQM), Just-in-Time, inventory management, etc. These techniques enabled companies to trim some operational expenses (mostly inventories) in their plants (Huson and Nanda, 1995; Fullerton and McWatters, 2001). Issues such as manufacturing optimization, quality and inventory management have had a huge impact within firms but have not significantly influenced the way they operate with their partners. In the late 1990s, the emergence of robust information and communication systems drove manufacturing companies to seek out planning and collaboration tools to deal with the constant instability of demand (Rondeau and Litteral, 2001). The challenge for engineers, particularly industrial engineers, is to enable information sharing with their partners. Initiatives such as the Supply Chain Council's Supply-Chain Operations Reference model (SCOR- www.supply-chain.org) guide supply chain managers in defining of operational activities. SCOR and its partners have developed a framework that identifies key actions in several activities (plan, source, make, deliver). One of its objectives is to build a list of supply chain metrics that can be used in different industries. SCOR and other supply chain initiatives allow engineers to redesign important business processes, especially those directly linked to their partners. To increase visibility throughout the chain,

communications between the planning and manufacturing systems of all partners are crucial. Inside their businesses, each partner must be able to link its information systems directly to the shop floor (Pantaleano, 2001). The task is more difficult when key information must be collected from outside the company's walls. To fully capitalize on supply chain opportunities, engineers must understand their suppliers' manufacturing environment (bottlenecks, manufacturing capabilities, machinery, etc.) and also their customers' forecasting activities (planning and sales models). As a result, the skills and competencies required to manage supply chains have changed from functional activities to enterprise-based decisions. Eventually, these decisions will be based only on supply chain information (Muzumdar and Balachandran, 2001).

1.2.2 New types of relationships

Boyson (1999) discusses some collaborative forecasting and planning issues in his extended enterprise model, which posits real-time connectivity linking core distributors, suppliers and carriers. Boyson anticipates the exploitation of global bidding/sourcing systems on the Internet to manage knowledge for both core suppliers and spot suppliers. Prime contractors (also called Original Equipment Manufacturers (OEMs)) are adopting a range of technologies to manage information but their suppliers are still unable to access real-time dynamic information such as sales and operations plans, which makes forecasting more instable and inaccurate.

A first-tier supplier's interests may be comparable to the OEM's concerns but the means it uses are not likely to be the same. In many cases, an OEM with a clear picture of future

demands has implements a system that handles the necessary data and actively works on the transfer of information to its suppliers. Some proactive suppliers may acknowledge the fact that they have been blind-sided by the OEM's initiative and are dependent on their customers for such technology. The OEM's ability to adopt and maintain a straightforward, efficient method and the supplier's capacity to meet the customer's needs using simple technologies strongly influence the quality of the manufacturer-supplier relationship.

However, the flow of information to second-, third- and fourth-tier suppliers will eventually generate the most valuable advantages. Procurement and replenishment activities such as planning and forecasting will be the first step and, according to some authors, maybe the only one, in moving information through the entire chain. OEMs expect first-tier suppliers to learn from their involvement with them and reflect on the best methods for collaborating with the whole chain. Therefore, companies must treat their suppliers as if they were extensions of themselves (Stallkamp, 1998).

With the new information technologies, value-added partnerships emerged between the different levels of suppliers in a supply chain. But, there are few such partnerships since a significant amount of resources must be devoted to developing them. In the manufacturing sector, collaboration favors outsourcing to a smaller number of faithful suppliers (Bakos and Brynjolfsson, 1993). According to Kekre et al. (1995: 387) "in the purchasing function, many firms have discarded the traditional practice of using several sources of supply in favor of a drastic reduction in sources of supply." Indeed, Collins

and Bechler (1999) conclude in their study that the outsourcing of manufacturing has become a competitive imperative and is now a strategic choice for most organizations. In a single sourcing environment, activities such as co-design, production plan sharing, dedicating capacity and assuring demand have complementary and synergistic effects on both partners (Spina and Zotteri, 2000).

Furthermore, despite the increasing need for an integrated and flexible supply chain with a shift in focus from push management (forecast-driven) to pull management (demand-driven), long-term partnerships between manufacturers and suppliers are more beneficial than arm's-length relationships in terms of quality, time to market, and product development (Braithewaite and Christopher 1991; Groves and Valsamakis, 1998; Holland International Distribution Council, 1998; Collins and Bechler, 1999; Handfield et al., 1999; Heikkilä and Vollmann, 1999). In many industries, OEMs are reducing their supplier base and opting for demand-pull strategies but are still maintaining their power structure. In analyzing different types of buyer-supplier relationships, several authors have become convinced that a buyer with a dominant position can and should exploit its situation to benefit from the overall relationship (i.e. improve quality and reduce costs) (Anderson and Narus, 1990; Cox, 1999; Cox et al., 2000; Maloni and Benton, 2000; Cox et al., 2001).

1.2.3 Managing the supply chain

Reorganizing the supply chain also involves managing and maintaining the different activities related to information exchanges between partners. The term supply chain

management (SCM) was originally used in the early 1980s by numerous authors (Houlihan, 1984; Jones and Riley, 1985; Stevens, 1989; Oliver and Webber, 1992) but no single definition is widely accepted (Wisner and Tan, 2000; Mentzer et al., 2001).

However, a broad definition of supply chain is provided by the Global Supply Chain Forum, which defines SCM as follows: "Supply Chain Management is the key integration of key business processes from end user through original suppliers that provide products, services, and information that add value for customers and other stakeholders". (Lambert and Cooper, 2000). APICS (1998) proposes a similar general definition: "A supply chain is defined as the processes linking supplier and user companies, from the initial raw materials to the ultimate consumption of the finished product." One of the most comprehensive definitions comes from Schorr (1998): "It integrates planning and balances supply and demand across the entire supply chain – it ties suppliers and customers together in one concurrent business process that focuses on the ultimate customer." SCM is thus seen as a tool to help a company develop strong ties with its suppliers and customers. The management and flow of materials within organizations is increasingly extended beyond the borders of the firm to involve upstream and downstream activities (Lamming et al., 2000).

Supply chain management can be broken down into planning and execution (Muzumdar and Balachandran, 2001). This study focuses on supply chain planning (SCP), and Muzumdar and Balachandran (2001) offer particular insights in to its evolution (table 1.1).

Table 1.1 – Evolution of supply chain planning

	Phase 1 Functional/ Departmental	Phase 2 Integrated	Phase 3 Value Networked
Supply chain planning	• Done in functional silos • Ineffective due to limited information visibility and standardization across the enterprise	• Business process focus • Standardization of information across the enterprise • Integrated SCP: demand forecasting, planning and scheduling	• Collaborative planning • Extension of the planning process to include key partners (contract manufacturers, customers, suppliers)

Source: Muzumdar and Balachandran (2001)

The Value Networked Phase, which requires the participation of business partners in the planning of the supply chain, focuses on supply chain collaboration. In this phase, companies are required to accomplish key supply chain planning activities in order to collaborate with their partners. The following table pinpoints some of the most important collaboration initiatives in the various areas of a company (Muzumdar and Balachandran, 2001).

Table 1.2 – Supply chain planning activities in functional areas

Supply chain planning in the Value Networked Phase				
	Procurement	**Planning**	**Scheduling**	**Inventory management**
Phase 3: Value Net-worked	• Strategic sourcing • Supplier segmentation and long-term relationships	• Collaborative planning, forecasting and replenishment (CPFR) • Frequent sales and operations planning (S&OP)	• Dynamic constraint scheduling • Collaborative scheduling	• Dynamic network optimization • Collaborative replenishment and vendor-managed inventory (VMI)

Source: Muzumdar and Balachandran (2001)

The information produced by the activities listed in table 1.2 is not only exchanged across all functions of the company but with all partners of the chain. Planning for the Value Networked Phase, and particularly CPFR, has a direct impact on the supply chain's performance.

1.2.4 Collaboration and information systems

Management information systems play an important role when planning a supply chain both within and between firms (Rutner et al., 2001). First, information systems, such as Enterprise Resource Planning (ERP), are now used to circulate accurate information within firms. Most operational activities (planning, procurement, manufacturing) are pre-programmed in these large systems. Prior to the implementation of these systems, the management team must establish the roles of the different departments (or units) involved in the collaboration initiative. Specific processes, tools and rules are automatically exploited to facilitate relationships and collaboration within the company.

Information systems can also link firms and their business partners together, but not all companies embrace such collaboration. Some industries are very competitive, and collaboration with suppliers and customers is not always welcome. Håkansson and Snehota (1995) identified setbacks that are perceived by companies as preventing or altering the development of relationships:

1) Extent of resources needed to create and maintain relationships
2) Lack of control over key activities
3) Unexpected demands by partners

4) Having to neglect other interesting opportunities

5) Indeterminism due to the constant evolution of relationships

Electronic collaboration between firms is not the perfect solution and the setbacks that previously existed will certainly still be present when exploiting electronic methods such as the Internet. Nonetheless, some companies are adopting electronic collaboration both internally and externally. They expect that efficient, secure, reliable and more frequent information exchanges between supply chain partners will influence relationships by lessening setbacks.

Hence, companies are now looking to transfer their knowledge to their supply chain partners by integrating their internal processes with those of their partners and by collaborating closely to exchange critical information. The benefits of collaborating are numerous, as shown in table 1.3 (Mentzer et al., 2000). A number of authors are enthusiastic about the potential advantages of collaboration in a supply chain but very few have quantified these benefits.

Table 1.3 – Some benefits of supply chain collaboration

• Reduced inventory	• Faster time to market for new products
• Improved customer service	• Enhanced public image
• Efficient use of human resources	• Greater trust and interdependence
• Reduced cycle times	• Increased sharing of information
• Improved shareholder value	• Technological standardization

Source: Mentzer et al., 2000

Although enterprises often select sophisticated information systems that offer supply chain and collaboration tools, few invest in planning the collaboration with their partners. Roles, processes and rules are subsequently managed by the technology and not by people. Many collaboration techniques and tools are available to enable the exchange of information between supply chain partners. Table 1.4 identifies several collaboration initiatives for key activities in the supply chain.

Table 1.4 – Collaboration initiatives according to specific supply chain activities

Activities	**Collaboration Initiatives:**
Replenishment	Collaborative Planning, Forecasting and Replenishment (CPFR)
	Vendor-Managed Inventory (VMI)
	Scan-Based Trading
Buy Side	Procure to Pay
	Item/Product Information
Sell Side	Catalog Management
	Order to Cash
	Promotions Management
Fulfillment	Third-Party Logistics
	Transportation Planning

Modified version of http://www.ascet.com/

In table 1.4, CPFR is shown to be one of the most significant collaboration initiatives due to its influence on all other collaborative activities. The CPFR method plans all actions and measures that will affect supply chain partners in the future, for all supply chain activities. Table 1.5 gives a brief definition of the CPFR method and of the other initiatives it affects. A more detailed definition of CPFR is provided in section 1.2.6.

Table 1.5 – Definition of key collaboration initiatives

Collaboration Initiatives	Description
Collaborative Planning, Forecasting and Replenishment (CPFR)	Joint collaboration planning with suppliers and customers.
Vendor-Managed Inventory (VMI)	Customers' inventory managed by suppliers.
Scan-Based Trading	Inventory levels and point of sale (POS) information exchanged by partners (for replenishment and billing activities).
Procure to Pay transactions	Traditional transactions for purchase orders, changes and acknowledgement of receipt.
Item/Product Information	Sharing product information (in sync) for multiple suppliers and customers.
Catalog Management	Customer-oriented exchange with supplier catalog information.
Order to Cash	Traditional transactions for receipt of sales orders and invoicing.
Promotions Management	Planned promotion information provided to customers.
Third-Party Logistics	Outsourced logistical activities with exchange of sale order information and shipment details.
Transportation Planning	Delivery and tracking information shared with customers.

Based on http://www.ascet.com/

1.2.5 Supply chain technologies

Prime contractors and OEMs are increasingly outsourcing manufacturing activities and concentrating on their core activities such as R&D, marketing or logistics. They rely on supply chain technologies to supervise specialized firms (e.g. electronic manufacturing services) that are now carrying out design and manufacturing operations once accomplished by larger, vertically integrated corporations. Volume, time to market and profits are usually at stake when outsourcing manufacturing.

In a manufacturing environment, one main concern when managing a supply chain is to reduce the "bullwhip effect" (Lee et al., 1997a, 1997b), which represents the fluctuation of inventory at all levels of the chain. Accurate planning and forecasting analysis play an important role in controlling fluctuations. Different methodologies and tools help prime contractors to generate accurate forecasts and enable suppliers and customers to access real-time manufacturing information.

Vendor-Managed Inventory (VMI), Continuous Replenishment Program (CRP) and Collaborative Planning, Forecasting and Replenishment (CPFR) are all methods that enable inventories to be harmonized in a manufacturing environment. The first two methods, VMI and CRP, exchange critical information on short-term activities (procurement and production schedule, demand forecast, etc.). Suppliers merely react to real-time information provided by the distributor and often find it difficult to plan long-term demand. VMI increases customer-specific forecasting for manufacturers by making them responsible for managing of stock at their customers' storage locations (Waller et al., 1999; Cetinkaya and Lee, 2000). However, when partners use VMI methods, their collaboration is very limited (Katz et al., 2000; VICS, 1998). CRP is mainly inventory-oriented, as it facilitates the exchange of real-time inventory data between customers and suppliers and ensures continuous replenishment of inventory by suppliers (Raghunathan and Yeh, 2001).

CPFR, on the other hand, relies on close collaboration between partners. CPFR is forecast-oriented and based on joint business plans in an inter-enterprise environment.

The development of recent CPFR tools has made it possible to continuously update forecasts and joint plans.

1.2.6 Collaborative planning, forecasting and replenishment (CPFR)

CPFR is a method that enables companies to do collaborative forecasting with other members of a virtual organization. It also helps them develop an optimal plan for manufacturing and distribution resources to meet both expected demand and actual customer orders (VICS, 1998). CPFR has its origins in a series of programs implemented in the 1980s and 1990s to optimize inventory and replenishment activities. These programs, particularly VMI and CRP, were designed to bring supply chain partners closer together, however none of them really focus on information sharing between partners.

Collaborative planning, forecasting and replenishment captures the operational advantages of all these programs and adds collaborative mechanisms to facilitate information exchange in a multi-tiered supply chain. Unlike the other programs, CPFR functionalities allow companies to deal with some important aspects of planning and forecasting practices such as the necessity for:

- multiple, independent demand forecasts for different purposes.
- high level of detail in forecasting.
- continuous interaction between several tiers of the supply chain.
- time-phased forecasts across the value chain.
- customer demand-pull-based forecasts (and not manufacturing economics).

CPFR, which is an initiative developed by the Voluntary Interindustry Commerce Standards (VICS) association, is segmented into stages (see figure 1.1). The first stage, planning, involves two critical steps: front-end agreement and joint business plan. The next stage includes two forecast-oriented steps: sales-forecast collaboration and order-forecast collaboration. The final stage, replenishment, comprises one major step: order generation.

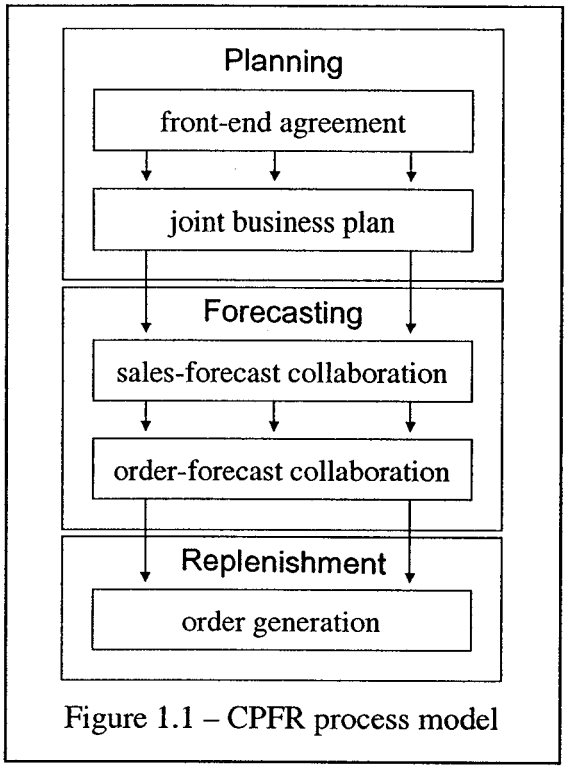


Figure 1.1 – CPFR process model

In developing a front-end agreement, participating companies formulate and agree on a collaborative program that identifies key supply chain metrics. This agreement guarantees an adequate commitment to collaboration by all supply chain partners and aligns all parties involved around common objectives. Top-level managers usually execute this CPFR activity to assert executive sponsorship at this early stage of collaboration. The next step involves the exchange of strategies and business plans between partners with the purpose of collaborating on the development of a joint business plan. Organizations share information about periodic business strategies and then input the details of the joint business plan into their own planning systems. This activity is regularly modified to include important changes (sales conditions, logistical changes, etc.).

In the sales-forecast collaboration step, OEMs and suppliers share demand forecasts. They identify different plans and try to solve any problems. Before joint forecasting can proceed, all stakeholders contribute internal sales forecasts that must be merged and reconciled. One party usually initiates a sales forecast, which is then transferred to the other party to be used as a baseline for generating the order forecast. In the order-forecast collaboration step, a specific order forecast that supports the shared sales forecast and the joint business plan is generated. The forecast is then applied in two distinct approaches, for order generation in the short term and for planning purposes in the longer term. These actions lead to increased trust between supply chain partners and to the consolidation of supply chain inventories.

In the last step, order generation, the order forecast is converted into a committed order. A large amount of data on point-of-sale information, orders, shipments, and inventories is shared between partners.

In the CPFR process, the planning phase is critical as partners develop collaboration initiatives and terms. The other two phases are mostly operational and must fall back on the principles set out in the first phase when difficulties arise. Experience with CPFR projects usually leads partners to collaborate on a weekly basis. These frequent contacts enable planning partners to review the joint business plan, discuss the impacts and benefits of collaborative actions and meet fluctuating demands (Katz and Hannah, 2000).

Different methods are used to assess the benefits of deploying the CPFR process throughout a supply chain. The advantages of CPFR are significant. Among the

advantages identified, CPFR partners have experienced sales increases, inventory reductions and improved customer service. They have also strengthened their relationships by improving and fostering trust in their exchanges (Katz and Hannah, 2000). These benefits are observed in a number of industries, not only in the consumer goods and retail industries where the majority of CPFR implementations have been completed (Schachtman, 2000; Wise and Fagan, 2001). CPFR, and especially the planning stage, is also being implemented in the high-tech and automotive industries, where companies like Dell and Volkswagen share production and forecasting plans with their suppliers (Schachtman, 2000).

More academic (mathematical) approaches are also used to quantify the benefits of CPFR. Raghunathan (1999) used a risk structure model to evaluate the differences between two suppliers, one of which used CPFR methods and the other of which did not. The results clearly indicate lower manufacturing and inventory costs for the supplier that followed CPFR guidelines. Aviv (2001) also demonstrates that collaborative forecasting initiatives provide significant benefits to the supply chain. Using simulation models and numerical studies, Aviv compares a two-stage supply chain consisting of a retailer and a supplier in three types of setting: local forecasting, collaborative forecasting and non-integrated forecast/replenishment. It is interesting to note that, in this analysis, CPFR initiatives are complementary to efficient consumer response methods (e.g. CRP).

In another study related to CPFR (with one capacitated supplier and multiple retailers facing uncertain demand), Zhao et al. (2002) proposes a model to simulate inventory

replenishment decisions by the retailers and production decisions by the supplier. The results indicate that information sharing and ordering coordination significantly impact the performance of a supply chain. The study also found that demand patterns and tight capacity significantly affect the value of sharing information and ordering coordination.

1.3 E-commerce in supply chain environments

The concept of supply chain management (SCM) has been around for a few decades but it became possible to maximize SCM when real-time, reliable communications became available to companies. The appearance of e-commerce and of easy-to-use communication methods such as the Internet offered new opportunities to the manufacturing world. Internet-based companies changed the way business is done and now face new challenges brought about by the complicated networks of companies in the so-called digital economy.

E-commerce technologies are perceived as techniques to eliminate non-value-added intermediaries from traditional processes (procurement, sales, etc.). According to several authors, partners such as distributors or vendors must transform themselves in order to survive in an e-commerce environment (Benjamin and Wigand, 1995; Schmitz, 2000; Hagel and Armstrong, 1997; Bailey and Bakos, 1997; Sarkar et al., 1998; Scott, 2000). In this context, electronic communications bring together partners and stakeholders with complementary roles and competencies to form a network enterprise (or virtual enterprise).

The emergence of new electronic communication channels such as the Internet has influenced supply chain relationships. At first, marketing was the primary target of e-commerce, and significant efforts were deployed to gather larger customer bases. However, companies soon realized that, to serve customers efficiently in an e-commerce environment, they also had to create and manage effective interactions with their suppliers so that they could react to stringent time-to-market demands and respond to fluctuating volume requirements. Some new e-commerce business models emerged from the evolution of the Internet. Traditional businesses (bricks-and-mortar companies (e.g. IBM) transformed their back-end systems to handle new ways of doing business electronically. On the other hand, new Internet start-ups (clicks-and-mortar companies (e.g. Dell)) struggled with their operational activities, in particular their logistical infrastructure.

These new business models require new types of inter-enterprise relationships and may involve a reorganization of the supply chain. In many industries, companies that use e-commerce have benefited from the development of stronger buyer-supplier relationships, which accounts for the greater volume of information exchanges between partners. In this environment, suppliers are no longer seen as potential competitors but as partners (Christopher, 1992; Laseter, 1998; PricewaterhouseCoopers, 1999; Horvath, 2001). Business relationships and supply chain relationships have been hot research topics for some time (Spekman et al., 1998; Bensaou, 1999; Humphreys et al., 2001) but the impact of communication infrastructures such as the Internet and the constant progress of information technology have stimulated other emerging research areas.

1.3.1 E-commerce

Many specialists have forecasted significant growth in e-commerce activities. A majority of companies have witnessed the potential benefits of e-commerce for their day-to-day activities in the last few years. Despite the economic slowdown in 2001, worldwide e-commerce spending was up 68%, reaching more than US$600 billion. According to forecasts, e-commerce spending should pass the US$1 trillion mark in 2002 (IDC, 2002).

There are several definitions of e-commerce, all of which differ to some degree. The OECD, in its e-commerce work program initiative (OECD, 1999), came up with the following: "Electronic commerce refers generally to commercial transactions, involving both organizations and individuals, that are based upon the processing and transmission of digitized data, including text, sound and visual images and that are carried out over open networks or closed networks that have a gateway onto an open network."

One strong promoter of supply chain integration, the Japanese Ministry of International Trade and Industry (MITI), defines e-commerce as "the conducting of commercial transactions (the exchange of merchandise, services, information, and/or money between suppliers and receivers for the commercial transfer of goods between economic actors) through electronic mediation using Internet technology" (Ministry of International Trade and Industry of Japan, 1999).

In many studies, e-commerce tends to be associated with activities related to sales and procurement (Jeffcoate et al., 2000). However, business-to-business e-commerce has a broader scope and touches upon specific activities such as product development,

forecasting, and production planning that go beyond traditional transactional processes. E-commerce, which concentrates on efficient information exchange between partners, includes the use of such methods as supply chain integration, marketplaces and extended enterprises. High levels of cross-functional integration are required to exploit business-to-business e-commerce initiatives and key supply chain processes (Lambert and Cooper, 2000). Integrated cross-functional supply chains require the alignment of inter-enterprise objectives such as sourcing decisions and customer needs, and intra-enterprise objectives such as manufacturing goals (Narasimhan and Jayaram, 1998).

Business-to-business e-commerce includes long-term relationships between several tiers of suppliers, which are vital to the success of products or services (Kalwani and Narayandas, 1995; Ittner and Larcker, 1997). Inter-organizational topics such as supply chain partnerships and buyer-seller relationships are at the forefront of business-to-business e-commerce (Sheth, 1996). Other complementary initiatives such as supply chain collaboration, supply chain integration and demand management are closely linked to the growth of e-commerce (Evans and Danks, 1998). Furthermore, now that efficient electronic information exchanges exist, collaboration and flexibility within the supply chain are essential for companies to compete and perform within their industry (Landeros and Monczka, 1989; Vickery et al., 1999; Mentzer et al., 2000). Companies now carefully scrutinize and select their partners based on their successful e-commerce activities, and the delivery and realization of a product or service is the responsibility of all supply chain partners involved.

1.3.2 E-commerce transaction processes

Catalogs, auctions and bidding systems have been the focus of most of the business-to-business e-commerce platforms that have emerged in the last few years. Most of these sectorial marketplaces intend to develop advanced technical and graphical exchange tools but very few have been able to market them effectively yet. Sectorial platforms such as the automobile and aeronautics industry platforms, along with more company-specific platforms such as GE's TPN system, offer basic transactional services but are still being challenged by advanced functionalities.

In order to attract innovative firms in a niche market, other companies such as E-vis have developed collaborative design and engineering platforms. SMEs (small and medium-sized enterprises), which often play an important role in designing a product (i.e. up to 70% of a car or a plane is designed by SMEs), are targeted by these advanced platforms. They will come to use these technologies and, most importantly, deal with them securely in order to transfer very strategic information.

1.3.3 Procurement activities in an e-commerce environment

Major changes are required when suppliers are integrated into product development processes. This kind of transformation obliges an organization to adjust several internal functions along with their respective key processes. Although they account for a small fraction of total product costs, activities such as design and engineering are critical because it is in those phases that 80% of the total cost of the product is determined (Handfield et al., 1999). Procurement is also crucial because purchased materials often

account for over 50% of the cost of goods sold – as high as 80% in some industries (Handfield et al., 1999).

Consequently, procurement and replenishment play a crucial role in product and process development, which includes the selection of technologies and suppliers. Partners involved in the leadership of cross-functional teams leverage opportunities throughout the supply chain (McGinnis and Mele Vallopra, 1999). The Boeing 777 project, which was designed entirely electronically, is a good example. Strategic suppliers for the project were integrated into the design process from the start, which resulted in the rapid development of the aircraft (Anderson and Katz, 1998).

Prompted by cross-functional objectives and highly collaborative environments, procurement has evolved from an operational function to a more strategic and proactive one (Segev et al., 2000). New planning and forecasting tools, along with efficient and secure transactional exchanges, have allowed a shift from current tasks to more value-added activities (Cassivi et al., 2000). Strategic practices, such as

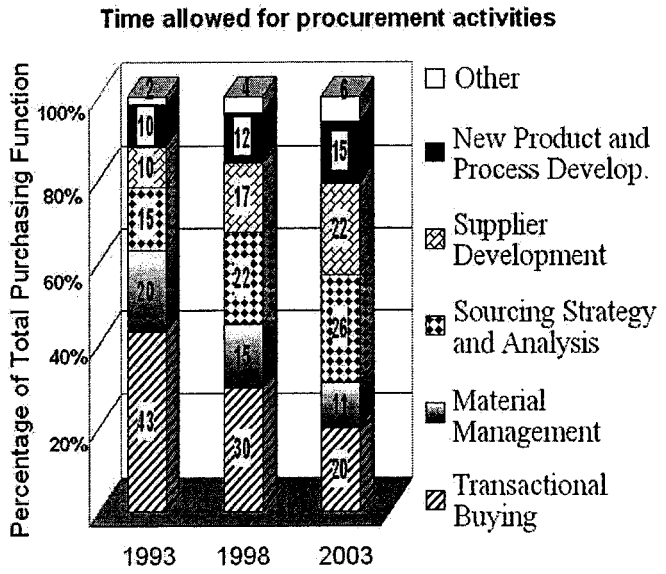


Figure 1.2 – Evolution of procurement

supply base optimization, buyer-supplier relationship development, supplier capability auditing and purchasing integration, require the development of new procurement-related competencies (Das and Narasimhan, 2000). As shown in figure 1.2, procurement functions, which used to be mostly related to transactional buying, are gradually shifting to key activities such as sourcing strategy and analysis, supplier development and new product and process development (Laseter, 1998). These activities are much more strategic in nature and may create important potential benefits for organizations.

In design-oriented industries such as the automobile sector, procurement and supply chain planning are the primary challenges for companies implementing business-to-business e-commerce. The focus then moves towards collaborative design and shorter market time cycles (Cooke, 2000). Developments in the design of modular products and modular production should greatly facilitate the transition to e-commerce (Van Hoeck and Weken, 1998).

1.4 The role of technology and innovation in the development of supply chain strategies

The development of supply chain strategies is a difficult task, mainly due to the continuous evolution of supply chain partners and of technologies available to conduct efficient supply chains. First, supply chain strategies are often designed around the capabilities of the e-commerce tools that support supply chain activities. Hence, the evolution of such strategies must follow the progress of electronic and collaboration tools. The technological waves model (section 1.4.2) outlines some of the technical

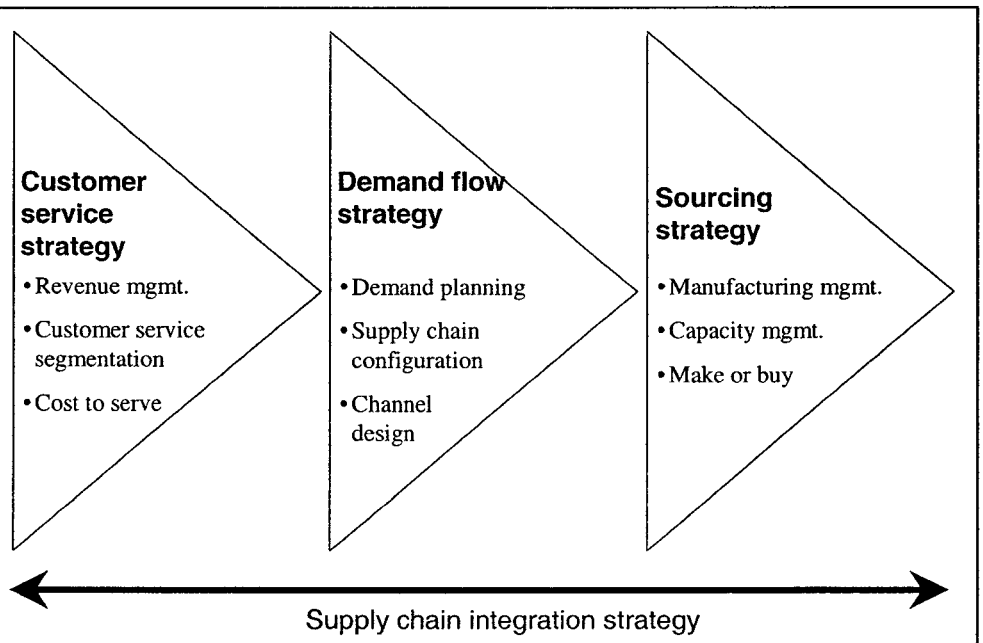
transitions required to support supply chain strategies. Furthermore, the creation of closer relationships and the sharing of advanced technologies between business partners transform the supply chain, whereas process and relational innovations are developed to improve supply chain capabilities and enhance the chain's performance. These critical supply chain issues are presented in this section, along with a summary of the most important empirical research carried out in the fields of supply chains and collaboration.

1.4.1 E-commerce, a support for supply chain strategies

In order to keep or develop a competitive edge, companies will have to exploit other forms of e-commerce tools to optimize the supply chain with their key suppliers. According to Schorr (1998), "the competition in the future will be supply chain to supply chain, not company to company." With that in mind, the key issue for a large manufacturer resides in creating a seamless interconnecting supply chain, while the key for suppliers is surviving the major downsizing of the supplier base and adopting the right tools to add value for the customer. Various mechanisms are being examined to close the gap in the supplier-manufacturer relationship, some of which are forecast-oriented while others are inventory-oriented. This study focuses on proactive supply chain strategies that shape forecast-oriented activities such as planning and forecasting.

A strategic supply chain framework put forward by Evans and Danks (1998: 23) posits four key strategic dimensions: supply chain integration strategy, demand flow strategy, sourcing strategy, and customer service strategy (see figure 1.3). Activities such as manufacturing management, make or buy decisions, and capacity management make up

sourcing strategy, whereas customer service strategy is represented by revenue management, service segmentation and cost to serve. These two strategies are not analyzed in this study since companies must deal with them (choose internal orientations) before initiating relationships with partners. However, demand flow strategy, which consists of demand planning, channel design and supply chain configuration, becomes a key aspect of collaborative supply chain strategies as the degree of integration with partners increases. Supply chain integration strategy relates to the type of supply chain to be implemented (with suppliers, distributors, customers, etc.) and the infrastructure that complements it (physical and informational). The physical infrastructure is characterized by the technology required to build the supply chain. The informational infrastructure guides the management and creation of knowledge in the chain.



Source: Evans and Danks (1998)

Figure 1.3 – Dimensions of strategic supply chain management

1.4.2 Technological waves

The critical role played by information systems and communications technology in the creation of a supply chain is undeniable. Most organizations are finding the concepts of e-commerce and supply chain management increasingly appealing. Reductions in inventory, product development time, time to market, procurement workforce, and the like, have encouraged large companies to adopt advanced technologies in order to achieve the potential supply chain savings. With new communication channels between buyers and suppliers, relationships are being transformed from adversarial, arm's-length transactions to collaborative processes (Humphreys et al., 2001). The main reason for this shift is that buyers now need suppliers in order to a gain competitive advantage in major markets. According to Laseter (1998), it is important at this point to have equilibrium between cooperation and competition in the supply chain. Some complex e-commerce transaction processes require the combination of several technologies that must evolve progressively in an integrated environment. A number of models have been developed to illustrate the complexity of technological integration in e-commerce or supply chain environments.

Evans and Berman (2001) elaborated a framework for evaluating collaboration within a supply chain. At first, supply chain partners opt for the adversarial level and prefer short-term relationships. At this stage, the price of the component/product is the most important factor in the relationship. The second level, semi-adversarial, sees major changes in the supply chain. The more prominent members of the chain have a strong influence on the

structure of the supplier base. The focus is on product quality and delivery performance, which eliminates some suppliers that were formerly contacted for spot buys. Finally, partnership represents the third level, where only a few top suppliers are still being used to realize products or services. This level calls for long-term relationships based on technological capability, financial strength, human competencies and product quality. Evans and Berman's framework is interesting for its broad approach to supply chain collaboration. However, companies involved in collaborative supply chains require more specific details concerning the role of collaborative technologies at each level of supply chain relationships.

Two groups of authors have developed similar frameworks that clearly distinguish levels of collaboration between supply chain partners. Spekman, Kamauff and Myhr (1998), in their investigation into supply chain management, identify critical aspects and different perspectives on partnerships. Four levels of supply chain relationships

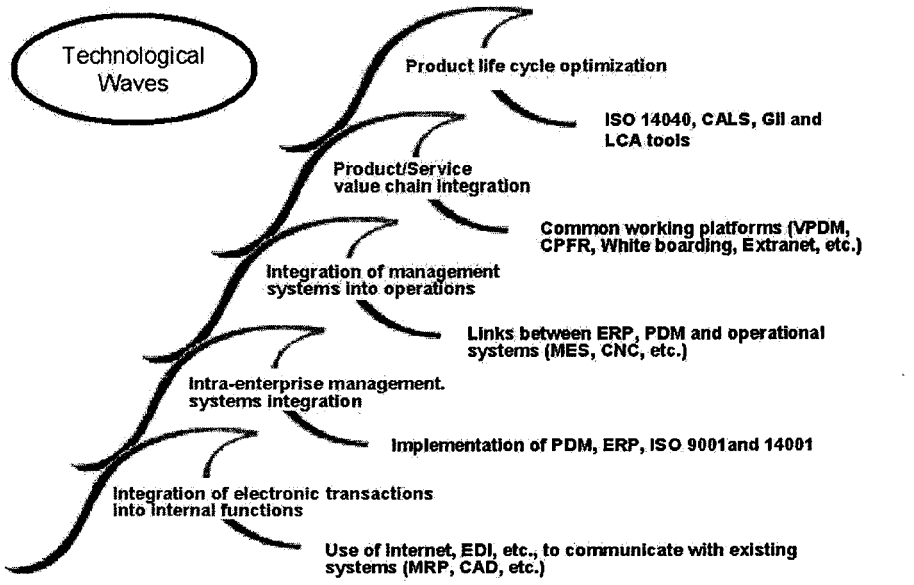
Langenwalter (2000) adds a little more detail by splitting Spekman's Coordination level into Single-Level Coordination and Multi-Level Coordination (see table 1.6). Although technological integration is not the primary focus of this model, the development of a supply chain is well presented. The highest level of collaboration generates flexible, seamless processes in a fully integrated supply chain. It entails wide-ranging collaboration through technology sharing and joint planning.are identified: Open Market Negotiation, Cooperation, Coordination and Collaboration.

Table 1.6 – Comparison of collaboration frameworks

Level	Spekman, Kamauff and Myhr	Level	Langenwalter
1	**Open Market Negotiation** • Price-based discussions • Adversarial relationships	1	**Open Market Negotiation** • Price-based discussions • Adversarial relationships
2	**Cooperation** • Fewer supplies • Longer-term contracts	2	**Cooperation** • Fewer supplies • Longer-term contracts
3	**Coordination** • Information linkage • WIP linkages • Electronic Data Interchange (EDI) exchange	3	**Single-Level Coordination** • EDI • Single source • Kanban • Vendor-Managed Inventory
		4	**Multi-Level Coordination** • Focus on final customer • Multi-level supply chain execution
4	**Collaboration** • Supply chain integration • Joint planning • Technology sharing	5	**Collaboration** • Supply chain integration • Joint planning

In order to categorize and present the potential evolution of information technologies, Lefebvre et al. (2001) developed a five-wave model (figure 1.4). With the growing number of e-commerce and supply chain initiatives being implemented in different sectors, companies are now required to support complex applications. This model, which accompanies an organization through the successive phases of technological integration, identifies different business-to-business e-commerce specifications and also detects technological requirements.

The first wave consists of the integration of electronic communication tools (Internet, EDI, etc.) with the organization's different internal systems (MRP, etc.). The systems involved in this wave usually support simple administrative functions such as invoicing but may also carry out more complex tasks such as production planning activities. Simple electronic links facilitate commercial transactions (sales, procurement, etc.) through these integrated systems. This first wave includes numerous activities ranging from the use of the Internet to regularly inform partners of the production plan modifications generated by an MRP system to bidding on a request for quote (RFQ) received electronically through private or public bidding platforms.



CAD: Computer-Aided Design
CALS: Continuous Acquisition and Lifecycle Support
CNC: Computerized Numerical Control
CPFR: Coll. Planning, Forecasting and Replenishment
EDI: Electronic Data Interchange
ERP: Enterprise Resource Planning
GII: Global Information Infrastructure
LCA: Life Cycle Assessment
MES: Manufacturing Execution System
MRP: Material Resource Planning
PDM: Product Data Manager
VPDM: Virtual Product Development Manager

Source: Lefebvre, Cassivi and Lefebvre, 2001

Figure 1.4 – Technological waves

The second wave is characterized by the adoption of large management systems to coordinate activities within an organization. Organizations must decide on a technological strategy: either the "best-of-breed" solution or the global ERP implementation. The first solution is achieved by the integration of independent management systems while the second involves a total or partial adoption of various modules of an ERP tool that may be complemented by specialized applications (e.g. strategic enterprise management (SEM) tool). The adoption of ERP systems in order to manage internal activities or the integration of an advanced planning and scheduling (APS) system into an MRP system to optimize production planning are examples of the second wave.

The third wave focuses on the integration of the information generated during operations (production, warehousing, distribution) into the company's management system (ERP, for example). The capture of information from the operating facilities is automated and synchronized with the demands formulated by the management systems. This operations-oriented stage may be represented by the following example: a manufacturing company may integrate its shop floor activities (CNC machines) with its ERP, using a manufacturing execution system (MES).

Collaboration forms the focal point of the fourth wave, Product/Service Value Chain Integration. It centers on sectorial collaboration among various companies from the same value chain to develop products and services in a virtual mode. At this stage, the integration of the customer into the value chain is critical, facilitating product or service

customization. Examples range from a group of companies using CPFR methods to monitor their supply chain activities to the simultaneous and collaborative design of a virtual prototype (engineering and manufacturing processes) by a prime contractor and its most strategic suppliers.

The product life cycle support strategy, which is based on the integration of multi-sector business-to-business platforms, is the emphasis of the fifth wave. At this stage, access to a larger number of subcontractors is facilitated by standardized communication technologies but it also entails supplier certification (e.g. ISO 14040), which is a barrier to entry for the supply base. The Product Life Cycle Optimization wave allows a consortium of independent enterprises to combine their respective competencies in order to create a product. A good example of the kinds of initiatives undertaken at this stage is the development of a system that optimizes the environmental impact during the design, manufacturing, utilization and recycling phases of a product.

1.4.3 Innovations

Partners collaborating on supply chain strategies and the development of e-commerce tools in a supply chain environment are often forced to innovate in order to compete in their sector (Mason-Jones and Towill, 1999). Such innovations, which are often driven by one major customer or supplier, may take different forms and may also be evaluated according to the environment in which they are used.

Brown and Eisenhardt (1995) identified two major innovation-related research streams. Many authors (Nord and Tucker, 1987; Rogers, 1995; O'Neill et al., 1998) have worked

on the first stream, which is centered on the diffusion of innovations (new technologies, strategies, or management practices) across industries, nations, and organizations.

The second stream identified by Brown and Eisenhardt (1995), which includes this study, observes the impact of organizational structures, processes, and relationships on the development of products and services. Three distinct types of innovations are often mentioned in the literature: process, product and relational innovations. The following sections present an overview of the characteristics of each type of innovation in a manufacturing environment.

1.4.3.1 Process innovations

Research into process innovations has been conducted for many years. Knight (1967) was among the first authors to characterize process innovations in intra-firm environments. Utterback and Abernathy (1975) also examined the role of process innovations in the adoption of new technologies. Process innovation is concerned with the way products and services are designed and produced. A process is defined by Davenport (1993: 5) as "a structured and measured set of activities designed to produce a specific output for a particular customer or market." Lambert and Cooper (2000: 76) consider a process as "a structure of activities designed for action with a focus on end customers and on the dynamic management of flows involving products, information, cash, knowledge, and ideas."

One of the main objectives in adopting e-commerce collaboration tools is to optimize the supply chain and support more efficient business processes. The use of e-commerce

collaboration tools in a manufacturing environment translates into two major process innovations: processes that improve visibility among partners of the supply chain and processes that support the implementation of supply chain strategies.

Visibility in the supply chain is achieved by making accurate information, such as forecasts, schedules and production capacity, accessible to all members of the chain. Current e-commerce initiatives improve visibility, mostly between manufacturers and sub-assemblers (Chopra et al., 2001). Web-based forecast tools enable sub-assemblers to improve production plans and anticipate fluctuations in demand. For manufacturers, schedule and capacity visibility allow them to better anticipate and manage shortages. In the long run, the real benefits will come from end-to-end visibility in the supply chain. Visibility tools enable OEMs to exchange accurate information concerning demand, thus improving forecasting for the supply chain. To exchange critical information such as delivery dates and tracking, inventory levels and anticipated demand, OEMs plan to link their internal systems to those of their supply chain partners.

In many industries, mass customization and diminishing manufacturing lead times are forcing the implementation of supply chain strategies at all levels of the chain. These strategies can be demand-pull-driven or inventory-push-driven. A majority of OEMs concentrate on demand-pull strategies to keep inventories level with demand by producing only what has been sold. They must then rely on short procurement cycles to fulfill their needs, which necessitates integrated planning and scheduling activities with the assistance of advanced collaboration tools. In some industries, companies that have

adopted demand-driven supply chain processes have achieved strong financial and operational performance (Langabeer and Joshi, 2001).

In order to really benefit from e-collaboration tools, sub-assemblers and manufacturers may have to rethink the way their internal systems are configured. For example, APS tools, which represent a major process innovation for sub-assemblers, can be exploited to ensure flexible production plans and shorter response times.

1.4.3.2 Product innovations

Product innovation has been and will undoubtedly continue to be a popular research topic. The very high number of definitions of the types of product innovation makes the use of this term ambiguous in the new product development literature (Garcia and Calantone, 2002). Categorizations such as radical, routine, incremental, discontinuous, and commercially successful are employed in many product innovativeness research initiatives (Utterback and Abernathy, 1975; von Hippel, 1986; Nord and Tucker, 1987; von Hippel, 1988).

The various product innovation-related disciplines (marketing, engineering, and new product development) all have different perceptions of the term, which makes it difficult to isolate a consistent definition (Garcia and Calantone, 2002). Product innovation's tight link with process innovation makes it more difficult to define, as it may also be tricky to differentiate between the two types of innovations (Bhoovaraghavan et al., 1996). A good example is Utterback and Abernathy's (1975) use of process versus product innovations to analyze the adoption of emerging technologies. Some studies have tried to clarify the

meaning of product innovativeness (Danneels and Kleinschmidt, 2001). Nevertheless, according to Myers and Marquis (1969), a product innovation refers to a new product that an organization has created for the market and is represented by the commercialization of an invention. These innovative products may take different forms, such as upgrades, variations and extensions of existing products (Li and Atuahene-Gima, 2001). When partners collaborate in a supply chain, product innovations will mostly occur in a product development environment where the majority of companies focus on design and engineering activities.

Research initiatives have applied different approaches, two of the most important being the examination of all the activities needed to conceive, design, produce, and deliver a new product to the market (Zirger and Maidique, 1990) or the study of product innovation as a dimension of a firm's entrepreneurial position (Zahra and Covin, 1993). This dissertation is oriented towards the first approach, as it will examine the impact of collaboration planning on product innovativeness.

1.4.3.3 Relational innovations

Relational innovations in a supply chain are defined as new (or improved) methods for governing buyer-seller interactions (e.g. assembler-supplier in a manufacturing environment). Numerous aspects such as trust, loyalty and market segmentation determine the existence of relational innovations in a supply chain. Previous studies have identified trust and commitment as critical elements in buyer-supplier relationships and in

alliances (Anderson and Narus, 1990; Ring and Van de Ven, 1994; Handy, 1995; Moore, 1998; Zaheer et al., 1998).

Inter-organizational relationships have also been an important issue affecting the use of e-commerce tools (Archer and Yuan, 2000; Tang et al., 2001). As mentioned earlier, e-commerce may make supply chain relationships closer. The interaction between commitment and technology improves trust within an organization and among supply chain partners (Welty and Becerra-Fernandez, 2001). This interaction may also create problems and conceal opportunities that are only discovered during the implementation of electronic collaborative initiatives (Boddy et al., 2000).

Suppliers adopting e-commerce need to invest time and money to adapt their internal processes and systems and develop the human competencies needed to handle new e-commerce challenges. The effort and infrastructure that suppliers need if they are to adopt new methods of communication tend to favor close, long-term partnerships with a small number of partners.

1.4.4 Performance of the supply chain

Traditionally, empirical research on supply chain management has centered on specific individual activities such as procurement, manufacturing and logistics (Narasimhan and Jayaram, 1998), but some of the latest studies focus on several corporate functions at once. Table 1.7 summarizes some of the major empirical studies carried out in the fields of collaboration (partnership) and supply chains (buyer-seller relationships).

In order to compare the research initiatives, seven categories are retained to structure the most important information from the SCM/collaboration studies. First, the research strategy chosen by the researchers is identified; most studies are survey-based: empirical data is collected and analyzed. Strategies such as case studies have also obtained interesting results. Questionnaires and interviews are the most frequent data collection methods used by the researchers.

The type of evidence consists of the variables used by the researchers. Most of the variables in the studies concentrate on performance measures in a supply chain environment. The type and number of organizations involved in these supply chain/collaboration studies are important as they affect the type of performance measures favored. For instance, a manufacturing company (e.g. automobile assembler) involved in a supply chain will measure its performance differently than a service-oriented company (e.g. bank). In the studies listed in the table, the number and type of respondents are not very important as the information obtained from senior managers, mid-level managers or purchasing managers is basically of the same nature (some strategic but mostly operational information). The "Objectives" column in the table clarifies the intent and purpose of the study. The "Main results" are the major conclusions put forward by the researchers; these are often compared to the initial hypotheses and assumptions presented in the objectives.

Table 1.7 – Summary of the most important empirical studies in the field of supply chain and collaboration

Authors, date	Research strategy	Data collection method	Type of evidence	Number & type of organizations	Number & type of respondents	Objectives	Main results
1. Boddy, MacBeth and Wagner (2000)	Case studies	Interviews and observations during management meetings	Contextual factors	Two-year study of 7 companies in two supply chains	Based on two supply chains of companies involved in the study	Assess the implementation and management of an alliance in a supply chain	Conceptual model that analyzes the content and process of supply chain partnering
2. Golicic, Davis, McCarthy and Mentzer (2001)	Case studies	Interviews and public data (annual reports, websites)	Concentrates on e-com environment, performance, capabilities and forecasting.	7 companies engaged in e-commerce from diverse industries	22 on-site interviews with executives	Understand the characterristics of demand forecasting in an e-commerce environment	Formulation of guidelines for e-commerce forecasting
3. Ittner and Larcker (1997)	Explora-tory analysis	A 1991 consulting company survey	Process focus, HR management practices, information use, commitment, supply chain relations	249 firms from two industries (automobile and computer) in four countries	4.7 managers (average) from each organization participated in the survey	Impacts of process management techniques on overall firm profitability	Establishing long-term partnerships with suppliers and customers improves profitability
4. Jeffcoate, Chappell and Feindt (2000)	Case studies	Interviews	Business process improvement, partnership development and integration of IT systems	27 SMEs from different sectors involved in Esprit Kite project	SMEs actively involved in e-commerce	Study SME best practices in e-commerce	Recommendations for SMEs to support e-commerce by adopting best practices for process improvement, partnership and integration

Table 1.7 – Summary of the most important empirical studies in the field of supply chain and collaboration (continued)

Authors, date	Research strategy	Data collection method	Type of evidence	Number & type of organi-zations	Number & type of respondents	Objectives	Main results
5. Kalwani and Narayandas (1995)	Multiple matching and z-test	Compustat and compact disclosure data bases	Net sales, inventory turnover, gross margin, and profitability	76 SMEs from SIC codes 3400 to 3899	N/A	Assess the impact of long-term relationships on the performance of supplier firms	Suppliers in long-term relationships achieve the same level of growth as with transactional approaches
6. Kaufman, Wood and Theyel (2000)	Exploratory (empirically based)	Question-naire	26 variables for collabo-ration 22 variables for techno-logy	200 SMEs from four SIC codes (in New Hampshire)	Presidents and CEOs	Explore relation-ships among collaboration, technology and innovation in manufacturing SMEs	Development of a supplier typology that explains the composition and performance of various types of suppliers
7. Lambert and Cooper (2000)	Case studies	Interviews	Supply chain network struc-ture, supply chain business processes and SCM components	15 companies in 9 supply chains	90 interviews with managers in order fulfil., cust. service, product dev., procurement, demand mgmt.	Determine how to accomplish cross-functional integration using supply chain management	- Structure of processes within and between companies is cri-tical for high competitiveness - Integrating business processes with partners and coordinating activities internally is key in SCM
8. McGinnis and Mele Vallopra (2001)	Survey	Question-naire	Variables that affect supplier effectiveness	Manufactu ring firms	169 senior purchasing managers	Identify strategies for maximizing supplier contri-butions to process develop./improve. in manufacturing organizations	- 97% of companies say that suppliers are involved in process development./improvement - Supplier contributions to process development are facilitated when processes are a source of competitive advantage

Table 1.7– Summary of the most important empirical studies in the field of supply chain and collaboration (continued)

Authors, date	Research strategy	Data collection method	Type of evidence	Number & type of organizations	Number & type of respondents	Objectives	Main results
9. Moore (1998)	Survey	Questionnaire	Relationship effectiveness and relationship commitment	Firms engaged in logistical alliances	Sample of 339 firms	Evaluate the importance of trust and commitment in logistical alliances	Trust and commitment are important elements in logistical alliances. The involvement of a third party affects the development of trust and commitment
10. Myers, Daugherty and Autry (2000)	Survey	Questionnaire	ARP service and cost effectiveness Economic and strategic perfor-mance of the firm	98 companies (75 manu-facturers and 23 retailers)	Business executives in companies that use automatic replenishment programs (ARP)	Investigate the use and the effectiveness of ARP	Managerial commitment is important for an effective ARP, which is also effective when a firm applies a market-oriented strategy
11. Ramdas and Spekman (2000)	Survey	Questionnaire	6 variables.: quality, inventory time, order fulfill., customer focus and customer satisfaction	Survey of 22 supply chains from South and North America and Europe (across 6 sectors)	160 valid responses	Build on Fisher's work (innovative versus functional products)	Innovative-product supply chains reflect greater information sharing (greater integration)
12. Shin, Collier and Wilson (2000)	Survey	Questionnaire	Performance construct (for supplier and buyer performance)	176 companies in the US automobile industry	Mid-level managers at manufacturing plants	Test the impact of a supply management orientation (SMO) on suppliers and buyers	- Strong SMO improves supplier and buyer performance - SMO influences quality and delivery more than cost and flexibility

Table 1.7 – Summary of the most important empirical studies in the field of supply chain and collaboration (continued)

Authors, date	Research strategy	Data collection method	Type of evidence	Number & type of organizations	Number & type of respondents	Objectives	Main results
13. Tracey and Tan (2001)	Survey	Questionnaire	Supplier selection, supplier involvement, competitive pricing, firm performance, delivery service, product quality and variety	Manufacturing firms	180 senior executives	Empirically examine the relationships among supplier selection criteria, supplier involvement, continuous improvement programs, customer satisfaction and overall firm performance	Focus should be on reliability, quality, performance, and involving suppliers in supply chain activities rather than on reducing the material price
14. Vonderembse and Tracey (1999)	Survey	Questionnaire	Supplier performance, manufacturing performance, supplier selection criteria and supplier involvement	Discrete part manufacturing companies in North America	268 purchasing managers	Investigate the use of supplier selection criteria and supplier involvement in product design and continuous improvement activities by manufacturing companies	Implementing supplier selection criteria and involving suppliers have a positive impact on manufacturing performance
15. Zaheer, McEvily and Perrone (1998)	Survey	Interviews and questionnaire	Competitive pricing, high quality supply, timeliness of delivery and flexibility	153 dyads surveyed with completed questionnaires from 99 purchasing managers and their lead suppliers	325 questionnaires were returned, from120 purchasing managers, 120 supplier representatives and 85 second respondents in the purchasing organization	Determine the impact of trust on buyer-supplier relationships	The level of inter-organizational trust has a powerful influence on buyer-supplier relationships

1.5 Synthesis of past research

This section first analyzes each of the research initiatives enumerated in table 1.7, by pointing out the major contributions and the weaknesses of each. The key elements that emerge from these initiatives are then summarized.

1.5.1 Analysis of past research

Table 1.8 lists the strengths and weaknesses of the research initiatives listed in table 1.7.

Table 1.8 – Evaluation of the major studies in the field of supply chain and collaboration

Authors, date	Contributions	Weaknesses
1. Boddy, MacBeth and Wagner (2000)	• Longitudinal study (2 years) • Built on prior research into supply chain partnerships and collaboration	• Specific case study results • General results (model)
2. Golicic, Davis, McCarthy and Mentzer (2001)	• Concentrates on forecasting techniques in an e-commerce environment • Various points of view (from different industries)	• Use of qualitative data • Overly broad results
3. Ittner and Larcker (1997)	• Strong empirical analysis • Views from different managers in each organization (cross-functional)	• Focuses on two specific performance measures (return on assets and return on sales) • Old database (1991)
4. Jeffcoate, Chappell and Feindt (2000)	• Involves best e-commerce practices • Process-oriented research	• Only SMEs involved • Position in supply chain is unclear (customer/client) • Qualitative data

Authors, date	Contributions	Weaknesses
5. Kalwani and Narayandas (1995)	• Manufacturing-oriented • Empirically based	• Performance is cost-oriented only (growth) • Absence of electronic communication tools • Database is old (1986 – 1992)
6. Kaufman, Wood and Theyel (2000)	• Process, product and relational innovation are analyzed • Focuses on a few sectors • Interesting empirical analysis	• Focus on technology in general and not on collaboration technologies
7. Lambert and Cooper (2000)	• Good understanding of the role of supply chain management in a network of partners • Supply chain principles are well presented	• Overview of the issues in supply chain management • General conclusions, no specific results from the interviews (case studies)
8. McGinnis and Mele Vallopra (2001)	• Specific results in a manufacturing environment	• Concentrates on process development only • Multi-industry, does not focus on questions specific to certain industries (supply chains)
9. Moore (1998)	• Looks into relational innovation in a collaborative environment (outsourcing)	• Logistical part of supply chain management is evaluated. • Does not look at the role and influence of e-commerce tools
10. Myers, Daugherty and Autry (2000)	• Studies electronic collaboration initiatives (ARPs, CPFR) • Firm performance is evaluated using both strategic and economic measures	• Operational view of collaboration (inventory replenishment) • Multi-industry (mostly oriented towards retailers and their suppliers)
11. Ramdas and Spekman (2000)	• Focus on supply chain performance in an extended enterprise • Specific results (empirical)	• The performance of the SC is moderated by a single variable (type of product) • Not industry-specific

Authors, date	Contributions	Weaknesses
12. Shin, Collier and Wilson (2000)	• Focuses on a single innovative manufacturing industry (automobile) • Interesting performance measures for both suppliers and manufacturers	• No special attention is paid to supply chain collaboration (focus is on supply chain orientation) • The supplier side is evaluated, but not the customer side
13. Tracey and Tan (2001)	• Detailed performance measures • Manufacturing environment • Strong empirical study	• Collaboration factors are almost non-existent • Emphasis on the supplier selection activity of the supply chain
14. Vonderembse and Tracey (1999)	• Detailed performance measures • Limited environment (discrete manufacturing)	• Collaboration factors are almost non-existent
15. Zaheer, McEvily and Perrone (1998)	• Dual analysis of buyers and suppliers	• Focus on relational innovations • Basic empirical analysis (general results)

Most of these studies examine different aspects of collaboration and supply chains. They can be distinguished by their different approaches – technological, socio-economic, operational and organizational – but all are valuable to the progress of research in these emerging fields.

1.5.2 Important elements of past research

Five important elements were singled out during the analysis of these studies: broad vs. industry-specific initiatives, study of both the upstream and downstream parts of the chain, research combining both supply chain planning and electronic collaboration, the importance of a complete set supply chain metrics, and a focus on planning activities in

collaboration rather than on the collaboration activity itself. This section describes these elements and uncovers four important facts that must be addressed in future supply chain research studies.

First, due to the complexity and scope of supply chain environments, the results of some of the research initiatives are generic and do not necessarily reflect the situation of other specific industries (Boddy et al., 2000; Lambert and Cooper, 2000; Ramdas and Spekman, 2000; Golicic et al., 2001). One must sometimes drill down into these overly general results before one can fully understand the implications of electronic collaboration and SCM in a specific sector. The characteristics of a supply chain in the telecommunications or computer sectors are different from those in more traditional sectors such as pulp and paper or oil and gas. To counter this problem, researchers carrying out multi-industry studies use an activity-based approach to group together similar cases, e.g. manufacturing companies (Kalwani and Narayandas, 1995; Jeffcoate et al., 2000; McGinnis and Mele Vallopra, 2001; Tracey and Tan, 2001).

Some of the studies analyze only one side of the supply chain. Optimizing the supply chain through collaboration initiatives involves the participation of both the supply side (upstream) and the demand side (downstream). The performance of a supply chain can only be assessed when both sides are taken into account. Zaheer, McEvily and Perrone (1998) addressed this fact by questioning both suppliers and manufacturers involved in supply chain relationships.

Supply chain planning and electronic collaboration will transform the way companies exchange and transfer information. They alter relationships and modify processes between partners. Interesting studies have been done on each of these subjects (Zaheer et al., 1998; Moore, 1998) but very few have included both topics in their research methodology. Supply chain studies often leave important variables aside to concentrate on particular aspects of their analysis (e.g. supplier selection); for example, some studies neglect critical variables such as collaboration (Vonderembse and Tracey, 1999; Tracey and Tan, 2001). In other analyses, performance is assessed from a technological standpoint, thus overlooking important issues such as collaboration in supply chains (Kaufman et al., 2000).

Studies involving performance measurement involve different sets of metrics. Operational performance metrics are used to quantify the impact of collaboration on a supply chain. However, these sets are rarely complete (exhaustive), as recent studies have tended to concentrate on one particular aspect of performance (manufacturing, supplier, etc.), e.g. Ittner and Larcker (1997). It is important to identify the right metrics and to ensure that they cover all aspects of operations (quality, outputs, material and human resources, etc.) within the supply chain. Research initiatives such as Kalwani and Narayandas (1995), Shin et al. (2000), Myers et al. (2000), and Vonderembse and Tracey (1999) have identified strong complementary metrics in their approaches.

Finally, research into supply chain performance has analyzed the impact of collaboration on tangible collaborative actions taken by companies to exchange critical information

with their partners. However, none of the studies looked at the planning of collaboration actions to be undertaken in the future. To be correctly executed, collaboration must be planned, just like production or distribution activities. Researchers have tended to focus on the consequences (impacts) of the actions taken (for example, information exchange methods, implementation of tools, etc.).

Our reviewing of these major studies revealed certain gaps left by researchers; this research is an effort to embrace the following considerations:

1. Planning is as important as carrying out a supply chain activity: Planning is one of the strong points of the CPFR methodology when dealing with supply chain partners.

2. Supply chain studies must delimit their scope to obtain precise results: The telecommunications equipment industry supply chain is an especially interesting sector due to the increasing number of activities being outsourced to partners

3. Performance measures must be aligned with the innovative processes being created and with the new forms of relationships generated by these processes: E-commerce and collaboration tools have transformed the methods used by supply chain partners to exchange information on operations (inventory, production plans, etc.). The development of new communication tools within the supply chain has created an opportunity to assess the impact on the chain of process and relational innovations.

4. Both demand and supply sides are required to fully assess the impact of collaboration on a supply chain: Questionnaires must be designed to gather important information from both the people involved with suppliers and the people dealing with the customers.

These four important facts became the cornerstones of this study of the telecommunications equipment sector. The supply chain of the OEM in question formed the ideal environment to study the effects of collaboration planning and electronic collaboration tools on a supply chain's performance.

CHAPTER 2 - RESEARCH DESIGN

This chapter presents the conceptual model and the research variables required to support this study. The model, presented in section 2.1, is used to analyze the operational performance of a manufacturing supply chain. The origins and roles of the different research variables found in the conceptual model are explained in detail in section 2.2. The supply chain performance variables are described in section 2.2.1. Collaboration planning variables and of innovation variables are explained in sections 2.2.2 and 2.2.3, respectively. The chapter concludes with the formulation of research propositions in section 2.2.4.

2.1 Conceptual model

The purpose of this research is to empirically assess the impact of collaborative planning activities on a manufacturing supply chain. Collaboration issues keep changing the way business is carried out between supply chain partners. They are stimulating innovation in proactive companies and industries. Therefore, the operational performance of a supply chain will be affected by the changes in collaboration and communication methods deployed between the partners. The supply chain's performance is also critically linked to the innovations applied during the development of supply chain collaboration initiatives.

Figure 2.1 summarizes the conceptual model that supports this research initiative. It was developed to analyze the impact of planning and collaboration tools on supply chain performance. Different types of variables influence the performance of a supply chain in

a manufacturing environment, such as the type of product/component fabricated, the level or tier at which it operates, and the degree of collaboration exercised by supply chain partners.

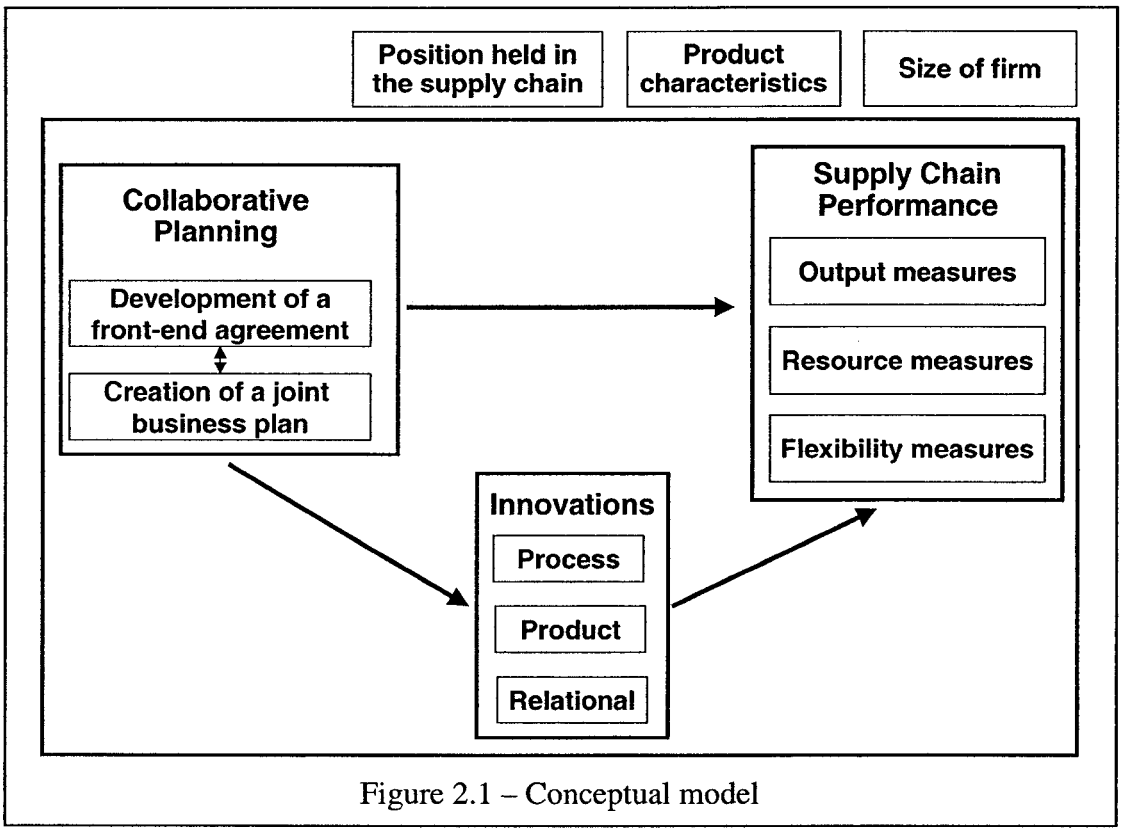


Figure 2.1 – Conceptual model

Section 2.2 describes and illustrates each of the variables in the conceptual model.

2.2 Justification of the research variables

This section presents the variables selected to represent the impact of collaborative planning on the performance of a supply chain. These variables were obtained either from the literature, as is the case for supply chain performance (section 2.2.1), or from methodologies and tools used in several industries, such as collaborative planning variables (section 2.2.2) and innovation-related variables (section 2.2.3).

2.2.1 Supply chain performance

Several research fields focus on quantifying the operational performance of individual firms, of specific departments within a company, of entire industries and of key suppliers. The competitive environments of several industries now call for the performance evaluation of complete supply chains (from the suppliers' suppliers to the customers' customers). Authors such as Van Hoek (1998) have remarked on how difficult it is to measure and improve performance in a supply chain. Hence, some researchers have developed conceptual frameworks for analyzing the performance of SCM systems (described later in this section).

In this research, particular attention is paid to performance measures for supply chain partnerships. Organizations such as the International Organization for Standardization (ISO) have developed standards to certify the work of suppliers for example. The ISO 9000 family of standards refers to quality management, which ensures that products or components conform to the customer's requirements. The ISO 14000 family is mostly concerned with environmental management; it evaluates the actions taken by a company to minimize harmful effects on the environment caused by its activities. These standards evaluate how organizations go about their work, and do not directly assess the outputs of their activities. They consist of standards and guidelines relating to management systems.

The Capacity Maturity Model (CMM) is another tool, this one used to evaluate the performance of software companies. Developed by the Software Engineering Institute (SEI), the CMM assists organizations in improving their software processes.

The organizations discussed above focus either on very specific measures (software attributes) or on general business processes in the company (ISO). But, in order to identify operational performance measures for a supply chain, a good understanding of the most important research initiatives in logistics, manufacturing and operations activities is necessary. The cross-boundary management required for an efficient supply chain demands that company's management team work across traditional internal functional areas and manage external interactions with both suppliers and customers. Hence, in order to monitor progress and adjust the development of a supply chain, performance indicators should primarily be based on process performance, not on financial performance (Lummus et al., 1998).

Several research initiatives have divided the performance of a supply chain into different categories. In their study of power influences in the supply chain, Maloni and Benton (2000) grouped performance measures into three categories: supplier performance, manufacturer performance and supply chain performance. Shin et al. (2000) also identify supplier and buyer performance measures in their study. The left-hand side of table 2.1 lists the variables in the supplier performance construct. Using a larger number of performance measures, Shin's study also allows for a more complete assessment of buyer performance. The right-hand side of the table presents the measures that structure the buyer performance construct.

Table 2.1 – Shin et al.'s (2000) supplier and buyer performance measures

Supplier performance measures	Buyer performance measures
lead times	process flexibility and volume flexibility
product quality	production cost and production lead times
product cost	product quality
on-time delivery	speed of delivery, delivery reliability and delivery lead time
delivery reliability (fill rate)	

Spekman et al. (1998) investigate the roles and characteristics of partnerships in supply chains. In this research initiative, two separate performance measures are identified to assess the performance of partnering in a supply chain: cost reduction and customer satisfaction. Numerous other research initiatives combine different measures to assess the performance of different elements of a supply chain. For example, Davis (1993) measures the effectiveness of supply chain management through two main characteristics: customer responsiveness and costs. Lead times, stock-out probabilities and fill rate shape customer responsiveness, whereas costs involve inventory and operation expenses. Arntzen et al. (1995), in a study of a large computer company, concentrate on the time consumed during the execution of supply chain activities. Flexibility is the focus in another interesting study in the chemical industry (Voudouris, 1996). Key performance indicators are also associated with efficient consumer response programs. Indicators such as order fill rate, on-time delivery, order fulfillment lead time and product introduction lead time, volume growth, and supply chain inventory turnaround are all correlated with a supply chain's replenishment activities (Lummus et al., 1998).

However, after scrutinizing the most important studies on operational performance measures, we found the most complete set of operational performance measures in Beamon's (1999) study, which incorporates all of the critical performance measures identified by the previously mentioned authors. Supply chain performance is measured with three different types of operational measures. The first type brings together all resources (e.g. human and material) involved in running an effective supply chain. But, in order to complete Beamon's set of measures, we added two important operational measures (inventory and operating costs) used in several other studies. The resource measures selected for this study, which are represented by quantity- or efficiency-related measures, are listed in table 2.2.

Table 2.2 – Resource measures

inventory levels	personnel requirements
inventory costs	equipment use
operating costs	energy usage and costs

The second type of measure identified by Beamon (1999) focuses on outputs produced by supply chain partners. Supply chain partners frequently, if not always, use this traditional category of operational measure. The following indicators make up Beamon's output measures: number of items produced, time required to produce a product/component, number of on-time deliveries, customer satisfaction, and product quality. In a demand-driven supply chain where activities are customer-oriented (Frohlich and Westbrook, 2002), additional output measures such as lead times and fulfillment rate can be added to Beamon's measures. These additional measures are necessary in efficient supply chains

where only a few suppliers are able to quickly provide critical high-tech components with short life cycles. Table 2.3 lists the output measures that are retained for this study.

Table 2.3 – Output measures

number of items produced	lead times
number of on-time deliveries	fulfillment rate
customer satisfaction	time required to produce a product/component
product quality	

Finally, the last class of measures concerns all the flexibility aspects of a supply chain. The ability for a supply chain to adapt to major fluctuations in demand (volume flexibility), to offer a large variety of products (product mix) (Thonemann and Bradley 2002), and to offer different distribution scenarios (delivery agility) are important measures identified by Beamon (1999) in this third category. Another important measure found in the product development literature enhances the flexibility measure type. The capability to rapidly design new modular products is essential to a supply chain's flexibility. The flexibility measures used in this study are identified in table 2.4.

Table 2.4 – Flexibility measures

volume flexibility
product mix
delivery agility
rate of new product development

2.2.2 Collaborative planning in a supply chain

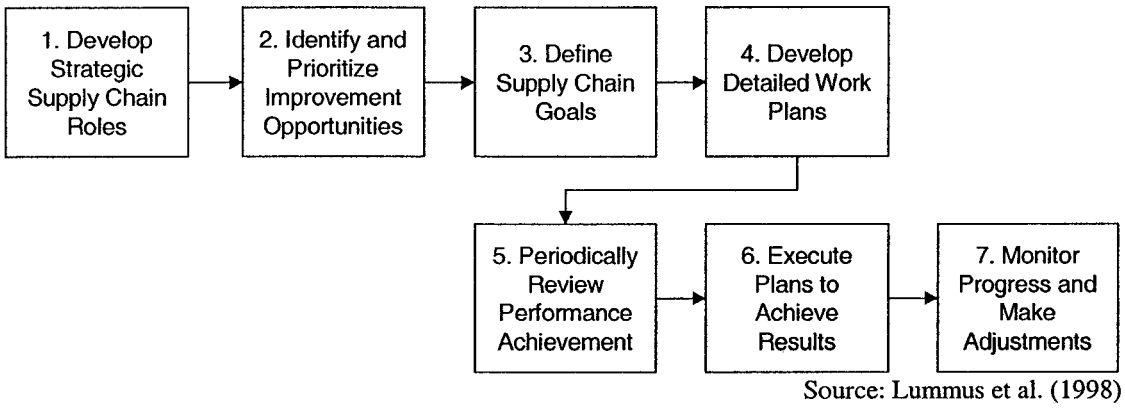
Supplier-buyer relationships have been the subject of many research studies in the past. Success and failure factors in these specific types of relationships are described in numerous papers (Ellram, 1995; Landeros and Monczka, 1989). However, very few research initiatives have focused on the process of partnering (Boddy et al., 2000). The

conception and development of partnerships begin with excellent communications between potential supply chain partners.

In their empirical study of supply chain partnering, Boddy et al. (2000) present an interaction model composed of seven factors. This study of supply chain partnerships implies that the outcome of a partnership depends on the interactions among people and among other contextual elements. According to Boddy et al. (2000), the following elements must be well developed during the partnering process:

1. Business processes that are designed to transfer information and material along the supply chain
2. Technology exploited by supply chain partners (information systems, machinery, physical facilities, etc.)
3. Resources (mainly financial), required to function efficiently
4. Structure, which is necessary to coordinate the principal tasks between supply chain partners
5. People, represented by the knowledge, competencies and attitudes of the employees working for the partners
6. Culture, which is made up of values, norms and beliefs of supply chain partners
7. Power, characterized by the amount and distribution of identifiable sources of power available to people

The combination of these seven critical elements is essential to the development of partnership and collaboration initiatives in a supply chain. However, partners also need a planned series of interdependent actions to assure effective collaboration methods.

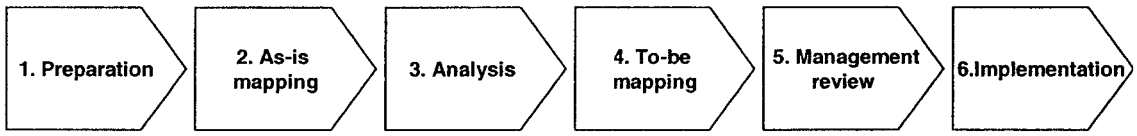


Source: Lummus et al. (1998)

Figure 2.2 – Supply chain strategic framework

In their supply chain strategic framework, Lummus et al. (1998) identified a series of important steps in the implementation of collaborative supply chain strategies (figure 2.2). The first step consists of identifying supply chain roles that support the companies' business strategies. It is important to make sure that these roles are aligned with strategic imperatives. In evaluating supply chain capabilities, the second step identifies opportunities to improve the supply chain's performance. For each of the roles identified in the first step, current capabilities are defined and the performance requirements that support supply chain strategies are specified. In the third step, definition of supply chain goals, a company benchmarks improvement requirements against other companies in its industry and targets measurable objectives for the realization of the supply chain. The development of a detailed work plan to meet these goals shapes the fourth step, where the milestones, tasks and resources to be exploited are detailed.

The fifth step integrates improvement plans into operating measurements across the company. At this stage, the supply chain strategic plan must be translated into precise objectives and measures for the company's various departments. The sixth step consists of the execution of the plan. Project management tools and pilot studies are sometimes used to test assumptions made during the development of the strategic plan. In the final step, supply chain partners conduct performance reviews and adjust plans and objectives accordingly. Performance indicators, developed during the goal-setting step, should be examined according to the strategic plan (daily, weekly, monthly and quarterly targets).



Source: Corbett et al. (1999)

Figure 2.3 – Road map for joint supply chain projects

A roadmap elaborated by Corbett et al. (1999) provides another interesting method for planning collaboration between supply chain partners. As shown in figure 2.3, the authors identified six critical steps in the development of joint supply chain projects. The first phase, Preparation, has partners agree on processes, prepare data, set timetables and decide on benefit-sharing principles. The As-Is Mapping step establishes the direction for improvement and maps current processes (informational and physical flows). Analysis forms the third phase, which concentrates on value-added analysis and on process reengineering.

The fourth phase, To-Be Mapping, enables partners to agree on implementation plans and performance measures. During this phase, it is also important for partners to be creative and to approach the redefinition of the supply chain from new perspectives. Validation is the key element in the Management Review phase; the joint effort is presented to senior managers for approval. Finally, the Implementation phase is carefully managed to ensure that the plan is correctly implemented. It is also important at this step for partners to evaluate the performance of the supply chain and to adjust the processes if need be.

Lummus's framework and Corbett's roadmap raise some important points about planning collaboration in a supply chain. However, the level of detail of the actions to be taken by supply chain partners is still broad. These authors identify critical phases that supply chain partners experience in their collaborative creation process but concrete practical actions are not well defined.

A more detailed (down-to-earth) method, known as Collaborative planning, forecasting and replenishment (CPFR), introduces a sequential approach that defines key actions to be undertaken during the formulation of collaboration initiatives. CPFR, which is an initiative of the Voluntary Interindustry Commerce Standards association (VICS), defines the operational activities that enable partners to design collaboration initiatives in supply chains. As described in section 1.2.6, the CPFR methodology was developed by a group of experienced people who had implemented collaborative initiatives in several industries.

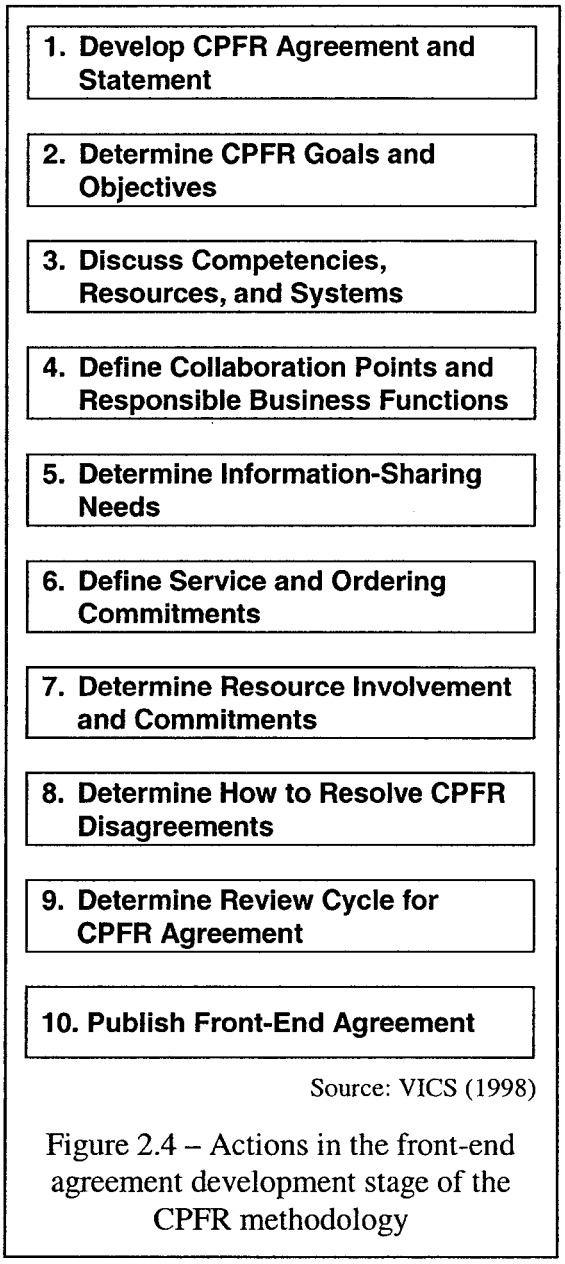
When planning supply chain relationships, the first two stages in the CPFR methodology are critical. The first stage is the development of a front-end agreement, where all partners' requirements and objectives in the collaboration are clarified. The second stage is the creation of a joint business plan, which enables partners to drill down through the collaboration process to the product/item information being exchanged.

2.2.2.1 Development of a front-end agreement

A solid agreement between partners is necessary to avoid any complications in evolving supply chain relations. First, as shown in figure 2.4, the potential partners jointly produce a statement that sets out the objectives of collaboration, the principles of confidentiality and the empowerment of resources. The next action is the formulation of the goals and objectives of the collaborative initiative. This involves the definition of opportunities, the identification of means of measurement and of common metrics, and the impact of this relationship on each supply chain partner's business. In the third step, each partner determines the competencies, resources, and systems required, and identifies its ability to contribute to the collaboration process.

The fourth action maps the collaboration points to each of the partners' competencies and assigns responsibility for each of the business functions related to the collaborative relationship. With more detail, the next action outlines the information to be shared by partners. This action is critical to the exchange of important data; issues such as the frequency with which information is to be updated, the methodology used to forecast demand, the technology used for the exchange of information, and the response time

agreed to by all partners when information is requested must be hammered out. The sixth action defines service and ordering commitment parameters for the collaboration process (e.g. frozen forecast periods, where the shared forecast becomes a firm order, etc.). The next step concentrates on determining the time commitment and human resources involved in managing the collaboration process. Staff is allocated to different collaborative initiatives and process improvements.



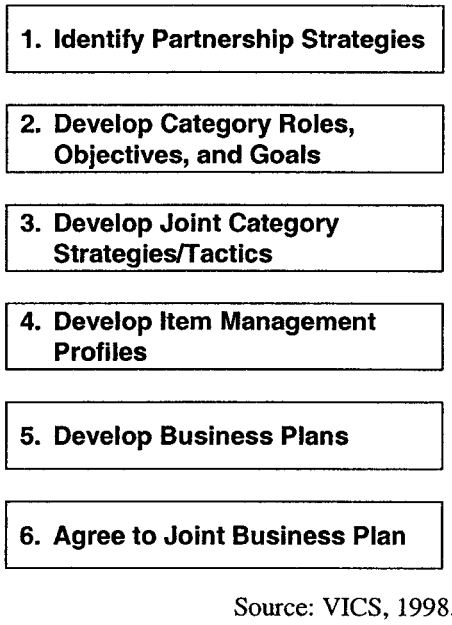
Source: VICS (1998)

Figure 2.4 – Actions in the front-end agreement development stage of the CPFR methodology

The last three actions of the front-end agreement development stage (actions 8, 9 and 10 in figure 2.4) are contractual in nature. First, ground rules are established in order to handle any future CPFR disagreements. Then, a continuous evaluation process is designed to benchmark the success of the collaborative relationship. Finally, an official agreement, to be applied by all the partners in the collaboration process, is published to guide their work.

2.2.2.2 *Creation of a joint business plan*

The creation of a joint business plan is the beginning of a tight long-term commitment between supply chain partners. The CPFR methodology identifies six key actions at this stage (figure 2.5). First, partners agree on a general partnership strategy that facilitates the sharing of strategic information such as periodic business objectives and business strategies. In the next action, partners increase the level of detail by developing the roles, objectives and goals for specific categories of items to be exchanged in the supply chain. The third action enables partners to identify and develop appropriate joint category strategies (pricing actions, transportation parameters, etc.). The next action instigates the development of item management profiles that support tactical parameters. Included in these parameters are order minimums, order multiples, order intervals, lead times, frozen time fence, and safety stock rules. The last two actions in the joint business plan creation stage (actions 5 and 6 in figure 2.5) focus on long-term planning. First, each supply chain partner develops an individual plan based on information previously shared between participants. These plans are then compared and agreed upon and a joint business plan for all supply chain partners is drawn up.



Source: VICS, 1998.

Figure 2.5 – Actions in the joint business plan creation stage of the CPFR methodology

The ten actions involved in the development of a front-end agreement and the six actions identified for the creation of a joint business plan were used to develop the collaboration planning section of the questionnaire used for data collection in this study.

These two first steps of the CPFR method transform the way supply chains are planned and managed. Collaboration planning makes it possible to establish close links early on in the supply chain relationship, but also to instigate some major changes. These positive modifications are often perceived as innovations that will transform business processes and business relationships.

2.2.3 Innovations

This study recognizes the fact that defining innovation is not an easy task. The Oslo Manual (OECD/Eurostat, 1997: 9) characterizes innovation as "changes, which require a significant degree of novelty for the firm." Innovations may relate to products, processes and organizational dynamics.

In a manufacturing environment, three types of innovation – process, product and relational – stand out when two business partners collaborate to optimize their supply chain. All of these types of innovations have the capacity to transform the way business is done in an efficient supply chain. This section describes the innovation variables that are affected by the planning of collaboration initiatives among supply chain partners.

2.2.3.1 Process innovation

The following definition, which is also from the Oslo Manual, outlines the nature and role of technological process innovation: "adoption of technologically new or significantly improved production methods, including methods of product delivery. These methods may involve changes in equipment or production organization, or a combination of these changes, and may be derived from the use of new knowledge" (OECD/Eurostat, 1997: 32). In this study, innovative processes not only influence functional areas within a company but also greatly affect the business partners' involvement in a supply chain. Hence, the impact of modifying one or more of these processes is significant. New competencies, new technologies and new resources are sometimes required to design and implement new processes within the company. However, some of the biggest process innovation challenges that companies face relate to the creation/modification of processes with supply chain partners. When creating new processes, the involvement of external members with different approaches is often a barrier to the successful implementation of these processes. Failure to understand objectives, the power influence and the incompatibility of different technologies used in supply chain partnerships are often key factors in the failure of such relationships.

But strong, collaborative supply chain relationships transform processes in three distinct areas of the company: logistics, production and design activities. First, the processes related to design are affected by supply chain collaboration. The ability to generate new design processes and to gear them to customer requirements is an important innovative aspect of a supply chain. In a supply chain relationship, logistics is often the most critical

activity linking partners. The capability to improve logistical processes, to increase the flexibility of distribution processes and to quickly respond to logistical demands by distribution partners is a critical process innovation related to logistics. Finally, supply chain capabilities also transform production-related processes. In order to respond to the needs of its supply chain partners, a company must be able to design new production processes and improve the flexibility of internal production. These variables, which are adapted from the OECD (2000) study, are listed in table 2.5.

Table 2.5 – Process innovation variables

• design process generation	• production process generation
• logistical process generation	• production flexibility
• flexibility of distribution	• process alignment to customer requirements
• responsiveness of distribution chains	

2.2.3.2 Product innovation

Different types of variables have been used to collect data on product innovation. Some of the variables relate to the firm's activities (R&D expenditures and the technical workforce available). However, this study looks into more subjective variables that may have an effect on supply chain partners.

Much work has been done on the inter-organizational relations in product development (Clark, 1989; Dyer, 1997; Sobrero and Roberts, 2001), but all of it combines process, relational and product innovation variables. Hence, three variables strictly related to product innovation stand out in the literature (see table 2.6):

- product diversification, which is the ability to develop new products (or families of products/services)
- product differentiation, which combines the skills needed to improve products and services by creating new features
- product customization, which is the ability to develop new methods of configuring products and services to the requirements of customers (partners)

Table 2.6 – Product innovation variables

• product diversification
• product differentiation
• product customization

2.2.3.3 Relational innovation

Collaborative tools also transform how supply chain partners interact with each other. Communication channels such as the Internet facilitate the exchange of information between partners. The emergence of such communication media has changed the way information is sent, but without a structured approach to collaboration, it may not have the same impact on relationships as would be the case if collaborative methods were used to plan supply chain activities. Relationship-oriented innovations may have a major impact on the supply chain's global operational performance.

Relational innovations are characterized by the following activities. First, market segmentation enables companies to target new groups of customers and suppliers. Relational innovations may also involve the development or improvement of trust with new and existing customers and suppliers. Trust is defined as "the firm's belief that another company will perform actions that will result in positive outcomes for the firm, as well as not take unexpected actions that would result in negative outcomes for the

firm" (Anderson and Narus, 1990: 45). Several studies confirm the importance of trust and coordination in collaborative relationships (Anderson and Narus, 1990; Pilling and Zhang, 1992; Smith et al., 1995). Furthermore, the quality of relationships and the importance for companies of retaining partners in long-term relationships are also critical elements of relational innovations. Hence, loyalty towards supply chain partners may also be affected by collaboration planning. Table 2.7 enumerates the relational innovation variables used here, which are also adapted from the OECD (2000) study.

Table 2.7 – Relational innovation variables

• development of new partners	• loyalty
• trust (with customers and suppliers)	• retention and management of partners, customers and suppliers
• quality of relationships	

Innovations emerge as supply chain partners strive to change the way business is carried out. Innovations may be either radical or incremental; sometimes they are easily transferable to partners and competitors. Indeed, process and relational innovations may generate advantages that are specific to a firm but they relate just as often to the efficiency of a group. The OECD (2000: 18) summarizes the potential effect of process and relational innovations as follows: "transferable effects tend to generate highly dynamic network phenomena that encompass wider groups of actors in a given environment."

2.2.4 Research propositions

From the literature review, certain relationships can be expected between the research variables identified in our conceptual model. The general research propositions examined here are illustrated in figure 2.6.

Proposed relationships between blocks of variables correspond to the five general propositions (P1, P2, P3, P4 and P5); subsets of these five propositions arise from the relationships between research variables (rather than blocks of variables) and are identified as P1.1 to P5.6. The propositions are discussed in more detail in the following sections.

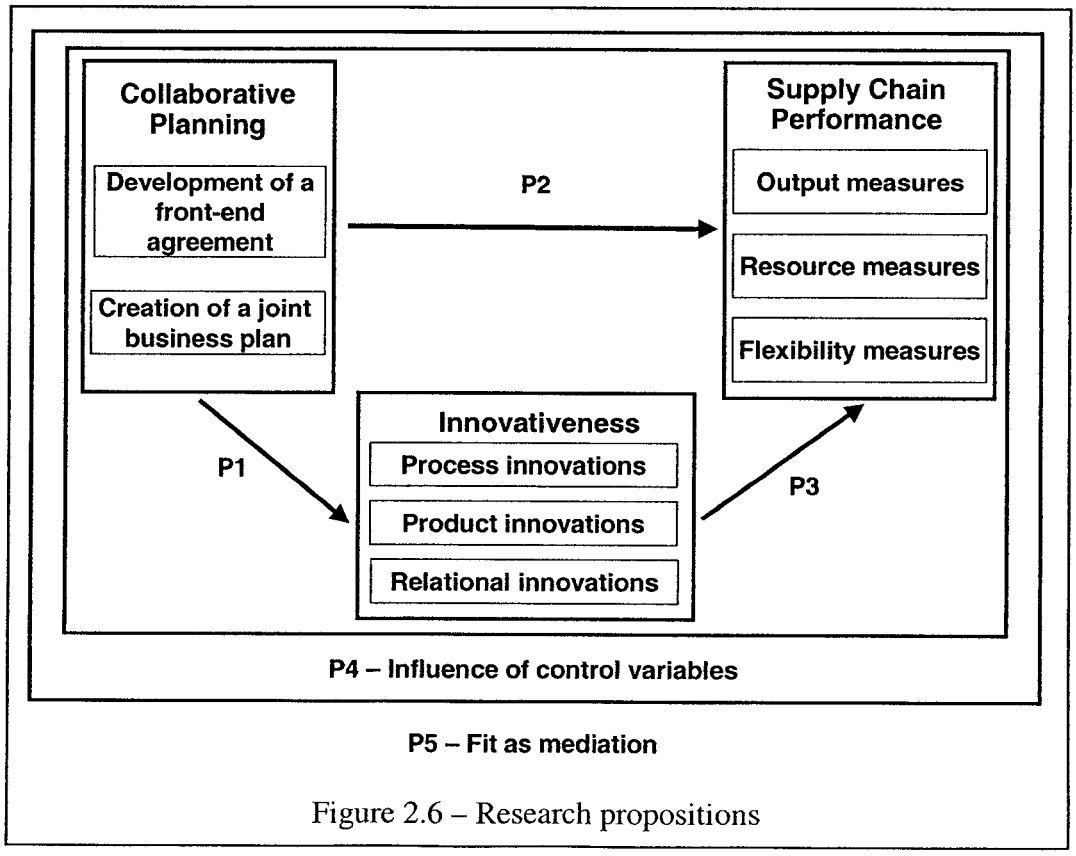


Figure 2.6 – Research propositions

2.2.4.1 Relationships between collaborative planning, innovativeness and supply chain performance

E-commerce and supply chain management tools enable companies to create and transform processes and also to foster and manage key relationships with partners. But what kind of collaborative activities induce supply chain partners to introduce new innovations? What influence does collaborative planning have on the performance of the supply chain? To what extent do innovations (stimulated by collaborative planning) improve the supply chain's performance?

These questions give rise to the first three general propositions (P1, P2 and P3) as well as the seven specific research propositions (P1.1 to P3.3):

P1: Collaborative planning has a positive influence on innovativeness.

More specifically,

P1.1: The development of a front-end agreement has a positive influence on innovativeness

P1.2: The creation of a joint business plan has a positive influence on innovativeness

P2: Collaborative planning has a positive influence on supply chain performance.

In particular,

P2.1: The development of a front-end agreement has a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

P2.2: The creation of a joint business plan has a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

P3: Innovativeness has a positive influence on supply chain performance.

More specifically,

P3.1: Process innovations have a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

P3.2: Relational innovations have a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

P3.3: Product innovations have a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

2.2.4.2 The role of control variables

The fourth general proposition simply accounts for the role of control variables.

P4: All relationships implied by P1, P2, P3 are influenced by control variables such as size, product demand/customization or position held by suppliers in the supply chain.

This fourth general proposition leads to these specific propositions:

P4.1: The relationships observed in P1 are controlled by variables such as size, product demand/customization or position held by suppliers in the supply chain

P4.2: The relationships observed in P2 are controlled by variables such as size, product demand/customization or position held by suppliers in the supply chain

P4.3: The relationships observed in P3 are controlled by variables such as size, product demand/customization or position held by suppliers in the supply chain

Let us briefly examine the role of each control variable.

Size of the firm

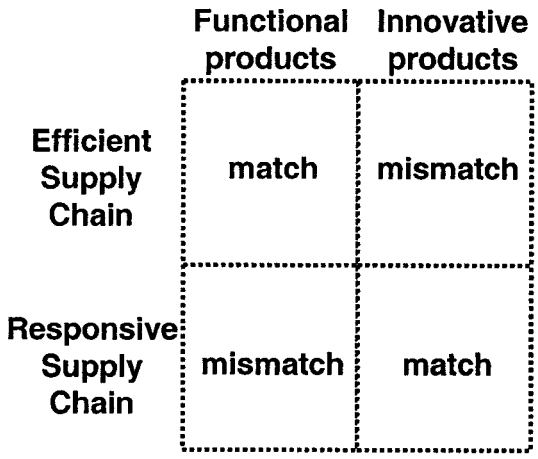
The size of the firm represents a frequently used control variable in research studies involving inter-organizational relationships. Size is directly linked to a firm's level of influence or power in the supply chain. The larger the firm is, the more it can influence decisions and actions along the chain (Cox, 1999; Cox et al., 2001). Size also represents a proxy for the level of resources (human and financial) assigned to collaborative planning activities within the supply chain (Lefebvre et al., 1997). Finally, the organizational structure may also be affected by firm size. The people in charge of supply chain collaborative planning activities in a smaller company may also be responsible for other managerial activities including top management positions. This is evidently not the case for larger companies.

Position held by suppliers in the supply chain

Very few studies have categorized the level at which suppliers operate in a supply chain. To our knowledge, this variable has never been introduced in any collaborative supply chain study. Some authors might associate the size of the firm with the level at which it operates in the supply chain. However, this is not the case in the telecommunications equipment industry, where small, specialized firms may be responsible for the final integration of the product (first tier) while large firms provide high-tech components (second, third and fourth tiers). Hence, a supplier that is mostly involved as a fourth-tier sub-assembler might not carry out collaborative planning activities in the same way as a first- tier supplier executing final assembly would.

Product characteristics – Innovative versus functional products

Fisher (1997) asserts that there is no single best way to effectively manage a supply chain. He argues that, in order to be effective, supply chains must be managed according to the nature of the product they make (see figure 2.7). Fisher categorizes products as either innovative of functional. This categorization is also used in other research initiatives, notably Ramdas and Spekman's (2000) supply chain performance study, which classifies supply chains according to the type of product they support: innovative or functional.



Source : Fisher (1997)

Figure 2.7 – Matching supply chain to products

Innovative products are characterized by unpredictable demand. High-tech products, with their constantly changing applications and attributes, are usually placed in this category. Life cycles of innovative products are short, which forces companies to minimize lead times in order to show a profit. Innovative products also need to be flexible so that they can change quickly over time. Flexibility of product characteristics (e.g. material) and of manufacturing processes (e.g. multiple routings) is usually important when producing customized innovative products.

Functional products are generally stationary items that have been on the market for a while. Manufacturing competencies and sales and marketing experience within the firm mean that functional products tend to have a stable, easy-to-forecast demand. These products usually have long life cycles as companies try to minimize their costs through low inventory and high production runs, an approach that is commonly called mass production. Table 2.8 identifies the types of product variables that are used in this analysis.

Table 2.8 – Types of product variables

1. unpredictable vs. stable demand
2. short vs. long life cycles
3. short vs. long lead times
4. low vs. high inventory
5. low vs. high production runs
6. customized vs. stationary product

2.2.4.3 The role of innovativeness as a mediator

The first four general research propositions (and the related specific propositions) are rather straightforward. The fifth general proposition is grounded in contingency theory and will explore how innovativeness acts as a mediator between collaborative planning and supply chain performance. The concept of fit represents the central theme in contingency theory, enabling researchers to investigate a subject through six different angles, namely fit as mediation, fit as moderation, fit as profile deviation, fit as gestalts, fit as covariation and fit as matching (Venkatraman, 1989).

For this study, fit as mediation seemed more appropriate according to three characteristics: (i) the degree of specificity of the theoretical relationships, (ii) the number of variables involved, and (iii) the elaboration of fit according to specific criterions (or criteron-free specification).

The purpose of collaboration planning is to specify and clarify the conditions to which supply chain partners must agree to in order to do business. However, with an ultimate goal of improving supply chain performance, partners may indirectly maintain, transform or develop processes and relationships to attain better results. The indirect nature of these process and relational innovations, and the degree of specificity (the strength and direction of innovativeness not being one issue) suggests the fit as mediation perspective. Moreover, researchers often make use of fit as moderation to analyze research propositions, but the important number of variables and the exploratory nature of this study make this perspective difficult to exploit.

The conceptual model illustrated in figure 2.6 clearly pushes in favor of fit as mediation since it indicates the presence of intervening effects between an antecedent variable (collaborative planning) and its consequent variable (supply chain performance).

Hence, the fifth proposition can be formulated as follows:

P5: The effect of collaborative planning on supply chain performance is mediated by innovativeness.

This fifth general proposition also generates a number of specific propositions:

P5.1: The effect of the development of a front-end agreement on supply chain performance is mediated by process innovations

P5.2: The effect of the development of a front-end agreement on supply chain performance is mediated by product innovations

P5.3: The effect of the development of a front-end agreement on supply chain performance is mediated by relational innovations

P5.4: The effect of the creation of a joint business plan on supply chain performance is mediated by process innovations

P5.5: The effect of the creation of a joint business plan on supply chain performance is mediated by product innovations

P5.6: The effect of the creation of a joint business plan on supply chain performance is mediated by relational innovations

In conclusion, these five general propositions and their respective subsets of specific propositions will be tested in chapters 4 and 5. The next chapter deals with the research strategy chosen to examine the propositions put forward in this section.

CHAPTER 3 - RESEARCH STRATEGY

As illustrated by our conceptual model in figure 2.6, this study focuses on the effects of collaborative planning on the innovativeness and performance of one supply chain. The following statement illustrates this aim:

> *The coupling response of the physical and cash flow velocity in a supply chain largely depends upon the maturity of the supplier-to-middle node-to-customer relationship and on a common operational discipline. Collaborative planning, forecasting, and replenishment (CPFR) best practices strive to build closely coupled relationships through open communications. The whole management team across a supply chain network seeks a common solution, rather than just the local management of the middle node attempting to optimize its operation alone. CPFR can provide greater visibility upstream and downstream within a supply chain network. The relationship coupling stays tight because a majority of nodes in the supply chain network stay synchronized in both their planning cycle and in the execution timing of their adjustments to capacity and inventory. While it's not perfect, collaboration does work to smooth out the extremes of physical flow and cash flow during upturns and downturns.*
>
> (Walker, 2002)

Although Walker mentions the role of collaboration in determining the performance of the supply chain, no empirical study that supports his claim can be found in the literature. This thesis will attempt to provide empirical evidence on this underinvestigated issue.

Due to the recent emergence of the collaboration planning and supply chain performance research fields, an exploratory approach is chosen. The purpose of this research is to gain a better understanding of the phenomenon of collaboration in an integrated supply chain.

With the recent development of collaboration processes and the rapid evolution of communications technologies to support such initiatives, this approach is more likely to yield interesting results in a field where few empirical studies have been conducted. Furthermore, the limited number of companies involved in collaboration planning in an e-commerce and supply chain environment and the complexity of inter-relationships within a supply chain also incited the conduct of an exploratory study.

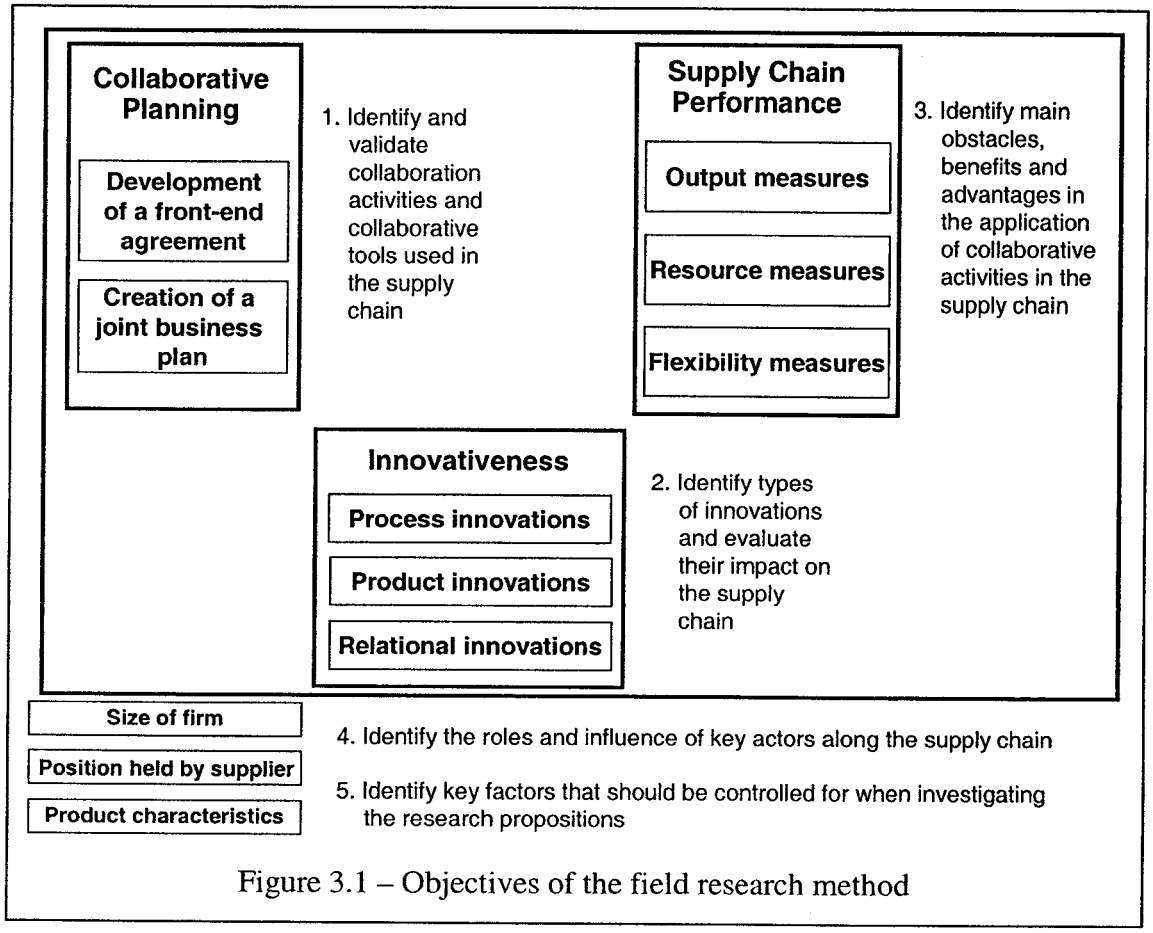


Figure 3.1 – Objectives of the field research method

Due to the exploratory nature of this research, two data collection strategies were chosen, namely the field research and the electronic survey methods, which pursue different and complementary research objectives. Figures 3.1 and 3.2 summarize the objectives of each

of these methods. Note that these research objectives are closely aligned with our research propositions (section 2.2.4).

The objectives of the field study and of the electronic survey will be pursued in chapters 4 and 5, respectively, of this dissertation.

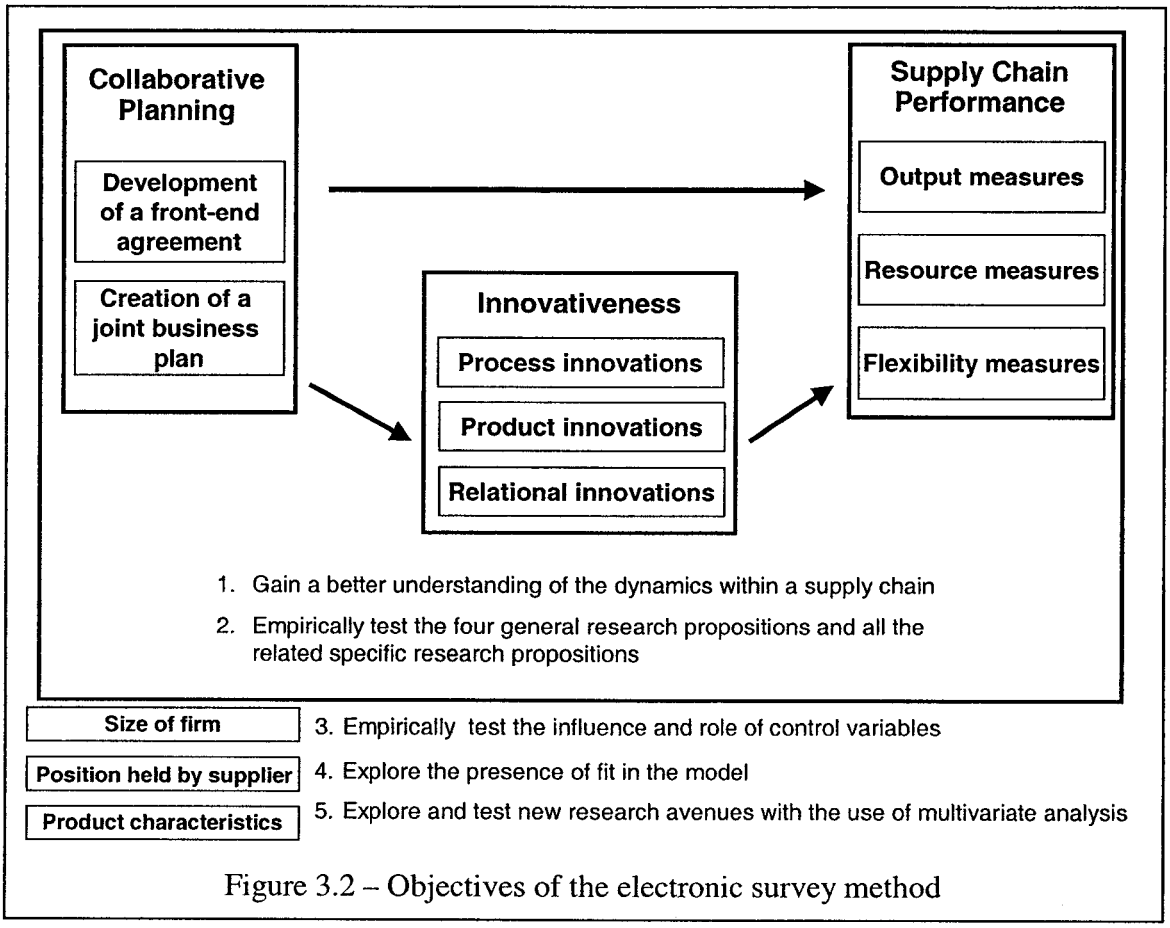


Figure 3.2 – Objectives of the electronic survey method

In the following sections, we will examine some of the critical elements of the research methodology. First, the grounds for selecting the research strategy are briefly discussed. Second, the imperatives governing the telecommunications equipment industry are identified and clarified. Third, each layer of the telecommunications equipment supply

chain is analyzed in order to understand the environment in which this study was conducted. Finally, the data collection methods for both the multiple-case study and the survey are described.

3.1 Exploratory research and grounded theory

Research on supply chain collaboration initiatives in an electronic environment is still in its infancy. The grounded theory method (Glaser and Strauss, 1967), which has been extensively used in the past, was chosen due to the unfamiliar environment and characteristics of such initiatives. Stern (1995) says "the strongest case for the use of grounded theory is in investigations of relatively uncharted water, or to gain a fresh perspective in a familiar situation."

This method, which involves an inductive approach, was mainly used in the first phase of this study (field research). The purpose of the first phase is to develop an understanding of the supply chain collaboration initiatives in the telecommunications equipment industry by identifying categories of events along with their relationships and implications (Becker, 1993). Strauss and Corbin (1990: 24) define the grounded theory approach as "a qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon."

With this approach, theory construction begins with reality; concepts are flexible as it may be necessary to reorient some of them (Sarantakos, 1993). To ensure that the analysis is based on the data, the grounded theory method also calls for preliminary data collection and analyses. Hence, the telecommunications equipment supply chain was

observed on several occasions before the research constructs and variables (described in chapter 2) were formulated.

An important feature of grounded theory is that data collection and data analysis activities take place simultaneously, so that initial data analysis shapes continuing data collection. The following sections describe why (characteristics) and how (data collection) the telecommunications equipment industry was examined.

3.2 Selection of one supply chain and industry imperatives

3.2.1 Justification for selecting one supply chain

A supply chain in the telecommunications equipment industry was chosen because of the widespread use of electronic tools and the growing percentage of outsourcing activities in the sector. In fact, a recent survey by a management consulting and systems integration firm that focuses on collaborative commerce and integration identified telecommunications as being one of the sectors with the greatest use of collaborative commerce among supply chain partners and with a high degree of internal integration. The report on this survey, conducted in 2002 with 162 businesses and IT executives of North American companies, stresses that "the biggest barriers to such collaborative commerce have less to do with the technical complexities of linking different companies' systems and more to do with the organizational complexities of getting companies to work together" (NerveWire, 2002).

3.2.2 Industry imperatives

The worldwide competitive dynamic of the telecommunications equipment industry is driven by two major imperatives. First, the key players in the industry must manage technological shift from voice to data transmission. Second, firms must constantly develop new methods to deal with the cyclic demand for capacity in the industry. The two imperatives are explained in this section.

3.2.2.1 Managing the technological shift

Until the mid-1990s, data transmission technologies such as EDI were only used by a handful of organizations. The data traffic was negligible when compared to voice, which was the prevailing form of traffic transmitted over telecommunication networks. A major technological shift was initiated with the popularization of the Internet (Li and Whalley, 2002). In the late 1990s, the widespread adoption of the Internet by organizations, individuals and governments transformed the telecommunications industry; in 1999, traffic generated by data transmission surpassed the traffic produced by voice transmission. This tendency is not expected to slow down, given that new wireless technologies regularly continue to come out on the market (Li and Whalley, 2002).

This technological shift has forced the players in the telecommunications industry to adapt their products and services to the emerging opportunities. Major adjustments of technical competencies are also required to tackle these new opportunities.

3.2.2.2 Managing the cyclic demand for bandwidth capacity

Forecasting demand is a challenge in many industries. It is all the more problematic in high-tech industries, especially in the telecommunications industry where short-life-cycle components are often quite expensive (Reyes et al., 2002). Managing the volatility of demand in this sector is essential if one is to reduce the financial risk of doing business in uncertain markets.

The scalability and flexibility of fiber optics and optical networking are perceived as a solution to the active demand for capacity. The traditional copper infrastructure that provided voice and data transmission is gradually being replaced by optical networks. Fundamental research and ongoing developments in fiber optics continue to improve products by increasing the medium's bandwidth capacity. Hence, the ability to constantly develop more efficient and more powerful telecommunications equipment and the capability to quickly introduce them on the market are among the requirements for success in this industry. However, the costs and complexity of R&D initiatives in the telecommunications industry have driven companies to collaborate with their partners, suppliers and clients to develop innovative products and manufacturing processes. The next section describes the classes of players in this industry.

3.3 The structure of telecommunications industry supply chains

The telecommunications equipment industry includes all companies involved in the manufacturing of equipment and software that execute the functions of information processing and communication, including transmission and display. Figure 3.3 illustrates

the four layers of the telecommunications equipment industry supply chain, beginning at the upper end with the network operators (i.e. the final users of the optical products) and ending with the sub-assemblers (i.e. the manufacturers of parts and components). Each layer includes several key players that manufacture, assemble, integrate or operate some type of telecommunications device (or equipment). We will briefly examine each of these layers.

3.3.1 Network operators

Network operators own and operate different types of communication networks (transport networks, metropolitan area networks and access networks). Several interesting opportunities have become available to network operators with the development of new services such as the Internet and the deregulation of the telecommunications industry in some regions. Network operators may address up to four major market segments: the local exchange market, the inter-exchange market, the Internet service provider market and the network service provider market. The local exchange carrier (LEC) gives businesses and individuals local telecommunications access. The interexchange carrier (IXC) (also known as a long-distance telephone carrier) links local

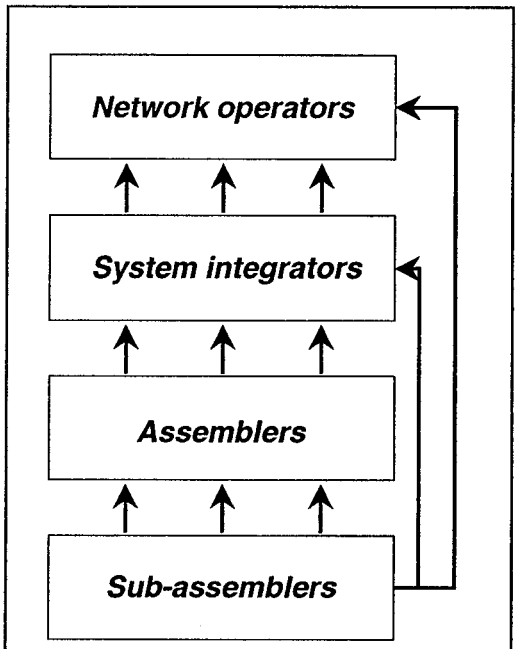


Figure 3.3 – Telecommunication equipment industry supply chain

exchanges in different geographic areas. Internet service providers (ISP) offer Internet access and all Internet-related services. Network service providers (NSP) provide data services by renting their telecommunications infrastructure to companies that need to transmit data from one point to another (e.g. extranet).

3.3.2 System integrators

In the telecommunications equipment industry, system integrators have the role of original equipment manufacturers (OEM). The major OEMs in the industry are mostly large multinational firms such as Alcatel, Ciena, Cisco, Fujitsu, Lucent, NEC, Nortel Networks, and Tellabs. System integrators must constantly invest in R&D to develop new products, tightly manage customer and supplier relationships, and integrate components to offer a solution that meets clients' requirements.

Traditionally, OEMs maintained core activities such as manufacturing and final assembly internally, and only made use of electronics manufacturing specialists (EMSs – see section 3.3.3) for situations that required excess capacity. For system integrators, the value of these core activities resides in knowledge creation. Hence, for competitive differentiation, they rely on product innovation, customer and network management, and brand marketing.

3.3.3 Assemblers

OEMs in the telecommunications industry are gradually outsourcing assembly activities to electronic manufacturing specialists (EMSs, also referred to as contract

manufacturers). The EMSs' ability to manufacture products with greater flexibility and at a much lower cost than most traditional system integrators could achieve is the critical factor behind this outsourcing trend in the telecommunications industry. EMSs maximize the use of their manufacturing equipment and profit from lower labor costs. With a high number of OEM plant acquisitions, EMSs are experiencing rapid growth (the worldwide EMS market is expected to reach US$150 billion in 2003). On the down side, rapid growth sometimes impairs design and manufacturing flexibility because of the integration of different systems, processes, and cultures.

The decision to outsource to EMSs is based on their ability to efficiently respond to highly fluctuating demands. For proprietary reasons, OEMs will often maintain the manufacturing of critical components on their own production lines but will outsource the manufacturing of other components, knowing that the EMSs have lower inventory levels and more flexible assembly lines. EMSs competencies are generally due to their continuing investments in manufacturing technology. Great effort (time and money) is devoted to the design of specific components, which are usually produced for a large number of customers. EMSs may assemble comparable products for competing OEMs; consequently the risk is spread across a portfolio of customers. In these cases, critical product information must be handled cautiously.

The major players in the EMS market are Solectron, Celestica, SCI Systems, Flextronics and Jabil Circuit but large contracts from major OEMs are granted to thousands of smaller EMSs worldwide.

3.3.4 Supplier base (sub-assemblers)

Sub-assemblers are the second-, third- and fourth-tier suppliers to either assemblers or system integrators. The size and status of sub-assemblers vary but their functions and tasks are basically the same. Some sub-assemblers are subsidiaries of large multinationals with global contracts; others are small and medium-sized enterprises (SMEs) that rely on established orders from one or two major customers. The principal activities carried out by sub-assemblers are component manufacturing and subsystem assembly.

Over the last few years, the telecommunications industry has been very competitive and sub-assemblers have been caught up in the middle of it. OEMs and EMSs are progressively reducing their very large supplier base to a few key suppliers, to include only efficient relationships. In this competitive environment, sub-assemblers are pressured to supply quality products with the fastest turnaround and the lowest prices, or else see a competitor steal their market share (Fawcett and Birou 1992; Ballou et al. 1998). However, once suppliers have proven to their customers (OEMs and EMSs) that they can handle rigorous requirements, they become an integral part of the reduced supplier base and engage in long-term relationships with the OEMs and EMSs.

3.4 Data collection strategy

The data collection strategy involved two consecutive phases:

(i) a field study, which was conducted in the context of an international study of e-commerce initiatives sponsored by the OECD in eight countries. In one of the countries, this particular undertaking focused on one large telecommunications

equipment manufacturer (system integrator) and a few strategic first-tier suppliers (assemblers). This phase provided the basis for fully understanding the collaboration methods and the various issues and concerns of the different members of the supply chain.

(ii) an electronic survey soliciting the participation of individual firms acting in the same supply chain for the same large telecommunications equipment manufacturer. Based on the results of the field study, an electronic questionnaire was developed to facilitate the input of information by both the managers involved in the upstream activities of the supply chain (supplier-related functions such as procurement and design) and those executives involved in the downstream activities (customer-related functions, for instance, sales and marketing). We will now describe in detail the data collection strategies for these two phases.

3.4.1 Phase 1 – Field research

In this first phase, an embedded multiple-case study was used to closely analyze the telecommunications equipment supply chain. Case studies are defined as in-depth, multifaceted investigations, using qualitative research methods, of a single phenomenon (Orum et al., 1991), while embedded case studies by definition involve more than one unit of analysis (Yin, 1994).

Several reasons supported the use of the embedded multiple-case study method in this phase. First, this method is dictated by the exploratory nature of supply chain issues. Since it is carried out in the actual context in which the supply chain actions occur, the

case study method has the further advantage of allowing researchers to analyze the concepts in a realistic environment. It also facilitates and promotes, in practice, the development of theoretical innovation and the generation of ideas and concepts (Orum et al., 1991) and leads to an improved understanding of complex issues (Yin, 1994). The second major reason is that different units of analysis appear to be more suitable when analyzing the complex links between the different layers of the selected supply chain (section 3.3) and between the research variables of the conceptual model (section 2.1).

Field research is also appropriate when the research questions focus on understanding "how" and "why". More specifically, some of the research questions in the first phase were related to how the partners in the telecommunications equipment supply chain collaborate (e.g. technologies, processes, etc.) and why they use e-commerce tools. During this first phase, the ability to explore several supply chain circumstances in depth and the capability to analyze different aspects of these situations were critical.

We have carefully followed the guidelines proposed by Stake (1995). As shown in the following table (3.1), these guiding principles are categorized into seven major steps.

Table 3.1 – Guidelines for doing a case study

Steps	Actions
1. Anticipation	Review or discover the expectations at the outset of the study. Consider the issues, questions and hypotheses already raised. Define the boundaries of the case. Form initial plan of action, including the definition of roles.

Steps	Actions
2. First visit	Arrange preliminary access and negotiate plan of action. Discuss arrangements for maintaining confidentiality of data. Discuss need for review of drafts to validate observations. Revise plan of action, roles, case boundaries and issues.
3. Further preparation for observation	Preliminary observations of activities. Select or develop instruments or procedures. Identify informants and sources of particular data. Work out record-keeping systems.
4. Further development of conceptualization	Reconsider issues or other theoretical structure. Sketch plan for final report and dissemination of findings. Allocate attention to different viewpoints, conceptualization.
5. Data gathering and data validation	Make observations and conduct interviews. Select vignettes, illustrations and special testimonies. Classify raw data; begin interpretation. Redefine issues, case boundaries. Gather additional data (replicate or triangulate) for validation.
6. Analysis of data	Review raw data under various interpretations. Search for patterns of data. Seek linkage between programs, activities and outcomes. Draw tentative conclusions and organize according to issues. Review data; gather new data.
7. Opportunity for understanding	Describe the setting within which the activity occurred. Draft reports and reproduce material. Revise and disseminate reports and materials. Talk to people.

Source: Adapted from Stake (1995: 52-53)

3.4.1.1 Data collection methods

The main data collection methods for this field research study consisted of semi-structured face-to-face interviews. The OECD provided the interview guide, to which we added questions. For analytical flexibility and ease, the interviews were recorded on audiotape. The majority of interviews were carried out in the provinces of Quebec and Ontario, with only one interview done by phone with a respondent located in the United States. A strict protocol was established for the transcription of the respondents' answers and observations. The main ideas captured during each interview were quickly transcribed in electronic format, usually within one hour. The answers recorded on audiotape were also transcribed within a few days. The interviews were complemented by on-site observations and documentation (press releases, reports, media articles, Web sites). The use of several data collection methods guarantees validity and reliability through the process of triangulation across the diverse sources of information (Stake, 1995; Denzin, 1989).

3.4.1.2 Selection of firms and respondents

A selected number of executives and supply chain professionals from the different layers of the supply chain were interviewed. The interviewees were chosen based on two simultaneous criteria:

(i) their specialized knowledge of and experience with collaborative e-commerce tools exploited in a supply chain environment;

(ii) their roles in the procurement or sales activities carried out in the supply chain.

The choice of respondents is also justified by the fact that members of every layer of the supply chain were interviewed to gain a clear overview of the operations of the entire chain. The selection of opposing respondents (buyers and sellers) was also necessary to take account of different views and experiences, thus comparing the perspectives of the different members of the supply chain. Hence, several members with different perspectives (buyer versus seller) were approached in each of the four layers (network operators, system integrators, assemblers and sub-assemblers) of the supply chain. Four firms were selected and sixteen key managers were interviewed. The following paragraphs briefly describe their respective roles in the telecommunications equipment supply chain.

A) At the network operator layer:

To fully understand the dynamics of the telecommunications equipment industry and the technological characteristics of telecommunications solutions, two network operators were approached. They provided critical information on the overall context in which the chosen supply chain operates and identified key players at the other three layers. They also facilitated all further contacts with other respondents (in all the layers of the chain).

B) At the system integrator layer:

A single company was chosen in the system integrator layer. This company produces leading-edge technologies and is at the forefront of manufacturing and research activities in the industry. This system integrator is renowned as a global Internet and communications leader in the optical, wireless, local Internet and e-business fields. The

supply chain analyzed in this study (described in section 3.2) is centred on this large OEM.

For downstream activities: the system integrator's customer service department deals with the different network operators to design and customize telecommunications equipment infrastructure. A salesperson and a technical marketing systems engineer were interviewed in order to understand the technical and commercial issues affecting the relationship between the system integrator and the network operators.

For upstream activities: the system integrator's supply management group focuses on the tools required to carry out supply chain activities with assemblers and sub-assemblers. Three managers were interviewed: 1) Supply chain design systems and process manager, 2) Web-tools project manager, and 3) Replenishment project manager.

C) At the assembler layer:

Two companies carrying out assembly activities were selected to participate in the multiple-case study. Both companies regularly made use of collaborative tools in their supply chain activities.

For downstream activities: customer service representatives from both of the assemblers were interviewed. The main issues related to the level of collaboration that can be achieved with system integrators.

For upstream activities: for one of the assemblers, three managers responded to the different questions concerning the supply chain relationships with the sub-assemblers. One of them managed the global supply management group while the other two were employed in the purchasing department. The latter two buyers were responsible for ensuring an adequate flow of inventory with their respective sub-assemblers.

The other assembler had two directors from the supply chain management department answer questions concerning the collaborative actions taken with their principal suppliers.

D) At the sub-assembler layer:

Two companies that were selected to represent this layer are component manufacturers.

For downstream activities: both technical and commercial aspects were covered with the participation of the information technology director from the first sub-assembler involved in the study and the customer service representative from the second sub-assembler. These respondents had close relationships with assemblers in the telecommunications equipment industry.

For upstream activities: the buyers for both component manufacturers covered the supplier side. They mainly conduct business with other third- and fourth-tier sub-assemblers.

Table 3.2 summarizes the origin and positions of the various respondents in this first phase. A total of sixteen respondents from four companies participated in the field research. Note that the two business units SI1 and AS1 are part of the same company (namely the OEM-ICT). The names of the companies and of the respondents have been suppressed to ensure confidentiality.

Table 3.2 – List of participants in the first phase of the study

Supply chain layer	**Company/ business unit** [1]	**Position**
System integrators	SI1 (unit of OEM-ICT)	Salesperson
		Marketing systems engineer
		Supply chain design systems and process manager
		Web-tools project manager
		Replenishment project manager
Assemblers	AS1 (unit of OEM-ICT)	Customer service representative
		Director, Supply chain management
		Director, Supply chain management
	AS2	Customer service representative
		Global eSupply strategic process leader
		Buyer
		Buyer
Sub-assemblers	SA3	Information technology director
		Buyer
	SA4	Customer service representative
		Buyer

1: SI1: system integrator 1, AS1: assembler 1, AS2: assembler 2, SA3: sub-assemblers 3, SA4: sub-assemblers 4.

3.4.2 Phase 2 – Electronic survey

Building on the results obtained from the field research, we developed and conducted an electronic survey. This kind of survey allows us to reach a larger number of respondents and therefore ensure increased external validity. Furthermore, it guarantees confidentiality and thus lowers the tension or pressure that may be present during face-to-face interviews.

3.4.2.1 Data collection methods

The questionnaire was made available on the Internet, where respondents could save and set aside the electronic survey in order to come back to it at any time. In comparing the use of electronic versus print surveys, Boyer et al. (2002) identified several advantages in carrying out a survey electronically, such as fewer missing responses and a more flexible presentation of the questions (different questions are presented depending on responses to earlier questions). Furthermore, the electronic survey approach can be justified by the following factors:

- An electronic survey offers interesting cost advantages (Weible and Wallace, 1998; Bachmann et al., 1996).
- An electronic survey also saves time when the respondents are located all around the world (see section 5.1).
- An electronic survey enables detailed descriptions to be added to questions or to words that may need explicit definitions.
- An electronic survey allows for the creation of an attractive instrument (use of pictures and colors), which is coherent with the idea that a survey should

interest the respondents (Couper, 2000; Crawford et al., 2001; Rogelberg et al., 2001).

- An electronic survey facilitates the logistical aspects of the research (easier to send the questionnaire through the Internet than to mail it).
- An electronic survey reduces the risk of errors due to the clerical task of re-capturing the information for statistical analysis.

Steps undertaken for the electronic survey

The electronic survey involved the four following steps:

(i) *Development of the questionnaire*

The questionnaire was developed using the main results and trends obtained from the multiple-case study. Questions were displayed in one of the five separate parts of the questionnaire, which were entitled 1) Company characteristics, 2) Degree of collaboration and product information, 3) Collaborative planning, 4) Innovativeness and 5) Supply chain performance. A seven-point Likert scale was used for the majority of the questions, which makes it easier for the respondent to answer the questions and for the researcher to analyze them. Furthermore, to avoid any misunderstanding of terms used in the questionnaire, the definitions of the more confusing words were available at the click of the mouse.

(ii) *Validation of the questionnaire*

Several groups analyzed the questionnaire before it was made available to the potential respondents. A few of the OEM's strategic suppliers tested the questionnaire and some adjustments were made based on their remarks and suggestions. Several departments

within the OEM were also involved in validating the questionnaire, including the Supply Management group, the Supplier Collaboration group and the eSourcing group (electronic marketplace). The OEM management team members involved in the validation of the questionnaire included:

- Global eSupply Strategic Process Leader, Global Supply Management
- Group Supplier, Chain Design Systems and Process, Global Supply Management
- Vice President, Supply Management
- Director, Infrastructure, Supply Management
- Manager, Supply Management
- Manager, Supplier Collaboration

(iii) *Programming, testing and sending of the questionnaire*

The electronic questionnaire was programmed using the Java language and was hosted on a server at the École Polytechnique in Montreal. The participating respondents could easily identify the questionnaire since two logos were posted on every page, the OEM-ICT logo and the university logo. A letter from the OEM-ICT was sent by e-mail inviting its suppliers to log on to the questionnaire.

(iv) *Follow-up and comments*

Respondents who had any questions or comments concerning the questionnaire could contact the researcher at any time. An e-mail address and a phone number were posted on the electronic questionnaire. We responded to a total of seven inquiries (four e-mails and three phone calls) sent by respondents during the data collection period.

3.4.2.2 Selection of firms and respondents

A total of 130 companies were asked to answer the electronic questionnaire, all of which belong to the OEM's supplier base. The sample of companies, identified by the system integrator SI1, included its supply chain partners in the telecommunications equipment sector. All companies may be characterized as assemblers or sub-assemblers. According SI1, they all play an important role in the development of collaborative tools in the supply chain. Just over 76% of the companies asked to answer the questionnaire are based in the United States, 12% in Canada and the remaining 12% in the rest of the world. They also represent a wide range of sizes, with large, medium and small enterprises targeted for the electronic survey.

3.4.2.3 Research variables and theoretical justification

The main focus of this research initiative was to analyze the effect of collaborative planning on the performance of the supply chain. Section 2.2 described the theoretical justification of the variables to be used in this study. The section complements the theoretical justification by presenting the structure of each type of research variable (dependent, independent, mediating and control) used in the electronic questionnaire. Table 3.3 summarizes the research variables used in the survey. It is followed by a description of each individual variable.

Table 3.3 – Summary of research variables used in the electronic survey

Dependent variables: Supply chain performance		
Research variables	**Operational measures**	**Theoretical justification**
Resource measures	1. Inventory levels	Beamon (1999), Frohlich and Westbrook (2002)
	2. inventory costs	Spekman et al. (1998), Davis (1993)
	3. operational costs	Spekman et al. (1998), Davis (1993)
	4. personnel required to provide a product or service	Beamon (1999)
	5. equipment costs	Beamon (1999)
Output measures	1. number of items produced	Beamon (1999)
	2. time required to manufacture	Beamon (1999), Arntzen et al. (1995)
	3. number of on-time deliveries	Beamon (1999), Shin et al. (2000), Lummus et al. (1998), Frohlich and Westbrook (2002)
	4. perceived level of customer satisfaction	Beamon (1999), Spekman et al. (1998)
	5. lead times to manufacture	Shin et al. (2000), Davis (1993), Lummus et al. (1998)
	6. number of stock-outs	Beamon (1999), Davis (1993)
	7. number of times orders have been filled (fill rate)	Davis (1993), Lummus et al. (1998)
	8. perceived quality of product	Beamon (1999), Shin et al. (2000)
	9. time required to offer product	Beamon (1999), Shin et al. (2000), Arntzen et al. (1995)
Flexibility measures	1. flexibility to offer volume	Beamon (1999), Voudouris (1996), Lummus et al. (1998)
	2. flexibility to deliver a product	Beamon (1999), Voudouris (1996)
	3. ability to offer a variety of products	Beamon (1999), Voudouris (1996)
	4. ability to introduce new products	Beamon (1999), Lummus et al. (1998)

Table 3.3 – Summary of research variables used in the electronic survey (continued)

Independent variables: Developing a front-end agreement		
Research variables	**Operational measures**	**Theoretical justification**
Collaboration agreement	1. common objectives of collaboration between supply chain partners	VICS-CPFR (1998)
	2. common objectives of confidentiality between supply chain partners	VICS-CPFR (1998)
	3. definition of each party's competencies and resources	VICS-CPFR (1998)
	4. opportunities and impacts on each supply chain partner	VICS-CPFR (1998)
	5. common means of measurement between supply chain partners	VICS-CPFR (1998)
Collaboration process mapping	1. contribution of systems (and functionalities) to the collaborative process	VICS-CPFR (1998)
	2. map collaboration points to partner competencies and establish business functions	VICS-CPFR (1998)
	3. outline information to be shared	VICS-CPFR (1998)
	4. definition of service and ordering commitment parameters	VICS-CPFR (1998)
	5. staffing involvement and time commitment to the collaborative process	VICS-CPFR (1998)
	6. assignment of resources to the process	VICS-CPFR (1998)
Continuous improvement	1. establishment of ground rules for handling disagreements	VICS-CPFR (1998)
	2. evaluation and benchmarking of the success of the supply chain relationship	VICS-CPFR (1998)
	3. written agreement on the collaboration parameters	VICS-CPFR (1998)

VICS-CPFR (1998) : VICS (Voluntary Interindustry Commerce Standards) is the association that produced the CPFR guidelines.

Table 3.3 – Summary of research variables used in the electronic survey (continued)

Independent variables: Creating a joint business plan		
Research variables	**Operational measures**	**Theoretical justification**
Strategic collaborative actions	1. develop an agreed-on partnership strategy	VICS-CPFR (1998)
	2. share information such as periodic business goals and objectives of all partners involved	VICS-CPFR (1998)
	3. compare business plans of partners and agree on a joint business plan	VICS-CPFR (1998)
Tactical collaborative actions	1. discuss roles, objectives, and goals for specific categories of items	VICS-CPFR (1998)
	2. identify and develop the appropriate pricing actions for specific categories of items	VICS-CPFR (1998)
	3. develop individual business plans based on previously shared information	VICS-CPFR (1998)
Collaboration tool efficiency	1. direct procurement	Field research observation
	2. replenishment	Field research observation
	3. shortages	Field research observation
	4. delivery and tracking	Field research observation
	5. design (CAD)	Field research observation
	6. forecasting	Field research observation
	7. capacity planning	Field research observation
	8. business strategy	Field research observation

The theoretical justifications of the independent variables are mainly based on the Voluntary Interindustry Commerce Standards (VICS-CPFR, 1998). When compared to other collaboration methods or frameworks, the CPFR method is very detailed in terms of actions to be taken in planning collaboration, which explains its importance in the theoretical justification of the research variables.

Table 3.3 – Summary of research variables used in the electronic survey (continued)

Intermediary or mediating variables: Innovativeness *		
Research variables	**Operational measures**	**Theoretical justification**
Process innovations		
Process creation	1. generate of new design processes	OECD (2000)
	2. gear processes to customer requirements	OECD (2000)
Logistical processes	1. improve logistical processes	OECD (2000)
	2. increase flexibility of distribution	OECD (2000)
	3. enhance responsiveness of distribution channels	OECD (2000)
Production processes	1. design new production processes	OECD (2000)
	2. increase production flexibility	OECD (2000)
Product innovations		
Product diversification	1. ability to develop new products (or families of products)	OECD (2000), Zirger and Maidique (1990)
Product differentiation	2. ability to create new product features	OECD (2000), Li and Atuahene-Gima, (2001)
Product customization	3. new methods of configuring products to the requirements of customers	OECD (2000)
Relational innovations		
Partnership development	1. ability to target new groups	OECD (2000), Smith et al. (1995)
	2. capacity to retain partners, customers and suppliers	OECD (2000),
Relationship improvement	1. build trust or improve trust between supply chain partners	OECD (2000), Moore, (1998), Zaheer et al. (1998)
	2. enrich quality of relations between partners	OECD (2000)
	3. improve loyalty in supply chain relationship	OECD (2000)

* To facilitate the reading of the text, only the term "mediating" will be used to describe these variables.

Table 3.3 – Summary of research variables used in the electronic survey (continued)

Control variables		
Research variables	**Operational measures**	**Theoretical justification**
Size of firm	1. number of employees	Lefebvre et al. (1997)
Position held by supplier in the supply chain	1. level at which supplier operates	Lefebvre et al. (2003)
Product demand/customization	1. product demand stability	Ramdas and Spekman (2000) (based on Fisher, 1997)
	2. product customization	Ramdas and Spekman (2000) (based on Fisher, 1997)

Dependent variables: supply chain performance

As mentioned in section 2.2.1, Beamon's work (1999) on supply chain performance was mainly used as the foundation for this research initiative. Three constructs were created according to Beamon's framework. The resource measures construct (table 3.3) presents five elements that are required to realize supply chain functions (inventory, money, personnel, equipment and energy). The output measures represent the results of the supply chain functions (nine items, including number of items, time spent, product quality, customer satisfaction and fulfillment rate). The flexibility measures construct contains all factors (four items) that permit the rapid transformation of supply chain functions to respond to technological and market imperatives (volume flexibility, product mix, logistical agility and product development).

Independent variables: collaborative planning

The conceptual model described in section 2.1 identifies two different groups of independent variables: front-end agreement development and joint business plan creation.

Based on the collaborative planning stages of CPFR, constructs have been developed for each of the six variables in the two groups (table 3.3) and will be used to define both upstream collaborative activities (dealing with suppliers) and downstream collaborative activities (dealing with customers).

Front-end agreement stage

The first fourteen items relating to collaborative planning were established using the ten actions of the CPFR front-end agreement stage (described in section 2.2.2.1). These items were grouped into three constructs, as shown in table 3.3. The first construct, collaboration agreement, brings together general collaboration issues (five items) that supply chain partners normally agree upon in the first meetings. Collaboration issues such as common objectives of collaboration, confidentiality, competencies and resources, opportunities and impacts, and the use of common metrics make up this construct.

The second construct, collaboration process mapping, is made up of six items. It involves very precise information on the design of the collaboration process such as the identification of systems and functionalities, the mapping of collaboration points, the information to be shared, the commitment (service, staff, time) to the collaboration process, and the resources required.

Finally, continuous improvement, which represents the third front-end agreement construct, comprises three items: the establishment of ground rules, the evaluation and benchmarking of the relationship, and the exchange of official agreements. These activities enhance and advance supply chain partnerships.

Joint business plan stage

We now focus on the joint business plan, which is the second stage of the collaborative planning portion of CPFR. This stage requires supply chain partners to come to a common understanding on data exchange methods and a joint vision of their collaboration. The six actions of the CPFR joint business plan stage (described in section 2.2.2.2) generated six items that were used in the questionnaire. These items were divided into two constructs, as shown in table 3.3.

The strategic collaborative actions variable groups three items that enable supply chain partners to gain a global understanding of the supply chain strategies to be undertaken by all parties involved in the chain: develop an agreed-upon partnership strategy, facilitate strategic information sharing, and compare business plans for the creation of a joint supply chain plan. This is a first step toward more tactical collaborative actions, which make up the second construct.

The tactical collaborative actions construct, also comprising of three items, is oriented towards products or families of products rather than the whole business (as is the case for strategic collaborative actions). The roles and objectives of specific categories of products, the planning of appropriate pricing and the development of individual plans based on previously shared information shape the tactical collaborative actions construct.

A third construct, which is not directly related to the CPFR methodology, completes the joint business plan section. The collaboration tool efficiency construct is made up of the

collaborative tools (see section 4.1.2 for a definition of each), which are used in supply chain relationships.

Mediating variables – innovativeness

Process innovations

Process innovations are split into three different variables: process creation, logistical processes and production processes (table 3.3). The process creation variable combines two items, generation of new processes and adjustment of processes to customer requirements. Logistics is the main focus of the second process innovation variable, with the following three items: logistical process improvement, distribution flexibility and responsiveness of the distribution chain. Finally, the third process innovation construct considered two items related to production: the design of new production processes and the flexibility of production.

Product innovations

Product innovations are represented by three variables: product diversification, product differentiation and product customization. These variables are strictly related to the innovative nature of the product (or service) and not to the processes that assist in developing of product innovation (which are categorized in the process innovation construct).

Relational innovations

Two variables shape the relational innovation aspect of this study. First, the development of partnerships is addressed with the following two items: target new groups (either suppliers or clients) and retain current partners, suppliers and customers. Three items – trust, quality of relations and loyalty –make up the second variable, relationship improvement.

Control variables – Size, product demand/customization and position in the supply chain

Size is simply captured by the total number of employees. Based on the observations from the field study, two items (product customization and product stability) are significant and relevant to all types of products. Stationary components (for mass production) with relatively stable demand are usually pre-designed to fit into numerous products (families of products) and have reached a certain maturity. In the telecommunications equipment industry, metal racks and switches are examples of such products. At the other end, newer high-tech components/products such as opto-electronic components are customized items with very unpredictable demand. Based on the analysis of the data gathered from the field research, the supplier's level in the chain seems to play a major role when dealing with collaborative processes. Thus, the suppliers' position in the chain is assessed in the electronic survey through a simple question (*At what level or tier supplier do you normally function*?).

CHAPTER 4 - ANALYSIS OF THE RESULTS OF THE FIELD STUDY

This chapter describes the results of the first phase of empirical investigation, the field study. The results of the statistical analyses of the data obtained from the electronic questionnaire are presented in chapter 5.

4.1 Results of the field study

We worked with one major player from the telecommunication equipment industry and its main suppliers, for a total of five organizational entities (see table 3.2). The level of internal integration and of electronic collaboration within the supply chain was high. The five units selected are key players in the supply chain and are positioned at the fourth technological wave of the wave model illustrated in section 1.4.2. Consequently, their technological posture, as characterized by their e-commerce initiatives, represented a great opportunity for this research.

The central player (called OEM-ICT for reasons of confidentiality) was founded over one hundred years ago and has a major role in the competitive dynamic of the telecommunications sector. In the late 1990s, it acquired a large data networks company. This major acquisition enabled OEM-ICT to strategically position itself as an integrated network solutions provider. With offices and manufacturing facilities in North America, Europe, Asia, Latin America, the Middle East and Africa, OEM-ICT has customers (service providers, carriers) in more than 100 countries around the world. In the late

1990s, it made a strategic decision to favor knowledge-intensive activities such as R&D, product design and system integration to increase its competitive advantage. Low-value-added activities such as manufacturing and assembly were outsourced.

OEM-ICT implemented this strategy by selling a significant number of its assembly plants to manufacturing specialists (e.g. SCI, Solectron, Flextronic, Celestica, etc.). However, its most strategic manufacturing processes continued to be executed in-house. The outsourcing of assembly-related activities provided OEM-ICT them with increased manufacturing flexibility and lower production costs. Furthermore, in order to respond efficiently to the critical time-to-market imperative, OEM-ICT implemented collaborative supply chain initiatives to support outsourcing activities in a demand-driven strategy.

This study is centered on OEM-ICT's optical unit, which produces the most valuable product lines: optical connectivity equipment. This unit controlled a large part of the US $1.5-billion annual worldwide market in 2000. OEM-ICT's optical unit's supplier base is composed of 350 to 400 sub-assemblers and component manufacturers and a limited number of large assemblers. Some 85% of these suppliers are very large enterprises (500+ employees) while small firms (10 to 250 employees) make up the remaining 15%.

The first phase of this study required the participation of OEM-ICT's optical unit and a selected group of suppliers that collaborate intensively with the system integrator. As mentioned previously, a total of four companies (including two business units of OEM-

ICT) were approached in order to collect data on the telecommunications equipment industry. The profiles of these four companies are described in table 4.1. In order to maintain confidentiality, sensitive information, which may point to certain specific companies, was removed.

Table 4.1 – Background information on the four members of the supply chain

	OEM-ICT (SI1 and AS1)	Assembler AS2	Sub-assembler SA3	Sub-assembler SA4
Main line of business	Optical transmission solutions and products	Printed circuit assembly (PCA)	Metal sheet transformation	Electromechanical components
Product demand/customization	- Highly customized and integrated into customer's needs - Very short life cycle - Complex and costly	- Product must be close to the customer. - Inventory in co-location	- Customized to customers' needs - Short life cycles	- Wide product range - Custom-built
Number of employees in 2000	5,500 in the optical division (87,000 total)	29,000	360	700
Revenues in 2000	$8.4 billion (optical division) $17.5 billion	$9.8 B	$65 M	$500 M
Number of suppliers	350–400 (85% are large enterprises and 15% SMEs)	800 to 900	250 (95% are SMEs)	1,100 (50% are very large enterprises)
Number of customers	150 to 200 (all of which are very large enterprises)	75 to 100 (all of which are very large enterprises)	100 (85% are SMEs)	50 to 75 (50% are very large enterprises)

The companies participating in the field study are quite different. From simple metal sheets to complex optical transmission solutions, the four companies offer different types of products (first line of table 4.1) with specific characteristics (second line of table 4.1). Company size also varies drastically, with 360 to 29000 employees and with revenues

ranging from $65 million to $9.8 billion in 2000. However, the numbers of suppliers and customers do not seem to be linked to size. The supplier base of sub-assembler SA4, which has $500 million in revenues, consists of 1,100 companies, while OEM-ICT has just 350 to 400 suppliers despite its $8.4 billion in revenues. The same observation can be made of the customer base; the $9.8-billion company provides PCAs to 75 to 100 customers, while the much smaller $65-million sub-assembler SA3 supplies metal sheets to over 100.

4.1.1 Technological and market trends in the supply chain

This section identifies and clarifies some of the general technological and market trends affecting each layer of the telecommunications equipment industry in 2001 and 2002. In the following statement, Reyes and his colleagues point out four clear objectives of the players operating in this industry: supply chain integration, supply chain visibility, reduction of inventories and return on investments.

> *The general push in the (telecommunication) industry is to increase integration throughout the entire supply chain with consistent and timely information, and visibility to all participating stakeholders (i.e., suppliers, distributors, customers), with the goal of reducing inventories and ultimately a better investment on working capital.* (Reyes et al., 2002)

To pursue these four objectives, different actions are taken by each layer of the supply chain. Table 4.2 summarizes the main trends observed in the field study for the system integrator, assembler and sub-assembler layers. These trends are identified based on both

interviews with key players in the industry and an extensive review of the literature. Each of these trends is explained in more detail in this section.

Table 4.2 –Trends in the telecommunications equipment industry

Main trends for system integrators	**Main trends for assemblers**	**Main trends for sub-assemblers**
1) Creation of knowledge	1) Plant acquisition and long-term relationships	1) New business opportunities and worldwide market visibility
2) Design of flexible supply chains	2) Diversification of offering	2) Adoption of new technologies
3) Establishing demand-driven manufacturing strategy	3) Wide geographic distribution	

4.1.1.1 Main trends for system integrators

In reaction to the industry imperatives described in section 3.2.2, system integrators are responding by investing in the creation of knowledge in optical networks, the development of flexible supply chains and the management of demand-driven manufacturing strategies. The need to reduce costs and increase market share motivates system integrators to provide innovative services to consumers. With product life cycles that have been reduced from years to months, strong pressure is put on all the members of the supply chain to coordinate design, production, procurement, and logistics activities. Furthermore, in order to efficiently respond to the growth in demand for bandwidth capacity, telecommunication OEMs have traditionally invested in R&D (10% to 15% of annual revenues). With the rapid development of fiber-optic technologies, OEMs need

not only count on their own R&D capacity to be successful. The industry changed drastically with numerous acquisitions of start-up companies and with an increase in outsourcing. In order to counter strong fluctuations in demand, the restructured OEMs were forced to develop flexible production processes within their supply chains. The flexibility to change and manage orders became key aspects in the development of an efficient supply chain.

The outsourcing of manufacturing activities to a network of EMSs has intensified with the continuous quest for fast design capabilities and increased production capacity. (Reyes et al., 2002). To rapidly manufacture telecommunication equipment, both OEMs and EMSs require shop floor agility and reliable information exchanges. In this environment of increased outsourcing, system integrators have opted for a demand-driven strategy where a virtual integration of supply chain processes is inevitable. The competition arises from consortia of companies linking their business processes together, not from established rivals. To come up on top, system integrators are trying to increase visibility throughout the supply chain and form an integrated information supply chain with key partners and critical suppliers. The use of collaborative and supply chain management tools is critical to coordinate demand capacity.

4.1.1.2 Main trends for assemblers

The offloading of some of the more generic manufacturing operations to geographically distributed EMSs is driven by the OEMs' need to reduce the cost of manufacturing. However, maintaining an efficient global supply chain becomes quite complex as levels

of material flows and information exchanges increase. EMSs are lured into buying worldwide OEM plants with promises of long-term contracts. These manufacturing facilities, which are spread around the world, provide faster service to nearby customers as EMSs can easily transfer and manage production in neighboring plants if necessary. Contract manufacturing and strong collaboration with system integrators have allowed sub-assemblers to offer complementary and high-value-added services. They have developed the ability to provide design, engineering, sourcing, and fulfillment services to their customers. In the telecommunications equipment industry, system integrators require more engineering-type services and are asking EMSs to perfprm very specific functions such as testing and distribution.

4.1.1.3 Main trends for sub-assemblers

Web-based collaboration tools, often developed or promoted by OEMs, are now being identified and configured to reduce cycle and fulfillment times. The adoption of these collaborative technologies will result in different relationships between sub-assemblers and their OEMs and assemblers. First, with easy-to-use transactional tools and worldwide market visibility, electronic marketplaces are providing new business opportunities for sub-assemblers. Furthermore, demand-driven strategies promoted by system integrators and assemblers are gradually influencing the sub-assemblers' shop floors. In 2000, the companies in this study were gearing up for enhanced manufacturing capabilities and better assembly flexibility.

4.1.2 Collaboration tools

The telecommunications industry supply chain uses a number of collaboration tools. The interviews with the sixteen respondents allowed us to identify eight electronic tools that are used to exchange critical information among supply chain partners. These electronic collaboration tools are briefly described in table 4.3.

Table 4.3 – Description of the electronic collaboration tools

• The **direct procurement tool**, in most cases Web-based, forwards purchase orders (POs) to pre-qualified suppliers. Direct procurement replaces fax systems, is usually an alternative to electronic data interchange (EDI) and is often linked to an ERP system. An acknowledgment of receipt and a confirmation of quantity, date and price are usually posted on the direct procurement tool by the supplier.
• The **replenishment tool** drives an ordering system from the shop floor. When material is needed on a production line, an order is placed through the replenishment system. The supplier usually has a specific amount of time to deliver the ordered material either to the production line (generally for high-value items) or to a stockroom (generally for low-value and high-volume items).
• The **projected shortages tool** scans the buyer's production plan to project expected component or material shortages. Suppliers access the tool frequently (weekly) and provide the delivery schedules of items with potential shortages. The tool also provides real-time information to manufacturing and supply management units and reduces the response time between them.
• The **delivery and tracking tool** generates a payment and a delivery request automatically when a product goes from a supplier to its customer. It is also designed to collect shipping information from the third-party logistics providers. It reduces the number of communications between partners and is tightly linked to the direct procurement tool to automatically close POs.

• The **design tool** enables the use of interactive engineering drawing and storage of computer-assisted design (CAD) designs by all the key stakeholders of the supply chain involved in product design. The collaborative design tool may be used to ensure that the final design meets all of the stakeholders' requirements. Meanwhile, it should help reduce the time to market while maximizing the quality and minimizing the costs of the product.
• The **forecasting tool** frequently exchanges the forecast information provided by both the buyer and supplier. The forecast, which is a prediction of sales and use of products in order to purchase the appropriate quantities in advance, is usually obtained from ERP software or from an advanced planning and scheduling (APS) tool.
• The **capacity planning tool** determines the amount of capacity required to produce. It establishes, measures and adjusts the levels of capacity in terms of the labor, machine resources and material necessary to accomplish the operational tasks. For instance, a supplier, with the increased visibility of capacity planning information, monitors its inventory levels according to its customer's inventory targets. The assembler/ manufacturer takes account of the supplier's inventory level to calculate its capacity.
• The **business strategy tool** collects and shares the actions that need to be taken to support the objectives and mission of the supply chain (or networked enterprise). Typically, general supply chain objectives are drawn from each organization's goals for participating in a collaborative relationship. The specific actions to achieve these common goals are then determined by the group.

The technological level and rate of adoption of these tools are, of course, not the same. All layers of the supply chain frequently use some of the more mature and simple tools, while only the largest members of the value chain exploit the more specialized tools.

Table 4.4 summarizes the level of use of these tools by the four case study companies, where "1" designates rare use of the tool, "2" denotes frequent use and "3" signifies continuous use of the tool. A zero (0) value indicates that the tool has never been used. The table also reveals whether each company uses the tools when collaborating with suppliers or when collaborating with customers.

Table 4.4 – Companies' level of use of collaboration tools with suppliers and customers

	OEM-ICT (SI1 and AS1)		**Assembler AS2**		**Sub-assembler SA3**		**Sub-assembler SA4**	
Collaboration tools	*with supp.*	*with cust.*	*with supp.*	*with cust.*	*with supp.*	*with cust.*	*with supp.*	*with cust.*
Direct procurement	2	1	2	3	0	2	0	2
Replenishment	2	0	3	2	2	3	0	2
Shortages	2	0	0	0	0	1	0	1
Delivery and tracking	1	1	0	1	0	0	0	2
Design (CAD)	1	0	2	2	0	2	0	0
Forecasting	1	0	2	2	1	2	0	2
Capacity planning	2	0	0	1	0	1	0	1
Business strategy	1	1	0	1	0	1	0	0

0: never, 1: rarely, 2: frequently, 3: always

OEM-ICT (SI1 and AS1):

When collaborating with customers:

Business processes between the system integrator and the network operator have remained the same for quite some time. System engineers are still using the same methods to exchange technical information on customized products/solutions. The industry is awaiting the development of a complete Web-based configuration solution. Some pilot projects are now being tested which would enable network operators to order

products directly without costly human intervention. However, the complexity of order-taking in the telecommunications equipment industry makes the adoption of this direct procurement tool very challenging. Configuring and customizing telecommunications products is difficult through a Web-based platform. For maintenance and repairs, the delivery and tracking tool is used when an assembler produces a component that is directly shipped to the network operator. The business strategy tool is very rarely used, although the sales department may use it to share critical information on the most important customers.

When collaborating with suppliers:

Since it was unable to quickly find tools that would satisfy its needs, OEM-ICT developed its own. As indicated in the table, OEM-ICT's major suppliers use a good number of the tools. OEM-ICT estimates that 90% to 95% of its suppliers use at least one of the electronic tools. The smaller suppliers with lower sale volumes use few (or none) of these tools due to infrequent exchanges and technical constraints. Companies providing high-value items use the replenishment system to speed up the ordering of material. The objective is to retain a low inventory level at the point of use.

Assembler AS2:

When collaborating with customers:

Short-term collaborative tools are the most frequently used by assembler AS2 when it deals with customers. The direct procurement tool is the main channel for purchasing activities but the replenishment, forecasting and design tools are also frequently

employed. Like most companies, AS2 only uses the more strategic tools containing critical information, such as capacity planning and business strategy, for very key products/components with a handful of important partners.

When collaborating with suppliers:

Fewer collaborative tools are exploited on the supplier side. One main reason is that, in contract manufacturing, the choice of suppliers is often imposed by customers. This fact affects the strength and time span of business relationships, since the suppliers are often larger than assembler AS2 and therefore push the use of their own technologies. When dealing with smaller suppliers, collaborative tools are mostly used for preparing the business transaction (only information exchange).

Sub-assembler SA3:

When collaborating with customers:

Like most large OEMs, OEM-ICT introduced a set of Web-based supply chain tools to be used with its suppliers. Sub-assembler SA3 was strongly urged to be among the first to adopt the Web tools when doing business with OEM-ICT. Sub-assembler SA3 estimates that 25% to 30% of its transactions with customers are realized electronically. Just like assembler AS2, sub-assembler SA3 mainly uses short-term collaborative tools. For now, the lack of integration of its internal system with the collaborative Web tools is slowing down the adoption of electronic transactions. It plans to carry out a greater number of electronic collaborative initiatives once it has implemented a superior ERP system.

When collaborating with suppliers:

Apart from a simple forecasting tool that is rarely utilized with the main suppliers, the replenishment tool is the only tool commonly used by SA3. A very limited number of suppliers are able to deal with replenishment systems that involve automatic reordering through EDI when a certain inventory level is reached. Reordering is done by fax for the remaining suppliers.

Sub-assembler SA4:

When collaborating with customers:

Sub-assembler SA4 uses a custom-made ERP system to which EDI transactions are linked. SA4 exploits some of the collaborative tools but the technology is a barrier to the level of data integration. When required by OEM-ICT, critical information (mainly for replenishment and forecasting purposes) is uploaded through spreadsheets to the Web tools. Sub-assembler SA4 uses the delivery and tracking tool to send products to its customers' customers but does not employ a collaborative design tool to carry out engineering and design activities with its partners.

When collaborating with suppliers:

Although sub-assembler SA4 is larger than SA3 ($500 million versus $65 million), it does not make use of electronic collaboration tools with its suppliers. Some preparation is done with the ERP system but transactions are eventually completed manually by fax and telephone. Up to now, this seems to be the only way to manage the 1,100 companies in its large supplier base (50% of which are large enterprises). With a wide range of custom-

built products, sub-assembler SA4 focuses on the quality of its products and not on product fulfillment time, unlike many sub-assemblers in the industry.

4.1.3 Impacts of collaboration tools

This section assesses the impacts of the different electronic collaboration initiatives identified in the telecommunications equipment industry. Our premise is that electronic tools may stimulate product innovation, lead to process innovation and facilitate relational innovation. A "transaction structure" was adopted (see the electronic commerce business impacts project (EBIP) methodology from the OECD), which analyzes how, when and why stakeholders exchange products and services while dealing with the evolution of new technologies to support their actions (OECD, 2000). The EBIP methodology focuses on the relationships between the different partners in the chain and analyzes the advances and changes within business practices and business structures.

Three types of transactions support fulfillment in the value chain: transaction preparation, transaction completion and production support (OECD, 2000). Transaction preparation involves the input and retrieval of product/service information. It is mainly used in marketing and sales activities but it includes all information exchanges related to transactions. All activities related to the settlement of the transaction make up transaction completion. Activities such as ordering, billing and transfer of payments are assigned to transaction completion but it also refers to the exchange of products and services within the supply chain. With the emergence of electronic tools, the OECD methodology generated the production support category to keep track of all the data mobilized for

transactions related to design, production and distribution processes. Production support refers to information capture and information management capabilities. It also refers to market analysis and market development competencies.

An evaluation grid summarizes the effects of the electronic collaboration tools on transaction preparation, transaction completion and production support for each type of innovation (process, product or relational) and for the three participating layers of the supply chain (system integrator, assembler and sub-assembler). For each category of innovation and for every layer of the chain, the impact of all eight collaboration tools is assessed one-by-one. The sum of these impacts is then labeled as either little, moderate, strong or very strong impact, and briefly explained.

4.1.3.1 Process innovations

Table 4.5 summarizes the level of impact of electronic collaboration tools on each company's processes. These processes are divided into four types:

- Design, where design processes are geared to customer feedback;
- Logistics, which comprises activities requiring flexibility and quick reactions by supply and distribution channels;
- Production, which includes all actions related to the production or assembly of products;
- Coordination and integration, where links are created between management and operations functionalities

Impact on OEM-ICT

Transaction preparation

The system integrator will use processes related to design with the help of a technical file transfer tool. This technical file transfer speeds up negotiations with suppliers during the preliminary stages of the transaction. Suppliers can quickly gain access to the electronic file and respond to OEM-ICT's demand, thus reducing the request for proposal (RFP) cycle time.

Several tools have improved the transaction preparation process, especially for logistics (forecasting and shortage tools), production (capacity planning and shortage tools) and coordination activities (capacity planning, forecasting and shortage tools). These tools are essential to carry out a demand-driven strategy, which, by sharing forecasts and capacity constraints with first-tier suppliers, reduces required inventory levels and avoids inventory increases.

Furthermore, supply chain tools have changed how OEM-ICT deals with its suppliers. Not only do first-tier suppliers exchange information on the main constraints in meeting demand for a particular market, but second- and third-tier suppliers do as well.

The replenishment tool assists in promoting coordination activities by accelerating the suppliers' response time in the replenishment negotiation process. It also assigns ordering responsibility directly to the production team leaders.

Table 4.5 – Impacts of electronic collaboration tools on process innovations

		Type of transaction support		
	Process innovations for	**Transaction Preparation**	**Transaction Completion**	**Production Support**
System Integrator OEM-ICT	**Design**	**Moderate impact** Quick response to demand Reduced RFQ/RFP cycle time	No impact	No impact
	Logistics	**Strong impact** Better understanding of terms and availabilities	**Strong impact** Facilitates direct product delivery from suppliers to network operators	No impact
	Production	**Strong impact** More responsibility for team leader	**Moderate impact** Pull system with frequent exchanges of information on final customer demand	No impact
	Coordination and integration	**Very strong impact** Enables demand-driven supply chain strategy	**Very strong impact** Ensures the reliability of communications Automates the closure of POs	**Moderate impact** Provides common method to capture and manage information
Assembler AS2	**Design**	**Moderate impact** Speeds up negotiations with suppliers	No impact	No impact
	Logistics	**Moderate impact** Optimized transport/ distribution plan	No impact	No impact
	Production	**Moderate impact** Repeat supplier program to share lead time and demand data	No impact	No impact
	Coordination and integration	**Very strong impact** Earlier involvement of all supply chain business partners (benchmarking)	**Strong impact** Integration of different systems into the ERP	No impact
Sub Assembler SA3	**Design**	**Moderate impact** Increases workability of electronic blueprints	No impact	No impact
	Logistics	**Strong impact** Faster channel for order processing	No impact	No impact
	Production	**Strong impact** Manual execution of production planning	**Very strong impact** Forced to respond to demand with a flexible shop floor	No impact
	Coordination and integration	No impact	**Moderate impact** Ensures data integrity	No impact

Sub-assembler SA4	**Design**	No impact	No impact	No impact
	Logistics	**Strong impact** Involves better overall planning of required resources	**Very strong impact** Ensures prompt payment and reduces the number of communications	No impact
	Production	**Strong impact** Fits with make-to-stock manufacturing strategy	**Strong impact** Proficient use of manufacturing system	No impact
	Coordination and integration	**Little impact** Centralizes management of the relationship with assembler around a single individual	**Moderate impact** Ensures data integrity	**Little impact** Stronger relationship management with individual assigned to supply chain partner

Transaction completion

The use of the direct procurement tool enables Web orders to be integrated into an ERP system, which ensures the integrity and reliability of the transactions between the system integrator and its supplier base. For production activities, the replenishment tool enables a real pull system with frequent exchanges of final customer demand information.

To complete the collaboration processes, the delivery and tracking facilitates direct product delivery from suppliers to network operators. It automates the closure of purchase orders in the system integrators' systems, and eventually triggers the payment and helps product tracking for logistical purposes.

Production support

The business strategy and capacity planning tools provide common supply chain means of capturing and managing information.

Impact on Assembler AS2

Transaction preparation

Assembler AS12 also relies on a design tool to speed up negotiations with suppliers at the transaction preparation stage. It uses this collaborative technology in the design process when dealing with its customers as well.

Tools to share demand planning have been an integral part of customer relationships at Assembler AS2 for some time now. For example, such tools enable the sharing of forecasts with assemblers and ultimately with component suppliers. The use of forecasting and capacity planning tools improves logistics-related process such as transport/distribution optimization and production-related activities such as production planning. However, in preparing transactions, these tools are most useful for the integration and coordination of all supply chain activities by involving both customers and suppliers.

The direct procurement tool (catalog) greatly improves the selection of suppliers and the coordination of processes. It also enables the assembler's customers to benchmark their supplier base against a larger database of potential business partners.

Transaction completion

When using the direct procurement tool with suppliers, Assembler AS2 completes transactions more quickly while improving the coordination of the supply chain. This tool also allows for a shorter order cycle time when it is used with customers.

Assembler AS2 exploits several systems that are integrated into its ERP system, thereby ensuring the speed and integrity of several supply chain processes.

Impact on sub-assembler SA3

Transaction preparation

The sub-assembler SA3 uses a technical file transfer mechanism (attached to a design tool), which accelerates design by increasing the workability of electronic blueprints. SA3 offers value-added activities through the adoption of easy data exchange formats and the reduction of RFP cycle time. When it uses the forecasting and shortage tools, logistical and production are the primary activities impacted during the transaction preparation process. This involves better overall planning, forecast sharing and weekly updates in a demand-driven environment. It creates a faster channel for order processing but has also found SA3 to do production planning manually.

Transaction completion

Sub-assembler SA3's manufacturing system is quite rigid and the collaborative actions taken by its customers have forced it to improve the flexibility of its shop floor, thus compensating for inadequate systems. Web POs foster process innovations in the ordering transaction. This tool provides a faster channel for procurement while ensuring data integrity.

Impact on sub-assembler SA4

Transaction preparation

Sub-assembler SA4 does not use a design tool when collaborating with supply chain partners, but as with sub-assembler SA3, collaboration tools have had major on the more operational activities (logistics and production). The whole collaborative initiative was well received by the assembler's production team due to its fit with the current make-to-stock manufacturing strategy. The different collaboration tools also help SA4 centralize relationship management with its assemblers around a few responsible individuals.

Transaction completion

The Web replenishment tool changed the way transactions are completed for sub-assembler SA4. The demand-driven initiative drove SA4 to implement a make-to-stock manufacturing strategy where standard products are made with a proficient manufacturing system. This information system facilitates replenishment data integration and benefits supply chain relationships with assemblers. While automating the settlement of purchase orders with assemblers, the delivery and tracking tool informs all parties involved that the delivery is under way. It influences the promptness of payment and reduces the number of communications for package tracking.

Production support

The use of collaborative tools has improved relationships with customers as individual staff members were assigned to specific supply chain partners, which was something new for this sub-assembler.

4.1.3.2 Product innovations

At the time the interviews for the field study were conducted, innovations relating to the use of electronic collaboration tools were mostly directed towards process and relational innovations. The companies involved in the study described very few impacts on their products. The following table illustrates the few product-related impacts found in our study. They are categorized into four groups:

- Differentiation, defined as the development of product features;
- Diversification, which is the development of new lines of products or services;
- Customization, where the innovative configuration of products is tailored to customers' needs;
- Bundling, which is the integration of products and support functions (e.g. solutions instead of products).

Table 4.6 – Impacts of electronic collaboration tools on product innovations

		Type of transaction support fulfillment		
	Product innovations for	**Transaction Preparation**	**Transaction Completion**	**Production Support**
System Integrator OEM-ICT	**Diversification**	No impact	No impact	No impact
		No impact	No impact	No impact
	Customization	No impact	No impact	No impact
	Bundling	No impact	No impact	No impact
Assembler AS2	**Diversification**	No impact	No impact	No impact
	Differentiation	No impact	No impact	No impact
	Customization	**Little impact** Minor product changes	**Little impact** Minor product changes	No impact
	Bundling	No impact	No impact	No impact
Sub-Assembler SA3	**Diversification**	No impact	No impact	No impact
	Differentiation	No impact	**Little impact** Minor product changes	No impact
	Customization	No impact	No impact	No impact
	Bundling	No impact	No impact	No impact
Sub-Assembler SA4	**Diversification**	No impact	No impact	No impact
	Differentiation	No impact	No impact	No impact
	Customization	No impact	No impact	No impact
	Bundling	No impact	No impact	No impact

Collaboration using design tools had a limited impact on product innovations for the assembler and one of the sub-assemblers. It enabled the assembler to propose slight changes (e.g. new material) to the product during the negotiation stage (the preparation of proposals and quotes). It also involved changes in the design files once the contract was signed, namely when exchanges occurred between the engineering departments. One sub-assembler used a design tool, but the only impact perceived was with its customers during the last steps of the collaborative design phase.

4.1.3.3 Relational innovations

The impact of collaboration tools on supply chain relationships in the telecommunications equipment industry is illustrated in table 4.7. Collaboration initiatives play an important role in the development of supply chain relationships, which include the following categories:

- Geographical expansion, that is, the geographical amplification of supply chain partners;
- Market segmentation, defined as the ability to target new customers and suppliers;
- Trust, characterized by the quality of relations with business partners;
- Loyalty, which is the capacity to retain partners.

Table 4.7 – Impacts of electronic collaboration tools on relational innovations

		Type of transaction support		
	Relational innovations	**Transaction Preparation**	**Transaction Completion**	**Production Support**
System Integrator OEM-ICT	**Geographical expansion**	No impact	No impact	**Moderate impact** Access to a larger supply base with electronic collaboration tools
	Market segmentation	No impact	No impact	No impact
	Trust	**Moderate impact** Design collaboration is carried out with trusted suppliers	No impact	**Strong impact** Better visibility enhances trust between business partners
	Loyalty	No impact	No impact	**Moderate impact** The extranet supports a lock-in strategy
Assembler AS2	**Geographical expansion**	No impact	No impact	**Little impact** Creates new relationships
	Market segmentation	No impact	No impact	**Little impact** Creates new relationships
	Trust	**Moderate impact** Use of collaborative design tool improves trust in the negotiation steps	No impact	**Moderate impact** Better relationships with customers
	Loyalty	No impact	No impact	**Moderate impact** Enhances customer loyalty
Sub-assembler SA3	**Geographical expansion**	No impact	No impact	No impact
	Market segmentation	No impact	No impact	**Moderate impact** Expands market to other industries and diversifies supply base.
	Trust	No impact	No impact	**Moderate impact** Common tool and better accuracy has increased trust in the assembler
	Loyalty	No impact	No impact	No impact
Sub-assembler SA4	**Geographical expansion**	No impact	No impact	No impact
	Market segmentation	No impact	No impact	**Moderate impact** Expands market to other industries and diversifies supply base.
	Trust	No impact	No impact	**Moderate impact** Common tool and better accuracy has increased trust in the assembler
	Loyalty	No impact	No impact	

Impact on OEM-ICT

Relationships have changed with the implementation of new collaboration tools. The design tool, which the system integrator uses to exchange critical information such as product designs, is used only by trusted suppliers. However, the overall use of the different collaborative tools, mainly the forecasting and shortage tools, improves visibility in the supply chain, which, from the perspective of the system integrator, enhances trust between business partners. The collaborative tools have also increased the supply possibilities: the system integrator can look not only to local suppliers for close partnerships but also to international suppliers, which now exchange real-time information. Finally, the competencies and the technology required to carry out collaborative activities may also create a lock-in situation as suppliers invest large amounts of money in the efficiency of the relationship.

Impact on Assembler AS2

The assembler considers that the collaborative tools positively affect not only the capture and management of information but also trust, loyalty and integration between supply chain partners. As explained earlier, it is costly for assemblers and sub-assemblers to adopt the tools and the effort required to improve supply chain collaboration increases the level of trust and the loyalty to customers. However, procurement activities, which are often executed by means of a catalog, may actually break off existing relationships as OEMs benchmark their suppliers.

Impact on sub-assemblers SA3 and SA4

Regarding relational innovations, both sub-assemblers have acted to link up with the direct procurement tools of different assemblers and sub-assemblers. Their presence in these electronic catalogs has enabled them to expand their market to other industries; they in the future will use these tools to diversify their supply base.

4.1.4 Obstacles and advantages

The field study also identified obstacles and advantages to the use of electronic collaboration tools within the telecommunication equipment industry. The main obstacles identified by each layer of the supply chain are described in the left-hand column of table 4.8. The central column lists the main advantages of carrying out electronic collaborative actions in the supply chain. The right-hand column depicts the main benefits, which are the tangible results of the main advantages described in the previous column.

Table 4.8 – Obstacles, advantages and benefits of the use of electronic collaboration tools

	Main obstacles	Main advantages	Main benefits
OEM-ICT	Product customization Importance of human factors for contract negotiation High level of interaction with customers Infrastructure needed for small companies Human resistance to change Process alterations Training issues Difficult for small suppliers to adopt or integrate tools	Reduced time to market Dealing with high-technology-profile companies Developing and maintaining core competencies within the company Improved visibility throughout the supply chain Improved negotiations with suppliers (access to archived information)	Reduction in errors Transactions processed faster Fewer information losses Simplified information access Inventory reductions Fewer problems on the shop floor (line stoppers) Usng flow management instead of lot management on the shop floor
Assembler AS2	Security and intellectual propriety issues Finding technological partners with real business experience Training and skill-set availability Technological reliability and dependencies (idle times are costly)	Reduction in time to market for new product introductions Earlier involvement of all business partners	Packaging consolidation Faster and more effective communication Contract negotiations with less human interaction.
Sub-assembler SA3	No or limited influence on the adoption of electronic tools by large customers and suppliers Flexibility needed to adapt to the required technological changes	Better accessibility of information Benefits derived from the demand-pull process	Reduction in the time spent on the phone Smaller workforce to manage the relationships with customers
Sub-assembler SA4	Lack of financial resources Cost of systems is a major obstacle Internal restructuring in order to deal with innovative tools	Better accessibility and visibility of information	Increased volume of information flowing from customers Fewer interactions with customers since information is available on-line

4.1.5 Key results of the field study and their implications for the electronic survey

The goal of this section is to consider the results as a whole and extract overall findings that may lead to future research initiatives. Certain findings profoundly affected the formulation of the electronic questionnaire, the second phase of our study:

(i) ***Focus on collaboration planning activities***

The main impacts tend to be encountered in the transaction preparation phase and the production support phase. These two activities strongly depend on how supply chain partners plan to collaborate and what actions are needed to ensure the quality and efficiency of the collaboration process. The assembler and the sub-assemblers had different experiences with the supply chain planning approach used with the OEM-ICT. In one instance, the feedback provided by sub-assembler SA4 influenced the design of several collaboration tools. In this case, the collaborative planning of the supply chain processes to be deployed with the OEM-ICT greatly affected the perceived performance of the collaboration tools. The other two members (sub-assembler SA3 and assembler AS2) had some of the tools imposed on them. No collaborative planning was done as they focused only on the execution of the collaborative processes.

These facts had a major impact on the second phase of our research initiative. The performance of each partner in the supply chain seemed to be most strongly related to the planning of the collaborative initiative rather than the execution of the process. Consequently, the electronic survey focuses on the collaborative planning activities carried out in the supply chain.

(ii) ***Strong impacts on process and relational innovations***

After analyzing the impacts of electronic collaboration tools on innovation (tables 4.5, 4.6 and 4.7), their lack of impact on product innovations (table 4.6) incited us to focus only on process and relational innovations as backbone variables in the second phase of the research.

(iii) ***Regional aspect and scope of the study***

Two other factors drove us to analyze collaborative issues using a survey method. First, the regional aspect of the field study (most supply chain partners are physically close to each other) may influence the level of collaboration procedures used; more geographically dispersed respondents need to be investigated in the survey. Second, in order to confirm some of the findings of the field study, the use of the survey method on a larger sample seems to be an appropriate methodological approach.

In conclusion, the field study led to a better understanding of the collaboration issues facing supply chain partners in an ever-changing technological environment. It is clear that these new electronic collaborative methods had changed the way information was exchanged between partners and that internal and external processes were modified (created or eliminated) to comply with this innovative way of doing business. Building on the results of the field study, the empirical aspects of the survey in the second phase of this research initiative embraced collaboration planning, process and relational innovation, and supply chain performance.

CHAPTER 5 - ANALYSIS OF THE RESULTS OF THE ELECTRONIC SURVEY

In this chapter, we present the key results of the electronic survey. First, the descriptive analysis outlines the profiles of the responding firms and assesses the reliability of the various constructs used in the second phase of our empirical investigation. Next, the research propositions developed in chapter 2 are tested and verified. Finally, additional multivariate statistical analyses (cluster and discriminant analysis) are conducted in order to characterize supply chain partners in the telecommunications industry.

5.1 Descriptive analysis

Due to the wide scope of the questionnaire, which covers activities upstream (procurement, design, etc.) and downstream (sales, etc.) in the supply chain, the electronic survey was made available to the respondents via the Internet. A total of 53 companies answered the Web survey, for a 40.8% response rate. Each responding firm completed both the supplier-related and the customer-related questions, which required the participation of multiple respondents in each company. When validating the questionnaire with a few companies, two respondents were usually required to answer the questionnaire entirely.

5.1.1 Characteristics of responding firms

The sample of companies identified by OEM-ICT as potential respondents is intentionally made up of different types of companies, large and small, from recent to

long-time partners, from different countries around the world, and representing several layers of the supply chain (as described in section 3.3).

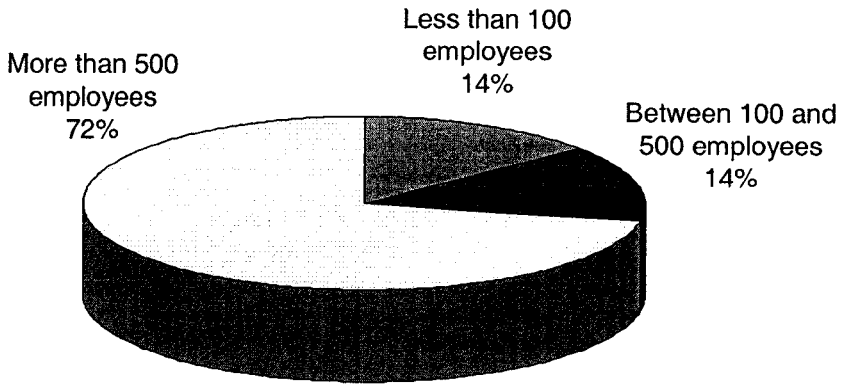


Figure 5.1 – Size of the firms

Responding firms are generally quite mature and have been active for some 33 years on average. As shown in figure 5.1, a majority of these firms are large companies (72% provide work for more than 500 employees); small (less than 100 employees) and medium-sized companies (between 100 and 500 employees) each account for 14% of the responding firms.

As presented in figure 5.2, the sales and import activities of the responding firms are mostly concentrated in the US. One important remark is that the companies involved in this survey are more inclined to sell their products to Europeans and depend more on Asia for their supplies: on average, sales to Europe represent 22% versus 16.3% to Asia, whereas buyers are attracted by Asia, with 25.9% of supplies originating there and only 11.9% in European countries.

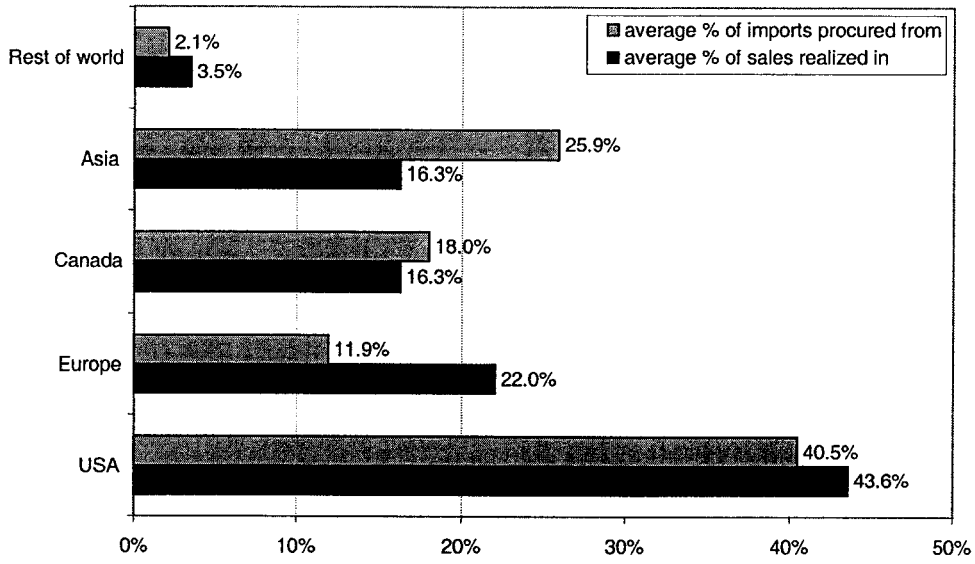


Figure 5.2 – Level of imports and exports

In order to understand and analyze the role of collaboration in the supply chain, it was crucial to target companies involved with a large supplier base active in different layers of the supply chain. This target was met, with 39% of responding firms being involved with three or more levels of suppliers and 41% dealing with two levels of suppliers (see figure 5.3). Since these companies were identified as the most important suppliers of the OEM, it is no surprise that 71% consider themselves to be first-tier suppliers in the industry (figure 5.4).

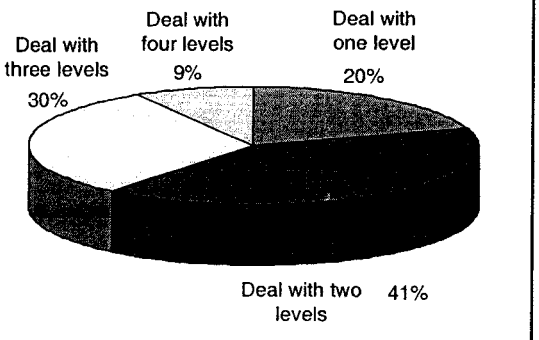


Figure 5.3 – Involvement of responding firms with different levels of suppliers

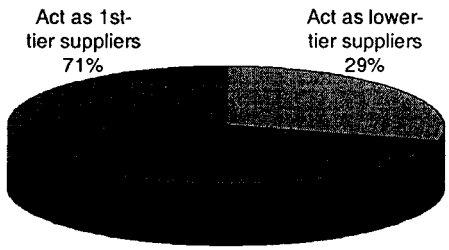


Figure 5.4 – Position of the responding firms within the supply chain

5.2 Reliability of constructs and descriptive statistics

Several constructs were presented in table 3.3: three constructs representing the dependent variables, six for the independent variables, five for the mediating variables and three for the control variables. This section examines the reliability of these constructs, which will be used later in the bivariate and multivariate statistical analyses, and offers descriptive statistics for the 53 responding firms.

5.2.1 Construct reliability

In each of the five groups of variables displayed in table 5.1, the Cronbach alpha coefficients confirm that the items in the constructs have strong relationships among themselves.

Table 5.1 – Independent and mediating constructs and their reliability

	⇐ When dealing with suppliers	When dealing ⇒ with customers	⇔ Internally
	Cronbach alpha	Cronbach alpha	Cronbach alpha
Front-end agreement[1]			
Collaboration agreement	.747	.702	
Collaboration process mapping	.918	.822	
Continuous improvement	.836	.836	
Joint business plan[2]			
Strategic collaborative actions	.8852	.7982	
Tactical collaborative actions	.7188	.7494	
Collaboration tools efficiency	.9175	.8998	
Process innovations[3]			
Process creation	.905	.668	
Logistical processes	.909	.909	
Production processes	.841	.840	
Relational innovations[4]			
Partnership development	.733	.777	
Relationship improvements	.972	.916	
Supply chain performance[5]			
Resource measures			.889
Output measures			.694
Flexibility measures			.786

1. See appendix B for more details
2. See appendix C for more details
3. See appendix D for more details
4. See appendix E for more details
5. See appendix A for more details

The reliability for each of the constructs is satisfactory for both upstream and downstream approaches as the Cronbach alphas are all between .668 and .972 (where 1.00 represents perfect reliability). In fact, the majority of constructs exceed the .70 mark set by Nunnally (1978).

5.2.2 Descriptive statistics

Table 5.2 presents the behavior of the four groups of independent and mediating variables. In the first group of independent variables, all three sets of activities pertaining to CPFR's first phase of collaborative planning (Front-end agreement) are shown to be carried out by many of the respondents, with means ranging from 4.85 to 5.59 for the supplier side (1 = does not execute these activities in the supply chain and 7 = executes these activities in the supply chain) and from 4.90 to 5.51 for the customer side. For both the upstream and the downstream approaches, collaborative planning activities are conducted more frequently than collaboration process mapping, which requires a lot more precise data (depth) in the information exchanges. Continuous improvement activities are also carried out but to a lesser extent, as companies do not always see the advantages of formally evaluating their supply chain relationships. When one compares the two sides of the supply chain, no significant differences are found between the supplier perspective and the customer perspective ($p = .583$, .417 and .886).

Typically, to improve collaboration with their supply chain partners, companies are more eager to develop and share tactical plans (e.g. objectives for specific categories of components) than to carry out activities related to strategic collaborative actions (e.g.

Table 5.2 – Independent and mediating variables:
The supplier's vs. the customer's perspective

Variables	⇐ When dealing with suppliers	When dealing ⇒ with customers	Paired t-test
	Mean	Mean	p[5]
Independent variables – Collaboration planning activities			
Front-end agreement[1]			
Collaboration agreement	5.59	5.51	.583
Collaboration process mapping	5.39	5.34	.417
Continuous improvement	4.85	4.90	.886
Joint business plan[2]			
Strategic collaborative actions	5.14	4.83	.150
Tactical collaborative actions	5.46	5.40	.517
Collaboration tools efficiency	5.12	4.85	.196
Mediating variables – Innovativeness			
Process innovations[3]			
Process creation	5.24	5.43	.138
Logistical processes	5.44	5.45	.830
Production processes	5.25	5.15	.251
Relational innovations[4]			
Partnership development	5.15	5.50	.062
Relationship improvements	5.63	5.61	.924

1. Based on Likert scales where 1 = does not execute these activities in the supply chain and 7 = executes these activities in the supply chain
2. For strategic and tactical collaborative actions: based on Likert scales where 1 = does not execute these strategies in the supply chain and 7 = executes these strategies in the supply chain
   For collaborative tools efficiency: based on Likert scales where 1 = tools not efficient during supply chain activities and 7 = tools efficient during supply chain activities
3. Based on Likert scales which measure the extent to which collaborative planning allows for the improvement of process innovations: 1 = disagrees that collaboration planning has a positive impact on process innovations and 7 = agrees that collaboration planning has a positive impact on process innovations
4. Based on Likert scales which measure the extent to which collaborative planning allows for the improvement of relational innovations: 1 = disagrees that collaboration planning has a positive impact on relational innovations and 7 = agrees that collaboration planning has a positive impact on relational innovations
5. Level of significance of Wilcoxon (paired t-test)

compare business plans). This is confirmed for the second group of independent variables (table 5.2), as average scores for tactical collaborative actions are higher than for strategic collaborative actions. The results also point to the fact that companies are slightly more inclined to exchange tactical and strategic supply chain information and to positively evaluate the efficiency of collaboration tools when dealing with their suppliers rather than with their customers. However, there are no significant differences between the two perspectives.

As we turn to the third group of variables in table 5.2, collaboration planning seems to have a positive impact, from both the supplier and customer perspectives, on logistical processes (5.44 and 5.45) and on production processes (5.25 and 5.15). Although there is a slight difference in the impact of collaborative planning on process creation between the two perspectives (in favor of the customer perspective), no significant difference can be observed ($p = .138$).

As for relational innovations (fourth group of variables in table 5.2), no real distinction is found in the improvement of relationships due to collaborative planning activities when one compares the supplier and customer perspectives. However, the average scores of 5.63 and 5.61 are quite high and therefore indicate the importance of collaboration in the enhancement of relationships (captured by underlying items such as trust and loyalty in supply chain relationships). On the other hand, collaboration planning more significantly improves the development of partnerships with customers than with suppliers ($p = .062$).

Table 5.3 – Supply chain performance constructs

Supply chain performance ⇔	Mean [1]
Resource measures	3.95
Output measures	4.74
Flexibility measures	4.94

1. Based on Likert scales where 1 = decrease in performance and 7= increase in performance due to the introduction of collaborative planning activities

Table 5.3 demonstrates that, for two performance variables (output measures, with an average score of 4.74, and flexibility measures, with an average score of 4.94), the companies retained in our sample experienced, on average, a slight increase in performance due to the introduction of collaborative planning activities in the supply chain. However, the mean score for the resource measures (3.95) is slightly under the mid-point of the Likert scales (4.00).

5.2.3 Control variables

The conceptual model proposed in section 2.1 identified product demand/customization, position in the supply chain and size as three potential control variables. The influence of these three variables on all research variables will be assessed in this section.

Table 5.4 – Cronbach alphas for control variables

Control variable	Cronbach alpha	Mean
Product demand/customization [1]	.737	3.21
Position in the supply chain	Not applicable	Not applicable
Size of the firm	Not applicable	Not applicable

1. Based on Likert scales where 1 = manufactures a very customized product with unpredictable demand and 7 = manufactures a very stationary product with stable demand

Product demand/customization is captured by two items: product demand stability and product customization. The level of reliability of the construct (Cronbach alpha of .737) is adequate (table 5.4). The product demand/customization construct, with an average of 3.21, leans slightly towards customized and unpredictable products, which is known to be the case in the telecommunications equipment industry.

5.2.3.1 Product demand/customization

Tables 5.5 and 5.6 assess the influence of product demand/customization on the dependent, mediating and independent variables. The sample is simply divided according to the median value for product demand/customization and the behavior of all research variables is compared from both the customer and supplier perspectives in table 5.5.

Overall, product demand/customization has no significant impact on the customer side, as there is no significant difference between the two groups of firms. From the supplier perspective, significant differences between the two groups are detectable for the following constructs: strategic collaborative actions ($p = .007$), tactical collaborative actions ($p = .015$), process creation ($p = .018$) and partnership development ($p = .035$). On the customer side, the only variable influenced by product demand/customization is the logistical process construct, with a p level of .097.

Table 5.5 – The influence of product demand/customization on the independent and mediating variables

	⇐ Suppliers			Customers ⇒		
	Customized product with unpredictable demand	Stationary product with stable demand	p [1]	Customized product with unpredictable demand	Stationary product with stable demand	p [1]
Front-end agreement						
Collaboration agreement	5.57	5.59	.753	5.40	5.57	.458
Collab. process mapping	5.26	5.51	.456	5.13	5.52	.206
Continuous improvement	4.87	4.84	.877	4.75	5.06	.714
Joint business plan						
Strategic collab. actions	4.61	5.59	.007	4.65	4.94	.255
Tactical collab. actions	5.07	5.85	.015	5.18	5.56	.150
Collab. tools efficiency	4.90	5.30	.279	4.71	4.94	.459
Process innovations						
Process creation	4.60	5.74	.018	5.18	5.65	.133
Logistical processes	5.12	5.68	.207	5.14	5.60	.097
Production processes	5.14	5.35	.744	4.78	5.10	.519
Relational innovations						
Partnership development	4.64	5.65	.035	5.36	5.68	.173
Relationship improvements	5.38	5.85	.176	5.57	5.64	.902

1. level of significance of t-test (one-tailed)

Furthermore, the results in table 5.6 reveal no influence of product demand/ customization on the supply chain performance measures.

Table 5.6 – The influence of product demand/customization on the dependent variables

	Customized product with unpredictable demand	Stationary product with stable demand	p [1]
Resource measures	4.66	4.78	.424
Output measures	4.78	5.07	.272
Flexibility measures	3.75	4.09	.361

1. Level of significance of t-test (one-tailed)

5.2.3.2 *Position in the supply chain*

For the second analysis, the companies describing themselves as first-tier suppliers were grouped together while the others formed the second group (second, third and fourth tier).

The results of the t-test shown in table 5.7 demonstrate that the position held in the supply chain influences:

(i) the relational innovations construct for both upstream (p = .093 and .053) and downstream activities (p = .021 and .0004) (see last two lines of table 5.7), and

(ii) some of the joint business plan variables on the customer side (strategic collaborative actions, p = .007, and tactical collaborative actions, p = .012).

Table 5.7 – The influence of position in the supply chain on the independent and mediating variables

	⇐ Suppliers			Customers ⇒		
	Tier 1	Tier 2 & +	p [1]	Tier 1	Tier 2 & +	p [1]
Front-end agreement						
Collaboration agreement	5.71	5.24	.104	5.58	5.41	.505
Collab. process mapping	5.70	4.49	.002	5.69	4.43	.0001
Continuous improvement	5.03	4.33	.198	5.02	4.61	.289
Joint business plan						
Strategic collab. actions	5.34	4.59	.193	5.17	4.00	.007
Tactical collab. actions	5.58	5.15	.103	5.64	4.82	.012
Collab. tools efficiency	5.21	4.84	.427	5.00	4.50	.153
Process innovations						
Process creation	5.33	5.05	.308	5.50	5.27	.497
Logistical processes	5.56	5.13	.242	5.59	5.08	.117
Production processes	5.33	5.05	.308	4.98	4.85	.751
Relational innovations						
Partnership development	5.34	4.72	.093	5.72	4.96	.021
Relationship improvements	5.80	5.15	.053	5.97	4.77	.0004

1. Level of significance of t-test (one-tailed)

The collaboration process mapping construct is also influenced by supplier positioning when dealing with both suppliers and customers (second line of table 5.7). As with the preceding control variable, no significant effect is noticeable on the performance measures when comparing the two groups (see table 5.8).

Table 5.8 – The influence of position in the supply chain on the dependent variables

	Tier 1	Tier 2 & +	p [1]
Resource measures	4.15	3.43	.104
Output measures	4.82	4.54	.264
Flexibility measures	5.01	4.77	.390

1: Level of significance of t-test (one-tailed)

5.2.3.3 Size of the firm

The size of the firm is the third control variable chosen for this study. The median number of employees (2,839) was used to divide companies into two groups: smaller firms and larger firms.

Table 5.9 – The influence of firm size on the independent and mediating variables

	⇐ Suppliers			Customers ⇒		
	Larger firms	Smaller firms	p [1]	Larger firms	Smaller firms	p [1]
Front-end agreement						
Collaboration agreement	5.65	5.56	.655	5.73	5.34	.146
Collab. process mapping	5.38	5.37	.990	5.31	5.32	.903
Continuous improvement	4.83	4.91	.728	4.91	4.92	.990
Joint business plan						
Strategic collab. actions	5.13	5.16	.813	5.21	4.52	.101
Tactical collab. actions	5.45	5.48	.833	5.45	5.39	.981
Collab. tools efficiency	5.24	5.00	.316	4.84	4.89	.971
Process innovations						
Process creation	5.26	5.20	.791	5.69	5.13	.067
Logistical processes	5.32	5.49	.774	5.64	5.19	.168
Production processes	5.00	5.56	.149	5.38	4.50	.062
Relational innovations						
Partnership development	5.26	5.03	.452	5.60	5.42	.535
Relationship improvements	5.52	5.75	.488	5.77	5.51	.418

1. Level of significance of t-test (one-tailed)

However, as illustrated in tables 5.9 and 5.10, the influence of size on the collaborative planning, innovativeness and performance research variables is negligible for both upstream and downstream activities. Therefore, this control variable will not be used in further statistical analyses.[1]

Table 5.10 – The influence of firm size on the dependent variables

	Larger firms	Smaller firms	p [1]
Resource measures	3.87	4.05	.942
Output measures	4.62	4.88	.077
Flexibility measures	4.86	5.06	.376

1. Level of significance of t-test (one-tailed)

Therefore, two of the three control variables have some influence on the rest of the variables involved in this research initiative. Hence, firm size will not be considered during the next steps of this research while both the position held in the supply chain and the product demand/customization will be included in the multivariate analyses.

[1] During the statistical tests, the size variable was divided in a number of different ways but the influence of size on the other variables was always non-significant.

5.3 Verification of the research propositions

The purpose of this section is to test the five propositions illustrated in figure 5.5.

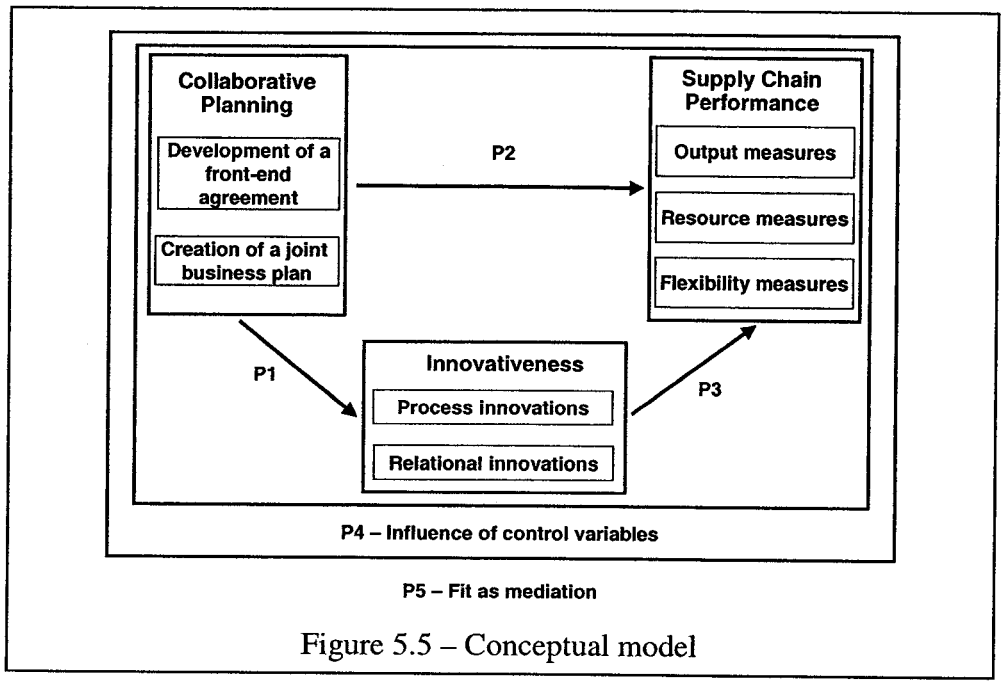


Figure 5.5 – Conceptual model

Proposition P1 deals with the influence of collaborative planning on innovativeness. As mentioned in section 4.1.5 and demonstrated in the field study research, collaborative planning was not found to enhance product innovation. We therefore decided to pursue this research initiative by focusing only on process and relational innovation variables. Proposition P2 assesses the effect of collaborative planning activities on supply chain performance. Proposition P3 analyzes the impact of innovativeness on supply chain performance. Each of these three propositions is evaluated from two perspectives: the supplier's and the customer's. We will also take into account the influence of the control variables (P4) on the relationships implied by P1, P2 and P3. Finally, proposition P5 explores the concept of fit as mediation or, more specifically, the mediating effect of

innovativeness variables on the relationship between collaborative planning and supply chain performance.

5.3.1 The influence of collaborative planning on innovativeness

As presented in section 2.3, proposition P1 is divided into two sub-propositions, namely:

P1.1: The development of a front-end agreement has a positive influence on innovativeness

P1.2: The creation of a joint business plan has a positive influence on innovativeness

If we go into more detail, these two sub-propositions (P1.1 and P2.1) involve four concepts that are captured by eleven variables (figure 5.6): the development of a front-end agreement is represented by three variables, the creation of a joint business plan by three additional variables, process innovations by three variables and relational innovation by two variables.

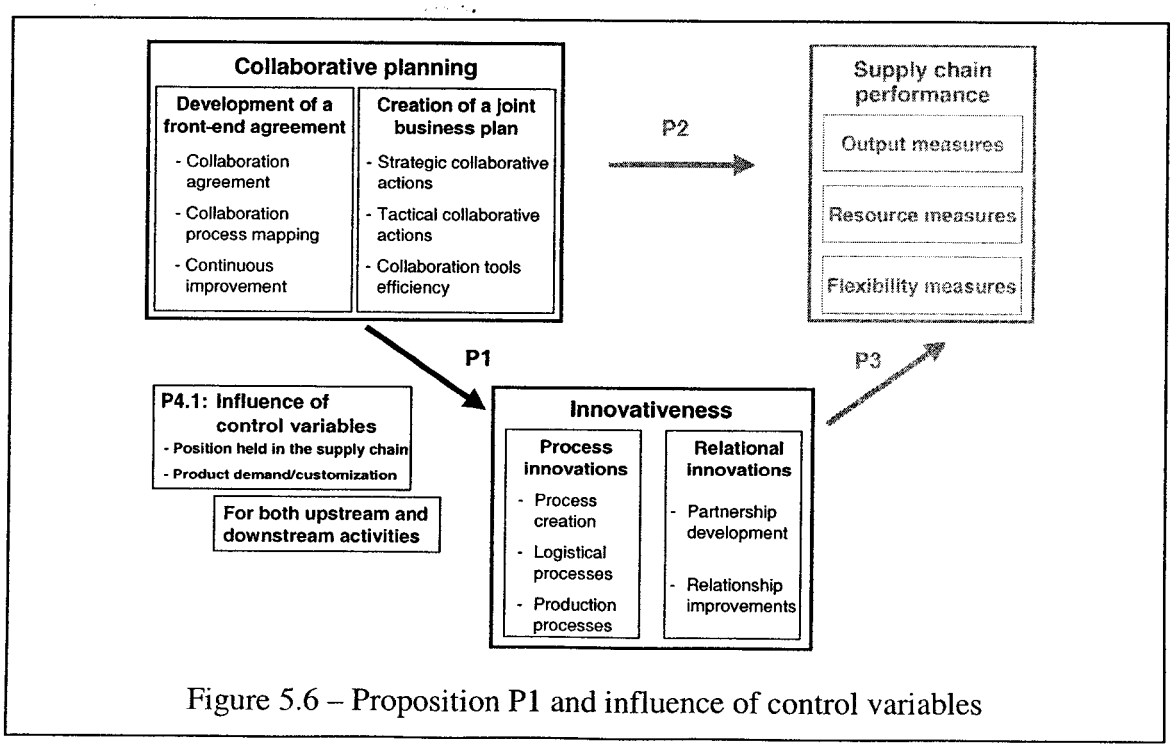


Figure 5.6 – Proposition P1 and influence of control variables

Testing the relationships between collaborative planning and innovativeness implies carrying out 30 bivariate tests (6 x 5), first upstream and then downstream, resulting in 60 Pearson correlation coefficients. Furthermore, all of these bivariate analyses must be conducted to take into account the role of the two control variables (P4.1 – see figure 5.6): first, controlling for the position held in the supply chain (60 Pearson correlation coefficients, 30 upstream and 30 downstream); then controlling for product demand/customization (60 additional Pearson correlation coefficients).

Pearson correlation coefficients ($r_{1,2}$) represent a rather commonly used and simple statistical bivariate procedure, which allows one to test the strength and direction of the relationship between two variables (x_i and x_j). Testing the influence of a third variable (x_k) on the relationship between x_i and x_j is done as follows:

$$r_{ijk} = \frac{r_{ij} - r_{ki}\, r_{kj}}{\sqrt{(1 - r_{ki}^2)\,(1 - r_{kj}^2)}}$$

Proposition P4.1 requires testing for the influence of each control variable using the above formula.

In summary, testing proposition P1 involves 60 Pearson correlation coefficients while testing the effect of both control variables on P1 implies another 120 Pearson correlation coefficients. We will therefore present only the most important results in this section; the complete set of statistical analyses is displayed in appendix F.

5.3.1.1 Testing propositions P1.1 and P1.2

The results shown in table 5.11 clearly indicate that propositions P1.1 and P1.2 are confirmed (supported) for upstream activities (i.e. with suppliers) since all of the collaborative planning variables are positively correlated to innovativeness variables.

Table 5.11 – Strength of the relationships between collaborative planning and innovativeness when dealing with suppliers

		⇐ **Innovativeness when dealing with suppliers**				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
⇐Collaborative planning		PCS [1]	LPS	PPS	PDS	RIS
Develop front-end agreement						
- Collaboration agreement	CAS	0.5716 ****	0.4207 ***	0.4804 ***	0.5687 ****	0.4088 ***
- Collaboration process mapping	CPMS	0.3880 **	0.4250 ***	0.2506 *	0.4533 ***	0.4008 ***
- Continuous improvement	CIS	0.3183 **	0.3065 **	0.3752 **	0.3171 **	0.1786
Create joint business plan						
- Strategic collaborative actions	SCAS	0.4317 ***	0.7561 ****	0.2842 **	0.6877 ****	0.6873 ****
- Tactical collaborative actions	TCAS	0.6208 ****	0.7486 ****	0.4417 ***	0.7587 ****	0.7272 ****
- Collaboration tools efficiency	CTES	0.5055 ***	0.7169 ****	0.3441 **	0.8113 ****	0.6525 ****

Pearson correlation coefficients — Level of significance one-tailed p = * < .1 **< .05 *** < .01 **** < .001

1: PCS = Process creation (when dealing with) suppliers.
All other construct abbreviations are formed similarly

Furthermore, nearly all relationships are significant (the only exception being $r_{CIS\text{-}RIS}$ = 0.1786). Overall, the joint business plan variables are more strongly correlated with innovativeness than the front-end agreement variables are, possibly as a result of the more pragmatic (practical) collaborative actions related to joint business plans. The

relationships between joint business plan variables, logistical process innovations and both relational innovation variables are particularly strong, with coefficients higher than or equal to 0.6525 ($r_{SCAS-LPS}$, $r_{TCAS-LPS}$, $r_{CTES-LPS}$, $r_{SCAS-PDS}$, $r_{TCAS-PDS}$, $r_{CTES-PDS}$, $r_{SCAS-RIS}$, $r_{TCAS-RIS}$, $r_{CTES-RIS}$, for all of which $p < .001$).

Table 5.12 – Strength of the relationships between collaborative planning and innovativeness when dealing with customers

		Innovativeness when dealing with customers ⇒				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
Collaborative planning ⇒		PCC [1]	LPC	PPC	PDC	RIC
Develop front-end agreement						
- Collaboration agreement	CAC	0.3421 **	0.2521 *	0.5204 ****	0.5126 ****	0.4353 ***
- Collaboration process mapping	CPMC	0.3173 **	0.2569 *	0.2995 **	0.4219 ***	0.3070 **
- Continuous improvement	CIC	0.2294 *	0.2336 *	0.2118 *	0.4064 ***	0.2352 *
Create joint business plan						
- Strategic collaborative actions	SCAC	0.1941	0.4398 ***	0.5905 ****	0.5517 ****	0.6057 ****
- Tactical collaborative actions	TCAC	0.4136 ***	0.4541 ***	0.6998 ****	0.6971 ****	0.6356 ****
- Collaboration tools efficiency	CTEC	0.4246 ***	0.3628 **	0.4663 ***	0.3084 **	0.3937 ***

Pearson correlation coefficients

Level of significance one-tailed p = * < .1 **< .05 *** < .01 **** < .001

1: PCC = process creation (when dealing with) customers.
All other construct abbreviations are formed similarly

To a lesser extent, propositions P1.1 and P1.2 are also supported for downstream activities (i.e. with customers), given that the correlation coefficients (displayed in table 5.12) for the relationships between collaborative planning and innovativeness are again

all positive and relatively strong, particularly for relationships between joint business plan variables and relational innovations.

Comparing upstream activities to downstream activities, we find that most correlation coefficients are stronger for collaboration with suppliers. In particular, apart from production process innovations ($r_{CTES\text{-}PPS}$ and $r_{CTEC\text{-}PPC}$), the efficiency of collaboration tools is not as strongly correlated with innovativeness for downstream activities (last line of table 5.12: $r_{CTEC\text{-}PCC}$, $r_{CTEC\text{-}LPC}$, $r_{CTEC\text{-}PDC}$, $r_{CTEC\text{-}RIC}$) as it is for upstream activities (last line of table 5.11: $r_{CTES\text{-}PCS}$, $r_{CTES\text{-}LPS}$, $r_{CTES\text{-}PDS}$, $r_{CTES\text{-}RIS}$).

This may be explained by the power structure in which buyers have a strong decisional position and the autonomy to innovate according to conditions they set. However, there are a few notable exceptions pointing towards stronger downstream relationships:

1. Most of the relationships (5 out of 6) between collaborative planning and production-related process innovations are stronger for the downstream perspective (comparison of the third column in tables 5.11 and 5.12). In joint planning activities, customers may persuade their suppliers to adopt new production processes in order to meet quality or performance standards (e.g. ISO 9000 or ISO 14000 standards) and consequently enhance production-related process innovations.

2. The correlations between continuous improvement activities and relational innovations are also more significant for downstream activities. Continuous improvement does in fact require frequent exchanges between business partners, especially with satisfied customers, which in turn leads to better supply chain relations.

5.3.1.2 Testing the influence of the control variables on the relationships related to P1.1 and P1.2

As illustrated in figure 5.6, the influence of the two control variables on the collaborative planning – innovativeness relationships is assessed by proposition P4.1.

> *P4.1: The relationships observed in P1 are controlled by variables such as size, product demand/customization or position held by suppliers in the supply chain*

Table 5.13 (upstream activities) and 5.14 (downstream activities) summarizes the 120 coefficients that assess the influence of these two variables on proposition P1. When one compares the results previously obtained for proposition P1 (tables 5.11 and 5.12) to those obtained when controlling for the position held in the supply chain or product demand/customization (see appendix F), one notices several variations. Tables 5.13 and 5.14 display only the variations greater or equal to 0.1 ($\Delta r \geq 0.10$).

Upstream activities

1. Relationship between Front-end agreement and Logistical process innovation

When dealing with suppliers (table 5.13), the influence of the position held in the supply chain (*supp*) is mostly detected in the relationship between collaboration planning and logistic-related process innovations (second column). Logistical activities have been outsourced to a great extent according to a recent study; more than three quarters of all companies (up to 90 percent in Europe and Asia) currently outsource a segment of their logistical activities to logistics service providers (Georgia Institute of Technology, 2002).

This is particularly true for smaller companies that do not have the competencies and equipment to carry out logistical activities internally. Hence, the influence of the position held in the supply chain (*supp*) impacts the front-end agreement – logistical process innovation relationships; the further down (third and fourth tiers) a company is at the supplier level, the more collaborative planning activities with suppliers (including logistics providers) improve logistics-related processes.

Similarly, the relationships between collaboration process mapping and logistical process innovation are also affected by product demand/customization (*pc*). A more stable product demand and a less customized product eliminate some insecurity in the collaborative supply chain relationship by facilitating the mapping of collaboration processes and therefore increasing the chances of improving logistical process innovation

Table 5.13 – Influence of control variables on P1 when dealing with suppliers (Δr)

		⇐ Innovativeness when dealing with suppliers				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
⇐Collaborative planning		PCS	LPS	PPS	PDS	RIS
Develop front-end agreement						
- Collaboration agreement	CAS		0.10 supp			0.13 pc
- Collaboration process mapping	CPMS		0.14 supp 0.18 pc			
- Continuous improvement	CIS		0.11 supp			
Create joint business plan						
- Strategic collaborative actions	SCAS					
- Tactical collaborative actions	TCAS		0.12 supp 0.11 pc			
- Collaboration tools efficiency	CTES					

Δr = variations of Pearson correlation coefficients between table 5.11 and tables F.1 and F.2 in appendix F.

2. *Relationship between Tactical collaborative actions and Logistical process innovation*

Due to specific component-related competencies, third- and fourth-tier suppliers tend to focus on more practical (down-to-earth) issues when planning collaborative activities with their supply chain partners. Therefore, the farther upstream a supplier is on the chain, the more tactical collaborative actions are capable of improving logistical process relationships. Furthermore, a stable product demand and a stationary product positively simplify the formulation of tactical collaborative actions and increase the chances of improving logistical processes.

3. Relationship between Collaboration agreement and Relationship improvements

It is no surprise to find that a more stable product demand and a more stationary product also influence the relationship between the existence of a collaboration agreement and relationship improvements (last column of table 5.13). Stable demand improves supplier trust and loyalty by eliminating uncertainty.

Downstream activities

Relationships between some collaborative planning activities and logistical process innovations are also greatly influenced by the control variables when dealing with customers (table 5.14), and are slightly different from the influence of control variables on the same relationships but for upstream activities (table 5.13).

1. Relationship between Continuous improvement and Logistical process innovation

As stated earlier, SMEs (often third- and fourth-tier suppliers) do not possess the necessary restricted logistics-related competencies. Their ability to transform logistical

processes is rather limited, as they usually prefer incremental change to more radical change. Therefore, the implementation of a continuous improvement procedure may be more beneficial for smaller suppliers when dealing with logistics-related issues.

In addition, the more stationary a product is and the more stable the demand for it, the stronger is the effect of continuous improvement activities on logistical process innovations. Planning a continuous benchmark on collaborative activities in order to improve collaboration processes is more efficient with a stable demand as all parties involved focus on finding an optimal method to deliver and package the product rather than on optimizing product demand.

Table 5.14 – Influence of control variables on P1 when dealing with customers (Δr)

		Innovativeness when dealing with customers ⇒				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
Collaborative planning ⇒		PCC	LPC	PPC	PDC	RIC
Develop front-end agreement						
- Collaboration agreement	CAC					
- Collaboration process mapping	CPMC			0.11 supp		-0.19 supp
- Continuous improvement	CIC		0.16 supp 0.15 pc		0.10 pc	0.10 supp 0.13 pc
Create joint business plan						
- Strategic collaborative actions	SCAC		-0.14 supp -0.12 pc			
- Tactical collaborative actions	TCAC					
- Collaboration tools efficiency	CTEC		0.10 supp 0.13 pc		0.12 pc	

Δr = variations of Pearson correlation coefficients between table 5.12 and tables F.3 and F.4 in appendix F.

2. Relationship between Strategic collaborative actions and Logistical process innovation

When dealing with customers, the strategic collaborative actions – logistical process innovation relationship is also influenced by both control variables ($\Delta r = -0.14$ and -0.12). The level held by the supplier influences this relationship, as the farther downstream a supplier is positioned in the supply chain (first tier rather than fourth tier), the less influence strategic collaborative actions have on logistical process innovation.[2] This fact may also be attributed to the large portion of outsourcing of logistical processes by third- and fourth-tier suppliers, which requires the exchange of global business strategies between partners (customer, distributor and supplier).

It is also not surprising to see that more unstable product demand is and the more customized the product is, the weaker the relationship becomes. This may be due to the type of intervention dictated by strategic collaborative actions where high-level collaboration issues are discussed (e.g. periodic goals and objectives). Topics related to product customization and product demand need to be discussed exhaustively through more tactical actions.

3. Relationship between Collaboration tools efficiency and Logistical process innovation

For downstream activities, the relationship between efficiency of collaboration tools and logistical process innovation is also influenced by the two control variables. First, a lower position in the supply chain (third and fourth tier) enhances the chances of improving logistical processes with collaboration tools. This may be linked to the use of the delivery

[2] Δr is negative due to the ordinal scale (first tier = 1 and fourth tier = 4)

and tracking tool, which automatically generates a delivery request when a product goes from second-, third- or fourth-tier suppliers directly to the first-tier supplier's customer. It is also designed to collect shipping information from the third-party logistics providers, which are used primarily by these smaller suppliers.

Second, product demand/customization also improves this relationship. The more stationary a product is and the more stable the demand, the stronger the relationship between collaboration tools efficiency and logistical process innovation. In general, steady product demand and an assembled-to-order or a make-to-stock manufacturing method require much less use of collaboration tools.

4. Relationship between Collaboration process mapping and Production process innovation

Other relationships displayed in table 5.14 are also influenced by the control variables. The position held in the supply chain variable influences the effect of collaboration planning on production process innovations. In particular, the relationship between the joint mapping of collaboration parameters and functionalities and the innovativeness of production processes is influenced positively by the position held in the supply chain. When a supplier is involved in lower tiers (third- and fourth-tier suppliers), the effect of mapping collaboration points and processes is stronger on production-related innovations. The somewhat confidential details related to manufacturing a product and the large number of processes involved in production make it difficult for a company to manage a supply chain environment. Unlike large companies, sub-assemblers need to go into

specific detail quite quickly when planning collaboration. Collaborative process mapping makes this first detailed step of collaborating with customers possible.

Moreover, when we look at relational innovations (last two columns of table 5.14), we find that only the product demand/customization control variable (pc) influences the relationship between collaborative planning and partnership development (fourth column of table 5.14, the first of the two categories of relational innovations):

5. Relationship between Collaboration tools efficiency and Partnership development

When dealing with customers, the efficiency of collaboration tools may help in targeting new customers or retaining existing ones. Evidently, the more stable the product is, the more efficient the collaboration tools are for planning, forecasting and replenishment activities, which in turn leads to the development of partnerships.

6. Relationship between Continuous improvement and Partnership development

Stable demand also positively influences the relationship between continuous improvement and partnership development. A company that approaches a potential customer to develop a partnership, with predefined collaboration parameters and ground rules, will certainly be helped by a stable historical record of product demand.

Finally, the two control variables also shape the effect of collaboration planning on relationship improvements (last column of table 5.14):

7. Relationship between Continuous improvement and Relationship improvements

The strength of this relationship increases for lower tier suppliers, as they are required to improve their electronic communications in order to be included in the shrinking supplier base of most major telecommunications OEMs. Continuous improvements are certainly useful to enhance communication media (from fax to EDI to electronic marketplaces) and to raise the level of trust between partners.

Product demand/customization also influences the relation between continuous improvement and relationship improvements. When dealing with customers, stable product demand and a stationary product enable partners to focus on the collaboration process rather than on product-related issues. Therefore, continuous improvement activities such as benchmarking the collaboration processes improve the supply chain relationship.

8. Relationship between Collaboration process mapping and Relationship improvements

As mentioned earlier, collaboration process mapping forces partners to discuss very specific collaboration issues at the front-end agreement level. For first-tier suppliers, this mapping process helps improve existing relationships by increasing the level of trust and loyalty with customers. Hence, the farther downstream a supplier is located (towards the first tier), the more collaboration process mapping improves relationships on the customer side. Oddly, lower-tier suppliers do not consider the effect of collaboration process mapping on relationship improvement to be as strong. This might be due to the types of activities performed by the system integrators and network operator, which focus on the integration of components rather than on manufacturing activities.

5.3.2 The influence of collaborative planning on supply chain performance

The second proposition examines the impact of collaborative planning on supply chain performance. The following two sub-propositions constitute P2:

P2.1: The development of a front-end agreement has a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

P2.2: The creation of a joint business plan has a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

As illustrated in figure 5.7, three concepts described by nine variables are involved in these propositions: the development of a front-end agreement and the creation of a joint business plan involve the same six variables as before while supply chain performance is represented by three dimensions, namely output, resource and flexibility measures.

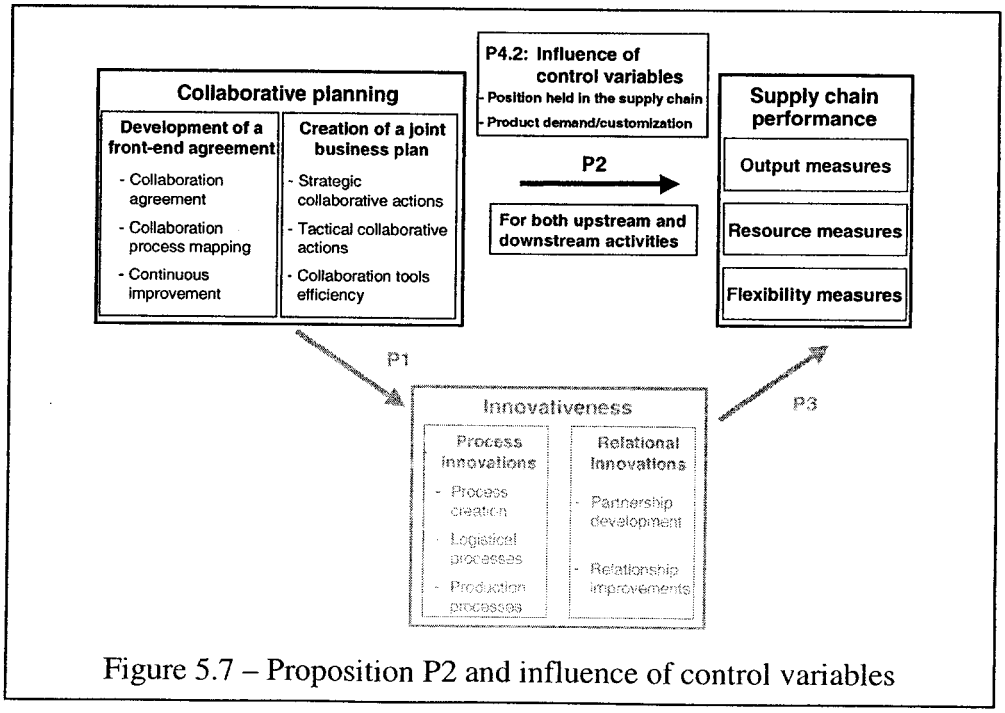


Figure 5.7 – Proposition P2 and influence of control variables

Proposition P2 is tested in the same way as proposition P1: a total of 36 Pearson correlation coefficients were carried out to test propositions P2.1 and P2.2 (18 upstream bivariate tests (6 x 3) and a further 18 tests downstream). As in proposition P1, the role of the two control variables (P4.2 in figure 5.7) is assessed through an additional 72 Pearson correlation coefficients: first by controlling for the position held in the supply chain (18 upstream Pearson correlation coefficients and 18 downstream Pearson correlation coefficients) and second by controlling for product demand/customization (36 additional Pearson correlation coefficients).

5.3.2.1 Testing propositions P2.1 and P2.2

The analysis of propositions P2.1 and P2.2 for upstream activities is based on the results presented in table 5.15. All of the collaboration planning variables are positively correlated to supply chain performance. However, in almost half of the cases (8 of 18), the correlation coefficients are not significant. Moreover, with the exception of the relationships between collaboration tools efficiency and supply chain performance (last line of table 5.15), significant correlations are not very strong ($p < .1$ in 5 of 18 cases and $p < .05$ in 2 of 18 cases). Therefore, the use of efficient collaboration tools when dealing with suppliers appears to be the most critical variable in supply chain performance improvement. The results from table 5.15 partly support propositions P2.1 and P2.2.

For downstream activities, propositions P2.1 and P2.2 are again partially supported. Although positively correlated, the results presented in table 5.16 show that the front-end agreement variables are not strongly related to supply chain performance ($p < .1$ for 3 out of 9 coefficients and $p < .05$ in only one case). However, the creation of a joint business

plan is positively and strongly related to flexibility measures ($p < .01$ for all three coefficients) and resource measures (significant for two coefficients: $r_{SCAC.RM} = 0.4879$ and $r_{TCAC.RM} = 0.3354$).

Table 5.15 – Strength of the relationships between collaborative planning and supply chain performance when dealing with suppliers

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
⇐ Collaborative planning		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAS	0.1903	0.1325	0.2626*
- Collaboration process mapping	CPMS	0.1955	0.3220**	0.2332*
- Continuous improvement	CIS	0.2654*	0.2960**	0.2325*
Create joint business plan				
- Strategic collaborative actions	SCAS	0.0634	0.1007	0.1440
- Tactical collaborative actions	TCAS	0.1351	0.1744	0.2595*
- Collaboration tools efficiency	CTES	0.4288***	0.3185**	0.4538***

Pearson correlation coefficients — Level of significance one-tailed p = * < .1 **< .05 *** < .01 **** < .001

Table 5.16 – Strength of the relationships between collaborative planning and supply chain performance when dealing with customers

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
Collaborative planning ⇒		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAC	0.2264*	0.2260*	0.1819
- Collaboration process mapping	CPMC	0.3457**	0.1674	0.2472*
- Continuous improvement	CIC	0.1336	0.1420	0.0429
Create joint business plan				
- Strategic collaborative actions	SCAC	0.1625	0.4879****	0.3696***
- Tactical collaborative actions	TCAC	0.1606	0.3354**	0.3853***
- Collaboration tools efficiency	CTEC	0.1865	0.0470	0.4029***

Pearson correlation coefficients — Level of significance one-tailed p = * < .1 **< .05 *** < .01 **** < .001

Several interesting observations result from a comparison of upstream activities (table 5.15) and downstream activities (table 5.16):

1. The relationship between continuous improvement and the performance supply chain (third row) is stronger for upstream activities (all coefficients higher than 0.2325) than for downstream activities (all lower than 0.1420). This comes as no surprise, since the power structure may incite a manufacturer to deal with less influential suppliers in its quest for continuous improvement. This uneven supply chain relationship initially drives suppliers to improve their performance, which in turn enhances the supply chain performance measures of the manufacturer (or assembler) in the long run.

2. The relationship between the efficiency of collaboration tools and supply chain performance is also stronger on the supplier side. The constant threat of being eliminated from the supplier base of a large OEM drives suppliers to use collaboration tools to carry out supply chain activities. When dealing with suppliers, an inefficient collaboration tool causes problems within the company (i.e. increase in stock-outs and lead times), and rapidly affects the relationship with the customer (i.e. on-time delivery).

3. An additional result, in comparing both sides of the supply chain, is the stronger relationship between strategic collaborative actions and supply chain performance in favor of downstream activities, with correlation coefficient values 2.5 times greater than the value of coefficients for upstream activities. This confirms the sales approach in the telecommunications industry in which collaborative supply chain relationships with customers (for instance, network operators) stay at an executive level (business plans and

corporate objectives), rather than the more in-depth approach to collaborative planning activities represented by the tactical collaborative actions.

4. Finally, the most interesting results reside in the relationship between collaboration tools efficiency and flexibility measures, which is one of the strongest coefficients for both the upstream and downstream sides ($r_{CTES\text{-}FM}$ = 0.4538 and $r_{CTEC\text{-}FM}$ = 0.4029 respectively). Flexibility measures are difficult to evaluate, as they often require the input of all supply chain stakeholders (e.g. for new product introduction and product variety). Relevant information from suppliers, customers and other business partners must be collected and analyzed before making key decisions. Therefore, the exchange of information through efficient collaboration tool becomes critical.

5.3.2.2 Testing the influence of the control variables on the relationships related to P2.1 and P2.2

As illustrated in figure 5.7, the influence of the two control variables on the relationship between collaborative planning and supply chain performance is evaluated through proposition P4.2 and is summarized in tables 5.17 (upstream activities) and 5.18 (downstream activities).

P4.2: The relationships observed in P2 are controlled by variables such as size, product demand/customization or position held by suppliers in the supply chain

When one compares the earlier results for proposition P2 (tables 5.15 and 5.16) to those obtained when controlling for the position held in the supply chain (36 Pearson correlation coefficients in tables F.6 and F.8 of appendix F) or product demand/customization (36 Pearson correlation coefficients in tables F.5 and F.7 of appendix F), some variations in the correlation coefficients (Δr) are observed.

Upstream activities

For upstream activities, the following points can be deduced from the analysis of the results in table 5.17:

Table 5.17 – Influence of control variables on P2 when dealing with suppliers (Δr)

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
⇐ Collaborative planning		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAS			
- Collaboration process mapping	CPMS	-0.16 supp	-0.21 supp -0.17 pc	
- Continuous improvement	CIS			
Create joint business plan				
- Strategic collaborative actions	SCAS			
- Tactical collaborative actions	TCAS			0.12 supp
- Collaboration tools efficiency	CTES			

Δr = variations of Pearson correlation coefficients between table 5.15 and tables F.5 and F.6 in appendix F.

1. Relationship between Collaboration process mapping and Output measures

The position held in the supply chain influences the relationship between collaboration process mapping and output measures since the farther downstream a supplier is positioned in the chain, the more beneficial collaborative process mapping (during the

front-end agreement) will be in terms of output measures. The early phase of collaboration process mapping requires the involvement of key players at numerous levels of a company for both supply and sale activities. Large corporations usually have the staff required to carry out this type of exercise, and therefore develop a significant amount of experience, which may lead to better results in terms of output measures.

2. Relationship between Collaboration process mapping and Resource measures

Similarly, the position held in the supply chain also influences the relationship between collaboration process mapping and resource measures, given that the availability of a skilled workforce during the development of the front-end agreement may influence supply chain performance through the resources included in the collaborative process.

Furthermore, product demand/customization also influences this relationship. The more unstable product demand is and the more customized the product is, the stronger the relationship between process mapping and resource measures. This is an expected result: unstable demand creates uncertainties in the supply chain, which can be managed through process mapping actions.

3. Relationship between Tactical collaborative actions and Flexibility measures

When dealing with suppliers, the position held in the chain also influences the relationship between tactical collaborative actions and flexibility measures. The tactical activities in the joint business plan require partners to elaborate on actions related to specific items. This procedure is particularly useful for smaller companies (sub-assemblers) in combining sale and operation plans (SOP) to generate manufacturing flexibility in the form of product variety and product mix.

Downstream activities

On the customer side, only the position held by a supplier in the chain influences relationships between collaborative planning and supply chain performance. More specifically, it affects the relationships between strategic collaborative actions and both output measures and resource measures (fourth row of table 5.18).

Table 5.18 – Influence of control variables on P2 when dealing with customers (Δr)

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
Collaborative planning ⇒		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAC			
- Collaboration process mapping	CPMC			
- Continuous improvement	CIC			
Create joint business plan				
- Strategic collaborative actions	SCAC	-0.10 supp	-0.10 supp	
- Tactical collaborative actions	TCAC			
- Collaboration tools efficiency	CTEC			

Δr = variations of Pearson correlation coefficients between table 5.16 and tables F.7 and F.8 in appendix F.

1. Relationship between Strategic collaborative actions and Output measures

Strategic collaborative actions include the exchange of periodic goals and objectives with the intention of developing a partnership. Larger corporations usually have a large enough workforce to execute all these actions while smaller companies quickly focus on a more detailed level. Therefore, it is not surprising to see that the farther downstream a supplier is positioned (first-tier), the stronger the relationship between strategic collaborative actions and output measures becomes.

2. Relationship between Strategic collaborative actions and Resource measures

The same explanation may apply to the relationship between strategic collaborative actions and resource measures. The larger companies tend to develop global partnership agreements with their customers before they exchange detailed information. Therefore, this relationship seems to work better with the participation of first-tier suppliers.

5.3.3 The influence of innovativeness on supply chain performance

The proposition that tests the effect of innovativeness on supply chain performance (P3) is subdivided into the following two sub-propositions:

P3.1: Process innovations have a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

P3.2: Relational innovations have a positive influence on supply chain performance, as assessed by output, resource and flexibility measures

Three concepts described by eight variables are involved in propositions P3.1 and P3.2 (see figure 5.8). As mentioned earlier, innovativeness is represented by three variables for process innovations (process creation, logistical processes and relational processes) and by two variables for relational innovations (partnership development and relationship improvements), whereas supply chain performance is characterized by the same three variables as before (output, resource and flexibility measures).

In order to test P3.1 and P3.2, a total of 15 bivariate tests for upstream activities and another 15 tests for downstream activities were conducted. Furthermore, an additional 30 Pearson correlation coefficients are required to evaluate the influence of the position held

in the supply chain on P3-related relationships (15 upstream coefficients and 15 downstream coefficients) and an extra 30 Pearson correlation coefficients to assess the role of product demand/customization on the same relationships (15 upstream coefficients and 15 downstream coefficients).

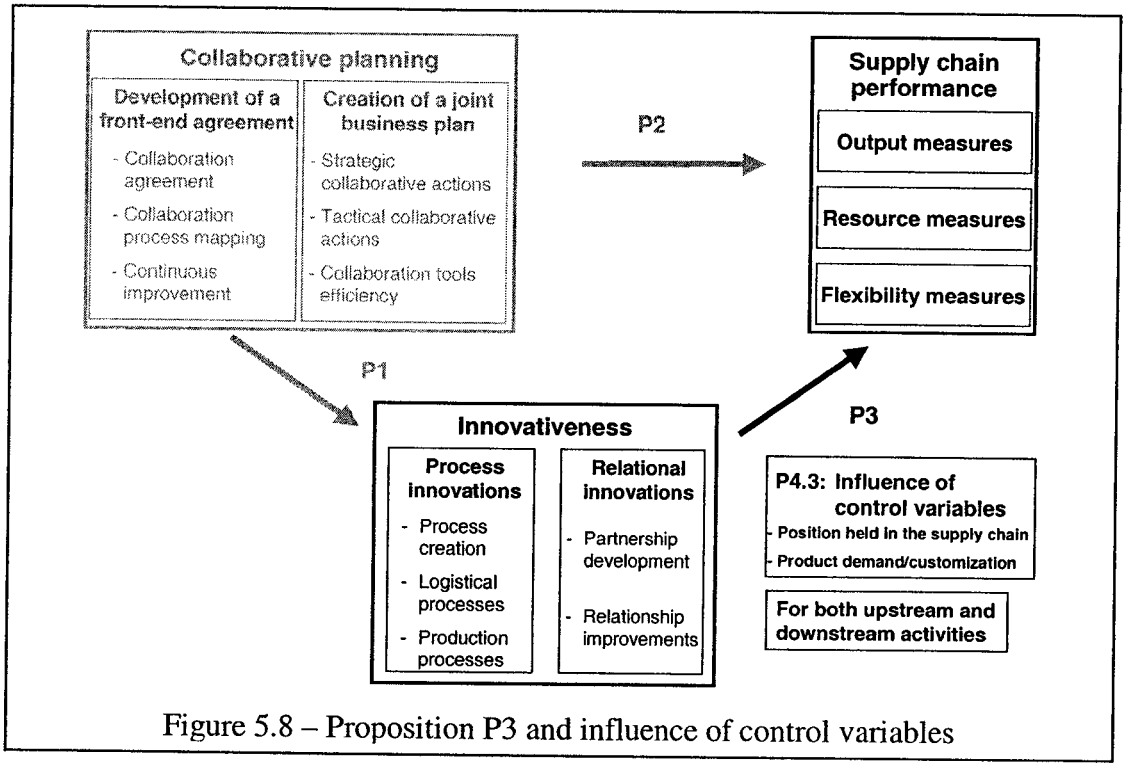


Figure 5.8 – Proposition P3 and influence of control variables

5.3.3.1 Testing propositions P3.1 and P3.2

The relationships between innovativeness and supply chain performance are all positive and the correlation coefficients in tables 5.19 and 5.20 enabled us to confirm propositions P3.1 and P3.2 for both upstream and downstream activities. The tables reveal that process and relational innovations are strongly related to the improvement in output and flexibility measures when dealing with both suppliers and customers. Resource measures are also related to innovativeness but in a lesser extent (for each relationship between

innovativeness and supply chain performance, resource measures obtain lower coefficients than output and flexibility measures for both upstream and downstream activities). For both sides of the supply chain, logistical and production-related process innovations are particularly closely linked to flexibility measures of the supply chain (coefficients of 0.5279 and 0.6421 upstream and 0.6417 and 0.5497 downstream). These types of process innovations (logistical and production) directly influence a company's core activities and its ability to adequately offer products and services to business partners.

Table 5.19 – Strength of the relationships between innovativeness and supply chain performance when dealing with suppliers

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
⇐ Innovativeness		OM	RM	FM
Process innovations				
- Process creation	PCS	0.3489 **	0.2228	0.3479 **
- Logistical processes	LPS	0.4480 ***	0.4479 ***	0.5279 ****
- Production processes	PPS	0.5335 ****	0.4116 ***	0.6421 ****
Relational innovations				
- Partnership development	PDS	0.4296 ***	0.3769 **	0.5592 ****
- Relationship improvements	RIS	0.3602 ***	0.2036	0.3341 **

Pearson correlation coefficients

Level of significance one-tailed p = * < .1 **< .05 *** < .01 **** < .001

Table 5.20 – Strength of the relationships between innovativeness and supply chain performance when dealing with customers

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
Innovativeness ⇒		OM	RM	FM
Process innovations				
- Process creation	PCC	0.3868 ***	0.0936	0.4487 ***
- Logistical processes	LPC	0.3457 **	0.2157 *	0.6417 ****
- Production processes	PPC	0.2934 **	0.1441	0.5497 ****
Relational innovations				
- Partnership development	PDC	0.4387 ***	0.2506 *	0.4572 ***
- Relationship improvements	RIC	0.4105 ***	0.3310 **	0.4054 ***

Pearson correlation coefficients

Level of significance one-tailed p = * < .1 **< .05 *** < .01 **** < .001

A comparison of the results for the two sides of the supply chain (tables 5.19 and 5.20) yields the following observations:

1. The relationships between process innovation and resource measures ($r_{PCS\text{-}RM}$, $r_{LPS\text{-}RM}$, $r_{PPS\text{-}RM}$ vs. $r_{PCC\text{-}RM}$, $r_{LPC\text{-}RM}$, $r_{PPC\text{-}RM}$) are stronger on the supplier side. Resource measures include inventory levels and costs, which represent an important link with suppliers. Therefore, this finding is not uncommon as process innovations relating to logistical and production issues will greatly affect resource measures.

2. When dealing with suppliers, the correlation coefficients between production-related process innovations and all three types of performance measures ($r_{PPS\text{-}OM}$, $r_{PPS\text{-}RM}$, $r_{PPS\text{-}FM}$ vs. $r_{PPC\text{-}OM}$, $r_{PPC\text{-}RM}$, $r_{PPC\text{-}FM}$) are high. This observation is not surprising in a demand-driven

environment. For instance, suppliers are required to deliver components to their customers' shop floors within a 24- to 48-hour period. Therefore, from the customer's point of view, the production process innovations will greatly affect its performance measures (e.g. output measures with shorter lead times, resource measures with lower inventory levels, and flexibility measures with the ability to produce different components in a short period of time).

3. The links between relationship improvement and supply chain performance ($r_{RIS\text{-}OM}$, $r_{RIS\text{-}RM}$, $r_{RIS\text{-}FM}$ vs. $r_{RIC\text{-}OM}$, $r_{RIC\text{-}RM}$, $r_{RIC\text{-}FM}$) are stronger for downstream activities than for upstream activities. All is well when the customer is happy! A loyal and trusting customer will order products frequently, thus stabilizing demand. This kind of relationship improvement increases the performance of the supply chain. As for the supplier side, optimizing processes is perceived as more important than improving relationships, since suppliers may not always be included in future supply chain activities.

5.3.3.2 Testing the influence of the control variables on the relationships related to P3.1 and P3.2

As illustrated in figure 5.8, the influence of two control variables on the relationships between innovativeness and supply chain performance is assessed through the following proposition.

P4.3: The relationships observed in P3 are controlled by variables such as size, product demand/customization or position held by suppliers in the supply chain

A summary of the impact of the position held in the supply chain and of product demand/customization on proposition P3 is displayed in tables 5.21 (upstream activities) and 5.22 (downstream activities). These two tables only display the significant differences between the results for proposition P3 (tables 5.19 and 5.20) and those obtained when controlling by the two control variables (see tables in appendix F).

Upstream activities

As illustrated in table 5.21, the significant variations due to the influence of the two control variables are all oriented in the same direction (negative), which basically indicates that:

- the farther downstream a supplier is positioned in the chain (i.e. higher tiers), the greater the chances that innovativeness will improve supply chain performance;
- the more unstable the product demand and the more customized the product, the greater are the chances that innovativeness will improve supply chain performance.

Table 5.21 – Influence of control variables on P3 when dealing with suppliers (Δr)

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
⇐ Innovativeness		OM	RM	FM
Process innovations				
- Process creation	PCS		-0.14 pc	
- Logistical processes	LPS	-0.15 supp -0.16 pc	-0.17 supp -0.23 pc	
- Production processes	PPS		-0.14 supp -0.18 pc	
Relational innovations				
- Partnership development	PDS	-0.10 supp -0.12 pc	-0.14 supp -0.24 pc	-0.12 pc
- Relationship improvements	RIS		-0.12 supp -0.14 pc	

Δr = variations of Pearson correlation coefficients between table 5.19 and tables F.9 and F.10 in appendix F.

In the following paragraphs, these variations of the Pearson correlation coefficients are explained in more detail, first the variations related to output measures, followed by the variations involving resource measures and, finally, the variations concerning flexibility measures.

1. Relationship between Logistical process innovation and Output measures

When dealing with suppliers, the position held in the supply chain influences the relationship between logistical process innovations and output measures, since the farther downstream a supplier is positioned in the chain, the greater the chances that logistics-related process innovations will improve the performance of the supply chain in terms of output measures. Moreover, the less stable product demand is and the more customized the product is, the better the chances of logistical process innovation's improving output measures. This result is predictable, given that demand-driven strategies call for more frequent (but smaller) product deliveries. The instability of product demand complicates these demand-driven logistical actions, but new advanced logistics technologies may reduce the complexity of managing a large number of deliveries.

2. Relationship between Partnership development and Output measures relationship

Similarly, both control variables influence the relationship between partnership development and output performance measures. First-tier suppliers are more inclined to find that the development of partnerships with suppliers improves output measures. The power structure (i.e. the customer dominates its suppliers) may again have an impact on this relationship. Product demand/customization also influences this relationship, as the

more unstable the product demand, the more the development of a partnership may improve output measures.

As illustrated in table 5.19, the correlations involving resource performance measures are the weakest ones among the relationships between innovativeness and supply chain performance. They become even weaker with the influence of the control variables:

3. Relationships between Process innovations and Resource measures

When dealing with suppliers, the position held by a supplier influences both relationships between logistical process innovation and resource measures ($r_{LPS\text{-}RM}$) and between production process innovation and resource measures ($r_{PPS\text{-}RM}$). A supplier positioned downstream has greater chances of finding that logistical or production-related innovations improve supply chain performance in terms of output measures. In the same way, unstable product demand and a customized product also enhance the chances that logistical and production-related innovations will improve output measures.

Furthermore, product demand/customization also influences the relationship between the creation of innovative processes and resource measures. Larger suppliers with customized products and an unstable demand are encouraged to improve and develop new processes to counter the bullwhip effect (Lee et al., 1997a). This may lead to better supply chain results in terms of the resources needed to manage collaborative actions.

4. Relationships between Relational innovations and Resource measures

Both relationships linking relational innovations to resource measures (partnership development – resource measures ($r_{PDS\text{-}RM}$) and relationship improvements – resource measures ($r_{RIS\text{-}RM}$)) are also influenced by the two control variables during upstream activities. Once again, the farther downstream a supplier is positioned, the stronger are the relationships between relational innovations and resource measures. In addition, with more unstable product demand and a more customized product, there are greater chances of having relational innovations improve resource measures.

Finally, the influence of the control variables on relationships involving flexibility measures is minor as only product demand/customization has an impact on the following relationship.

5. Relationship between Partnership development and Flexibility measures

Methods and technologies such as CPFR are implemented to support the development of partnerships in a supply chain environment with excessive demand fluctuations. Therefore, it is no surprise to see that unstable product demand and a customized product increase the chances that the development of a partnership will enhance flexibility measures in such an environment. Actions such as the implementation of forecasting and replenishment tools are required by supply chain partners to optimize visibility and flexibility in the supply chain.

Downstream activities

On the downstream side, the influence of the two control variables on the relationships between innovativeness and supply chain performance is not as widespread as in the upstream side. As illustrated in table 5.22, only two relationships involving resource measures are affected when controlling for the position held in the supply chain or product demand/customization.

Table 5.22 – Influence of control variables on P3 when dealing with customers (Δr)

		Supply chain performance ⇔		
		Output measures	Resource measures	Flexibility measures
Innovativeness ⇒		OM	RM	FM
Process innovations				
- Process creation	PCC			
- Logistical processes	LPC		-0.12 supp -0.14 pc	
- Production processes	PPC			
Relational innovations				
- Partnership development	PDC			
- Relationship improvements	RIC		-0.14 supp	

Δr=variations of Pearson correlation coefficients between table 5.20 and tables F.11 and F.12 in appendix F.

1. Relationship between Logistical process innovation and Resource measures

The relationship between logistical process innovation and resource measures ($r_{LPC\text{-}RM}$) is influenced by both control variables. When dealing with clients, the farther downstream in the chain a supplier is positioned, greater the chances that logistics-related process innovations will improve resource measures. Similarly, more unstable demand and a more customized product also enhance the chances of improving the relationship between logistical process innovation and resource measures.

2. Relationship between Relationship improvements and Resource measures

The correlation between relationship improvements and resource measures ($r_{RIC\text{-}RM}$) is influenced only by the position held in the supply chain. In the telecommunications equipment industry, the level of trust and loyalty on the customer side is quite important in relations between network operators and system integrators. The people you know and the people you work with are often decisive factors in the progress of a sales contract. These factors are not as important for lower-tier suppliers. Therefore, it is not surprising to observe that farther downstream a supplier is positioned, the better the chances of having relationship improvements on the customer side enhance resource measures.

5.3.4 The mediating effect of innovativeness on relationships between collaborative planning and supply chain performance

Proposition P5, which deals with the mediating effect of innovativeness on the collaborative planning – supply chain performance relationship, is articulated through the following sub-propositions:

P5.1: The effect of the development of a front-end agreement on supply chain performance is mediated by process innovations

P5.3: The effect of the development of a front-end agreement on supply chain performance is mediated by relational innovations

P5.4: The effect of the creation of a joint business plan on supply chain performance is mediated by process innovations

P5.6: The effect of the creation of a joint business plan on supply chain performance is mediated by relational innovations

As with the other three propositions (P1, P2 and P3), the mediation effect will be assessed for both upstream and downstream activities. Figure 5.9 illustrates proposition P5 with the three groups of variables involved in the mediation process.

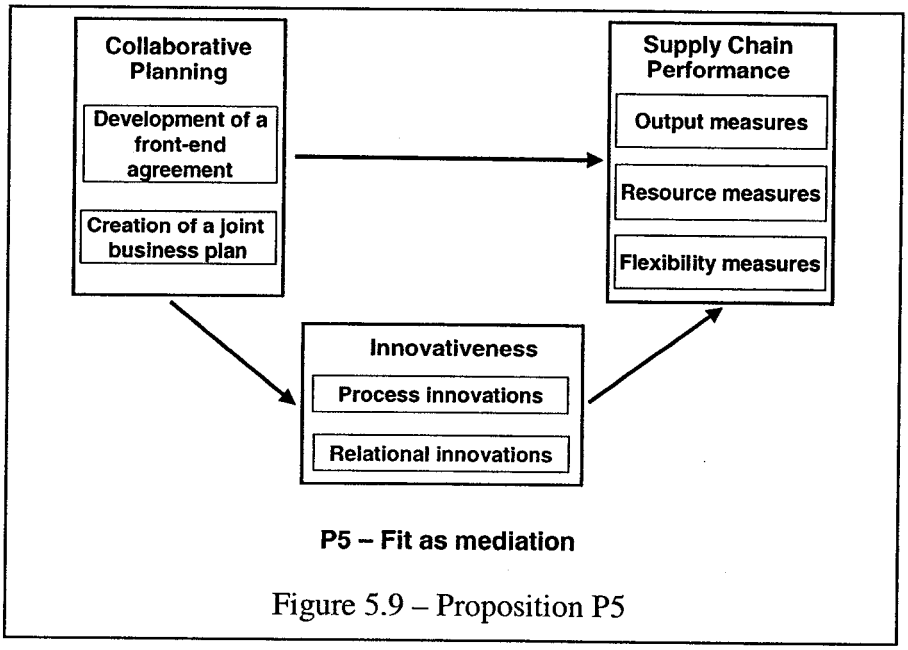


Figure 5.9 – Proposition P5

In order to analyze the mediation effect using a bivariate statistical technique, the following statements, taken from Cox and Cox (2001) and James and Brett (1984), must be true if there is a mediation effect:

1. The correlation between the independent variable and the dependent variable is significant
2. The correlation between the independent variable and the mediator variable is significant
3. The correlation between the mediator variable and the dependent variable is significant
4. The partial correlation between the independent variable and the dependent variable, when controlled by the mediator variable, is *not* significant

If all four statements apply, it indicates complete mediation. If the first three statements are true but the fourth is not (i.e. partial correlation is significant), it represents partial mediation (Kenny, 2001).

When applying this procedure to the variables of this study, we notice that the first three statements have already been validated in section 5.3: the first, second and third[3] were respectively presented in sections 5.3.1 (tables 5.11 and 5.12), 5.3.2 (tables 5.15 and 5.16), and 5.3.3 (tables 5.19 and 5.20). The fourth statement examines the relationship between collaborative planning and supply chain performance when controlling for innovativeness (mediator); validating it requires a total of 180 additional Pearson correlation coefficients (90 for upstream activities (see tables G.2 and G.3 in appendix G) and another 90 for downstream activities (see tables H.2 and H.3 in appendix H). The mediating effect of innovativeness on collaboration planning – supply chain performance relationships for upstream activities will be addressed first, in section 5.3.4.1. The analysis of the same mediating effect on downstream activities will follow in section 5.3.4.2.

5.3.4.1 Testing the role of mediators for upstream activities

Table 5.23 gives an overview of the mediation effects (CM for complete mediation or PM for partial mediation) of innovativeness on the relationships between collaboration planning and supply chain performance for upstream activities.[4]

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[3] These correlations are also summarized in tables G.1 and H.1 of appendices G and H.
[4] For more detail, refer to tables G.1, G.2 and G.3 in appendix G.

Table 5.23 –Overview of mediating effect (upstream)

Independent variables: ⇐ **Collaborative planning**	Mediator variables: ⇐ **Process innovations**			⇐ **Relational innovations**		Dependent Variables: ⇔ **Supply chain performance**
	Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements	
Develop front-end agreement						
Collaboration agreement						Output measures
						Resource measures
	CM	**CM**	**CM**	**CM**	**CM**	Flexibility measures
Collaboration process mapping						Output measures
		CM	*PM*	*PM*		Resource measures
	CM	**CM**	**CM**	**CM**	**CM**	Flexibility measures
Continuous improvement	**CM**	**CM**	**CM**	*PM*		Output measures
		CM	**CM**	*PM*		Resource measures
	CM	**CM**	**CM**	**CM**		Flexibility measures
Create joint business plan						
Strategic collaborative actions						Output measures
						Resource measures
						Flexibility measures
Tactical collaborative actions						Output measures
						Resource measures
	PM	*PM*	**CM**	**CM**	**CM**	Flexibility measures
Collaboration tools efficiency	**CM**	**CM**	*PM*	**CM**	*PM*	Output measures
		CM	**CM**	**CM**		Resource measures
	PM	**CM**	*PM*	**CM**	*PM*	Flexibility measures

CM indicates a complete mediation while PM indicates a partial mediation

The main mediation effects displayed in table 5.23 are explained as follows:

(i) All five innovation variables (process creation, logistical processes, production processes, partnership development and relationship development) have a strong mediating effect on the relationship between the three variables that represent the development of a front-end agreement and the flexibility measure of supply chain performance. The development of a front-end agreement is a first step towards supply chain collaboration with suppliers. To yield more intangible benefits, such as flexibility measures (product variety, product volumes flexibility and new product development), this high-level (not very detailed) front-end agreement between a supply chain member and its suppliers should be accompanied by the development of new, innovative activities in order to be more valuable. Reaching an agreement on the different supply chain issues is important, but transforming words into actions through process and relational innovations should improve supply chain flexibility.

(ii)The same five innovation variables play a mediating role (either complete or partial) on the relationship between two variables that represent the creation of a joint business plan (tactical collaborative actions and collaboration tools efficiency) and one of the performance variables (flexibility). These two joint business plan variables provide the details on the items produced, the resources required and the systems or tools to be used during supply chain activities. They have a strong direct influence on output and resource measures as these measures are often defined in the business plan. However, a more complex level of analysis is required for flexibility measures as they involve the interaction of a large number of variables (for example, flexibility

in production volumes must take into consideration variables such as supplier lead times, required workforce, equipment availability, distribution costs, etc.). Therefore, the development of innovative processes and relationships enabling a joint analysis of the material and information flowing upstream in the supply chain will positively influence (mediate) the relationship between these two joint business plan variables and the flexibility measures.

(iii) Three innovation variables (logistical processes, production processes and partnership development) act as mediators between three of the six collaboration planning variables (collaboration process mapping, continuous improvement and collaboration tools efficiency) and all three supply chain performance variables (output, resource and flexibility measures). Knowing how you are going to collaborate with your suppliers (collaboration process mapping), what steps are required to improve upstream supply chain relationships (continuous improvement), and how efficiently you use the tools to collaborate, will undoubtedly improve supply chain performance. However, when these activities are associated with specific processes (such as production and logistics-related processes) or supplier partnerships, better supply chain performance may be attained since the collaboration planning is accompanied by the improvement of identifiable activities rather than general supply chain issues.

(iv) Surprisingly, no mediating effects of innovation variables are observed on the relationships between strategic collaborative actions and supply chain performance. Strategic collaborative actions involve the sharing of precise information and the

formulation of partnership strategies, but they do not deal with global aspects of supply chain relationships (covered by the front-end agreement), or handle more practical actions (covered by the other two variables under the joint business plan). The strategic collaborative actions' overlapping functions may partially explain the fact that innovations do not mediate these relationships: generally, strategic collaborative actions yield hands-on tactical collaborative actions; when dealing with suppliers, processes and relational innovations are usually created to react to tactical actions rather than to more strategic ones.

5.3.4.2 Testing the role of mediators for downstream activities

For downstream activities, the main mediation effects of innovativeness on the relationships between collaboration planning and supply chain performance are summarized in table 5.24.[5] These main mediation effects are as follows:

(i) All five innovation variables have a mediating effect (partial mediation for process creation and complete mediation for the other four innovation variables) on the relationship between the collaboration agreement and two supply chain performance measures (output and resource). The collaboration agreement, which comprises activities such as the sharing of objectives and the definition of opportunities and metrics, is the first step of the collaboration initiative. In this case, process and relational innovations may help a firm to evaluate the efforts required to collaborate with a customer and clarify what should go into the relationship and what should come out of it.

[5] For more detail, refer to tables H.1, H.2 and H.3 in appendix H.

Table 5.24 –Overview of mediating effect (downstream)

Independent variables: ⇒ **Collaborative planning**	Mediator variables: **Process innovations ⇒** Process creation	Logistical processes	Production processes	**Relational innovations ⇒** Partnership development	Relationship improvements	Dependent Variables: ⇔ **Supply chain performance**
Develop front-end agreement						
Collaboration agreement	*PM*	**CM**	**CM**	**CM**	**CM**	Output measures
	PM	**CM**		**CM**	**CM**	Resource measures
						Flexibility measures
Collaboration process mapping	*PM*	*PM*	*PM*	*PM*	*PM*	Output measures
						Resource measures
	CM	**CM**	**CM**	**CM**	**CM**	Flexibility measures
Continuous improvement						Output measures
						Resource measures
						Flexibility measures
Create joint business plan						
Strategic collaborative actions						Output measures
		PM		*PM*	*PM*	Resource measures
		CM	**CM**	**CM**		Flexibility measures
Tactical collaborative actions						Output measures
		PM		*PM*	**CM**	Resource measures
		CM	**CM**	*PM*	**CM**	Flexibility measures
Collaboration tools efficiency						Output measures
						Resource measures
	PM	*PM*	**CM**	*PM*	*PM*	Flexibility measures

CM indicates a complete mediation while *PM* indicates a partial mediation

(ii) The same five innovation variables have a strong mediating effect on the relationship between collaboration process mapping and flexibility measures. The second step in the development of a front-end agreement specifies more detailed topics than the previous step (collaboration agreement), such as the launch of specific collaborative business functions and the identification of the information to be shared. In order to be efficient, especially from a flexibility standpoint, these collaboration topics need to be monitored. The development of innovative processes and of new relationships helps to manage the information originating from these actions, which are often required to improve flexibility.

(iii) Flexibility measures are once again part of the last mediation effect for downstream activities. The relationships between the three variables, that represent the creation of joint business plan, and the flexibility measures are mediated by four of the five innovation variables (the exception being process creation). The joint business plan is a fairly new approach for firms collaborating in a supply chain. As it involves the sharing of explicit strategic and tactical information, and the use of specialized collaboration tools, a great deal of information must be systematized and managed. The complexity of the relationship between this joint business plan and the flexibility dimension of performance is significant; but the relationship should be simplified (positively mediated) by the development of new production and logistical processes, which play an important role in supporting the actions of the joint business plan.

5.3.4.3 Mediation effect: Comparing upstream and downstream activities

When comparing upstream activities to downstream activities, one finds some noteworthy differences:

(i) ***Process and relational innovations:*** When dealing with customers, process innovations do not have the same mediating effect as they do for upstream activities. Although they affect some aspects of supply chain performance, compared to supplier relationships, process innovations do not have as much mediation impact on relationships between collaboration planning and supply chain performance for downstream activities. On the other hand, relational innovations are more important for downstream activities than for upstream ones. Relational innovations are key in this industry where business with customers is still carried out through personal contacts. Nurturing these relations by improving trust and loyalty is profitable in terms of supply chain performance measures.

(ii) ***Output and resource measures:*** For downstream activities, many mediating effects are measured through the collaboration agreement variable, whereby the mediators affect its relationships with output and resource measures. These effects are quite different from the supplier side, where the mediating role of innovation was mostly observed in (i) the collaborative improvement – supply chain performance relationship and (ii) the collaboration tool effectiveness variables – supply chain performance relationship. This result confirms the sales approach used in the telecommunications industry, where customer relationship management focuses on

business strategies but does not go into detail as to how the relationship will be managed.

(iii) ***Strategic collaborative actions:*** Another surprising difference to be found concerns the mediating role of innovation on the relationship between strategic collaborative actions and flexibility measures. The strategic collaborative actions variable is not affected by innovation for upstream activities, but when dealing with customers, actions such as partnership strategy involvement and periodic information sharing are positively reinforced by logistics and production-related processes as well as by relational innovations that target new partners and retain traditional ones. This finding is aligned with the strategic collaborative actions of many firms in the industry: customer relationships are strategic but supplier relationships are only routinely reactive (i.e. suppliers will react to customer choices).

5.3.5 Summary of the results for research propositions (P1, P2, P3, P4 and P5)

Table 5.25 displays the results of the tests carried out for propositions P1 to P5 (section 5.3). The table indicates the outcome for both upstream and downstream activities.

Table 5.25 – Summary of the results of propositions P1 to P5

Propositions		Upstream ⇐ activities	Downstream activities ⇒
P1.1: The development of a *front-end agreement* has a positive influence on *innovativeness*	Process innovations	Supported	Supported
	Relational innovations	Supported	Supported
P1.2: The creation of a *joint business plan* has a positive influence on *innovativeness*	Process innovations	Supported	Supported
	Relational innovations	Supported	Supported
P4.1: The relationships observed in P1 are controlled by variables such as *product demand/customization or position held by suppliers* in the supply chain	Product demand/ customization	Partly supported	Partly supported
	Position held by suppliers	Not supported	Partly supported
P2.1: The development of a *front-end agreement* has a positive influence on *supply chain performance*, as assessed by output, resource and flexibility measures	Output measures	Partly supported	Partly supported
	Resource measures	Partly supported	Partly supported
	Flexibility measures	Supported	Partly supported
P2.2: The creation of a *joint business plan* has a positive influence on *supply chain performance*, as assessed by output, resource and flexibility measures	Output measures	Partly supported	Not supported
	Resource measures	Partly supported	Partly supported
	Flexibility measures	Partly supported	Supported
P4.2: The relationships observed in P2 are controlled by variables such as *product demand/customization or position held by suppliers* in the supply chain	Product demand/ customization	Not supported	Not supported
	Position held by suppliers	Partly supported	Not supported
P3.1: *Process innovations* have a positive influence on *supply chain performance*, as assessed by output, resource and flexibility measures	Output measures	Supported	Supported
	Resource measures	Partly supported	Partly supported
	Flexibility measures	Supported	Supported

(In order for propositions P4.1, P4.2 and P4.3 (influence of control variables) to be partly supported, a variation of 10% in the relationships had to occur more than twice for each control variable.)

Propositions		Upstream ⇐ activities	Downstream activities ⇒
P3.2: *Relational innovations* have a positive influence on *supply chain performance*, as assessed by output, resource and flexibility measures	Output measures	Supported	Supported
	Resource measures	Partly supported	Supported
	Flexibility measures	Supported	Supported
P4.3: The relationships observed in P3 are controlled by variables such as *product demand/customization or position held by suppliers* in the supply chain	Product demand/ customization	Partly supported	Not supported
	Position held by suppliers	Partly supported	Not supported
P5.1: The effect of the development of a *front-end agreement* on supply chain performance is mediated by *process innovations*	Collaboration agreement	Partly supported	Partly supported
	Collaboration process mapping	Partly supported	Partly supported
	Continuous improvement	Supported	Not supported
P5.3: The effect of the development of a *front-end agreement* on supply chain performance is mediated by *relational innovations*	Collaboration agreement	Partly supported	Partly supported
	Collaboration process mapping	Partly supported	Partly supported
	Continuous improvement	Partly supported	Partly supported
P5.4: The effect of the creation of a *joint business plan* on supply chain performance is mediated by *process innovations*	Strategic collaborative actions	Not supported	Partly supported
	Tactical collaborative actions	Partly supported	Partly supported
	Collaboration tools	Supported	Not supported
P5.6: The effect of the creation of a *joint business plan* on supply chain performance is mediated by *relational innovations*	Strategic collaborative actions	Not supported	Partly supported
	Tactical collaborative actions	Partly supported	Partly supported
	Collaboration tools	Partly supported	Partly supported

5.4 Fit as gestalt: Towards collaboration configurations

Our research design is exploratory. We will therefore try to discover collaboration configurations (or common and repeated attributes of different types of collaboration) that were not specified in our research propositions (P1, P2, P3, P4 and P5). The analytical scheme retained here is an interdependence technique called cluster analysis, which is one of the most utilized fit as gestalt methods (Ketchen and Shook, 1996), and is often applied for exploratory purposes. This technique is used to group units and form typologies (Singh, 1990). It is well suited for forming groups with maximal homogeneity within groups and maximal heterogeneity between groups. In this study, the cluster analysis technique is used to develop a typology of collaboration among firms within a supply chain environment.

The cluster analysis was executed on four types of collaboration planning activities: front-end agreement and joint business plan for both upstream and downstream perspectives. The results of a cluster analysis reveal three major groups, differentiated by the level and focus of collaboration planning activities (table 5.26). The results obtained from the cluster analysis are quite robust since all three groups differ significantly ($p \leq .0006$) in terms of activities conducted to develop a front-end agreement and to create joint business plans with both suppliers and customers.

The first group, which contains 17 companies, carries out minimal collaboration planning on both sides of the supply chain. The mean scores for all four collaboration-planning variables (from 4.358 to 4.661) are lower than those in the other two clusters.

Table 5.26 – Clusters for collaboration planning variables

		Group 1	Group 2	Group 3	
		Minimal collaboration planning	Traditional one-way collaboration planning	Full two-way collaboration planning	
Collaborative planning		mean[1]	mean[1]	mean[1]	p[2]
Front-end agreement with supplier	FEAS	4.495	<u>6.121</u>	5.755	.0000
Joint business plan with supplier	JBPS	4.479	5.230	<u>6.043</u>	.0000
Front-end agreement with customer	FEAC	4.661	5.448	<u>5.787</u>	.0006
Joint business plan with customer	JBPC	4.358	4.505	<u>5.954</u>	.0000
% of firms in each group		*42.5%*	*17.5%*	*40%*	

Chebyshev measure, Ward method
underlined values: highest value of each row

1: Based on Likert scales where 1 = does not execute these CPFR activities in the supply chain and 7= executes these CPFR activities fully in the supply chain
2: Level of significance of Kruskal-Wallis (one-way)

The second and smallest of the three groups includes 7 companies that tend to plan collaboration in a more traditional manner by concentrating mainly on their suppliers (means for front-end agreement of 6.121 and joint business plan of 5.23 for upstream activities, versus 5.448 and 4.505, respectively, for downstream activities). These companies may bring the power structure in the supply chain into play and use their strong position to deal with suppliers.

Finally, the 16 companies in the third cluster aim at creating a seamless supply chain by planning collaboration on both sides of the chain. The means are relatively similar when comparing upstream activities (FEAS = 5.755 and JBPS =6.043) to downstream activities

(FEAC = 5.787 and JBPC =5.954) as companies in this third group are aware of the importance of collaborating with all partners (for both upstream and downstream).

As demonstrated in table 5.26, the three groups of firms have significantly different types of collaboration configurations. Further validation of these configurations can be obtained from discriminant analysis (see table 5.27). The objective of this procedure to predict the probability that a particular firm will belong to a particular group based on the four collaboration planning variables (Hair et al., 1998).

Table 5.27 – Classification matrix of collaboration planning discriminant analysis

Actual group	**Predicted group**			**Actual group size**	**Percentage correctly classified**
	1	2	3		
Group 1- Minimal collaboration planning	15	2	0	17	88.2%
Group 2- Traditional one-way collaboration planning	1	6	0	7	85.7%
Group 3- Full two-way collaboration planning	0	0	16	16	100%
Overall classification	16	8	16	40	**92.5%**

Box's M: 21.77 p = 0.6358 Direct method
Level of significance of 1st discriminant function: p = 0.0000, Wilks's lambda: 0.115, Eigenvalue: 3.654
Level of significance of 2nd discriminant function: p = 0.0001, Wilks's lambda: 0.536, Eigenvalue: 0.867

The results from the discriminant analysis are robust since:

(i) the Eigenvalues (distance between the centroids) are strong at 3.654 (p = .0000) and 0.867 (p =.0001);

(ii) the test for the equality of the covariance matrices is supported, with the statistical significance of Box's M being over 0.1 (p = .6358);

(iii) the overall classification rate is high, as companies are correctly classified in their respective groups in 92.5% of cases. Group 3 presents a perfect classification rate whereas group 2 has the lowest – but still quite adequate – classification rate, 85.7%.

The three groups differ in the way they collaborate with supply chain partners, but is there a link between collaboration planning configurations, innovativeness and supply chain performance?

The answer seems to be yes, based on the results shown in table 5.28. For process and relational innovations, it is no surprise to observe that the level of innovativeness is directly related to the intensity of collaboration planning in each group. Hence, group 1, minimal collaboration planning, obtains the lowest means for each of the four innovativeness variables. The traditional one-way collaboration planning cluster (group 2) produces means that are slightly higher than those for the minimal collaboration planning group (≈+0.40 for PINS, RINS and PINC and +0.84 for RINC) but is still quite far behind the full two-way collaboration planning group (group 3), which enjoys the strongest results for all four types of innovativeness (with differences of +0.83, +1.12, +1.33 and +0.43 in favor of the two-way collaboration planning cluster).

As for the performance of the supply chain, the most noticeable result is the mean of 5.48 attributed to flexibility measures for two-way collaboration planning (the only mean over the 5.0 mark). For resource measures, the results are weak in all three clusters, with mean

scores of 3.55, 3.82 and 4.44. For output measures, the level of significance of the Kruskal-Wallis test is not satisfactory as all three clusters have similar mean scores (4.61, 4.69 and 4.87). Therefore, in terms of supply chain performance, full two-way collaboration planning seems to be the only way for a company to differentiate itself from competitors by improving flexibility measures.

Table 5.28 – Fit as gestalt: Collaboration configurations, innovativeness and supply chain performance

		Group 1	Group 2	Group 3	
		Minimal collaboration planning	Traditional one-way collaboration planning	Full two-way collaboration planning	
		mean[1]	mean[1]	mean[1]	p[2]
Innovativeness					
Process innovation, supplier	PINS	4.70	5.11	5.94	.0007
Relational innovation, supplier	RINS	4.68	5.07	6.19	.0009
Process innovation, customer	PINC	4.53	4.73	6.06	.0004
Relational innovation, customer	RINC	4.92	5.76	6.19	.0024
Supply chain performance					
Resource measures	RM	3.55	3.82	4.44	.0056
Output measures	OM	4.61	4.69	4.87	.4921
Flexibility measures	FM	4.65	4.41	5.48	.0113

Chebyshev measure, Ward method

1: Based on Likert scales where 1 = does not execute these CPFR activities in the supply chain and 7= executes these CPFR activities fully in the supply chain

2: Level of significance of Kruskal-Wallis (one-way)

CHAPTER 6 - MAIN RESULTS, STRENGTHS AND WEAKNESSES AND FUTURE RESEARCH INITIATIVES

This chapter sums up the most important findings of this study. The main results presented in the two previous chapters are discussed in section 6.1. These results have to be interpreted in light of certain limitations (section 6.2). Theoretical and practical contributions are then outlined in section 6.3. Finally, section 6.4 looks into future research avenues related to supply chain collaboration and CPFR.

6.1 Main results

This study was carried out in two research phases in which different types of data collection methods were used. We will discuss the main results obtained from the field research and from the electronic survey.

6.1.1 Field research results

In addition to exploring issues that would be investigated in the second phase of the study (electronic survey), the field research was mainly conducted to identify collaboration initiatives ongoing in the telecommunications equipment supply chain. The main findings of this research are described in the following paragraphs.

First, the impact of collaboration tools on the dynamics of supply chain relationships was clearly an issue with the companies involved in the field research. For system integrators, different roles may be attributed to collaboration tools, given the constant changes in the telecommunications equipment supply chain: facilitating access to information, which

affects knowledge creation capabilities, and assisting in the design of flexible supply chains. However, the main purpose behind the development of these collaboration tools is the deployment of leaner manufacturing techniques using a demand-driven strategy. This is in line with other findings in the literature (Lummus and Vokurka, 1999; Karaesmen and Dallery, 2000; Vollmann et al., 2000; Frohlich and Westbrook, 2002).

A demand-driven strategy implies tight collaboration between business partners (Tan et al., 1999; Christopher and Towill, 2000; Simatupang and Sridharan, 2002). As the planning of collaboration becomes an integral part of supply chain management processes, the CPFR methodology appears to correspond to the approach chosen by some of the players in the telecommunications equipment supply chain. Collaborative initiatives need to be prepared through joint business plans and front-end agreements, especially in light of the power structure in the supply chain.

The field study also demonstrated that process and relational innovations are enhanced by the development of electronic collaboration activities within the telecommunications equipment supply chain. Supply chain collaboration initiatives such as CPFR change the way firms do business with partners (process innovation) and transform the way they interact with each other (relational innovation). However, they do not appear to influence product innovation, given that issues such as the improvement of product design, product customization, product differentiation and the development of new products were not affected by the deployment and use of electronic collaboration tools.

6.1.2 Electronic survey results

The most important results of the statistical analyses conducted on the data obtained from the electronic survey are as follows:

(i) Process and relational innovations are positively influenced by both the development of a front-end agreement and the creation of a joint business plan (P1). These propositions were supported for both upstream and downstream activities in the supply chain.

(ii) In general, supply chain performance is partly and positively related to the development of a front-end agreement and the creation of a joint business plan (P2). In addition, the development of front-end agreement positively influences flexibility measures for upstream activities while the creation of a joint business plan positively influences these same measures for downstream activities.

(iii) Supply chain performance is also positively influenced by process and relational innovations (P3). The effects of innovations on output and flexibility measures are significant, but resource measures are not as affected.

(iv) The influence of the control variables on propositions P1 to P3 is not very significant. They tend to affect upstream relationships slightly more than their downstream counterparts.

(v) The mediation effect on the relationship between the development of a front-end agreement and supply chain performance is roughly the same for process and relational innovations. The mediation effect is partly supported for the relationships between the first two steps of the front-end agreement (collaboration agreement and

collaboration process mapping) and supply chain performance. However, the relationships involving continuous improvement (third step of the front-end agreement) and supply chain performance are mediated by process innovations for upstream activities, but not for downstream activities. The mediation effect is only partly supported for these relationships (both upstream and downstream) using the relational innovation mediator.

(vi) As a whole, the effect of the creation of a joint business plan on supply chain performance is partly mediated by process innovations, and particularly by relational innovations. However, no mediating effect (of either process or relational innovations) is detectable in the relationship between strategic collaborative actions and supply chain performance during upstream activities.

(vii) Using cluster analysis, we attempted to create collaboration configurations. Three separate groups with different levels and types of collaboration planning were identified: 42.5% of firms are positioned in the minimal collaboration planning group, 17.5% in the traditional one-way collaboration planning group, and 40% in the full two-way collaboration planning group. These groups appropriately represent the telecommunications equipment supply chain, where firms are either deeply involved in supply chain collaboration or very minimally concerned by it. Furthermore, these groups are quite similar to those identified by Fawcett and Magnan (2002) where four different levels of supply chain integration are presented (47% of firms in the internal process integration group, 34% of firms in the first-tier supplier integration group, 11% in the key customers integration group, and 8% of firms in the two-way integration group).

6.2 Limitations

The methodology retained for the research design presents both strengths and weaknesses. Because two complementary types of data collection methods were carried out (i.e. field study and electronic survey), this research initiative is deeply rooted in the reality of the firms operating in one supply chain. However, the tight focus on one supply chain represents at the same time a limitation (i.e. sample size; see section 6.2.2) and a major strength (section 6.2.1).

6.2.1 Selection of a specific collaborative setting: One supply chain in one industry

The reasons for selecting one specific supply chain were as follows:

(i) the innovative setting of the telecommunications equipment industry, which is characterized by short product life-cycles and often requires the contribution of several supply chain partners;

(ii) the widespread use of electronic collaboration tools among supply chain partners, which is often a prerequisite to collaboration planning activities (e.g. CPFR);

(iii) the relatively high level of outsourcing activities in the industry, particularly for production-related activities, which drives supply chain members to collaborate;

(iv) the complexity of reaching several interconnecting levels of a supply chain which involves more than a dyadic buyer-seller relationship.

These reasons for the selection of one specific supply chain do not compensate for the lack of generalization to other supply chains, but this limitation is offset by the quality of information obtained from a more in-depth study. The dilemma of external versus internal validity is omnipresent with research initiatives and ours is no exception. Furthermore, the field study was geographically limited to firms located in eastern

Canada in order to reduce travel costs; however, the worldwide operations of the main OEM/system integrator studied motivated this research initiative to develop a method that would reach the largest number of international respondents. The regional aspect of the research initiatives was eliminated to a certain extent by the worldwide questionnaire available on the Internet.

Finally, the rich data obtained from the four participating firms is further validated by the additional information obtained from a larger number of firms (53 responding firms).

6.2.2 Sample size

By focusing on the collaboration initiatives of a specific supply chain, the study could only reach a certain number of firms carrying out collaboration planning activities in this particular context. Supply chain collaborative measures, such as CPFR, are still new in the telecommunications equipment industry, which limits the number of companies applying them with the use of specific electronic collaboration tools. These innovative measures have not yet reached full maturity in this industry and this appears to be one of the reasons for the limited number of respondents identified in this study. Nevertheless, the steady adoption of such collaborative practices by supply chain partners makes this exploratory study interesting although the number of respondents is not as large as it could have been with a more mature subject.

The limited number of firms that took part in the second phase of this research initiative imposed some restrictions on the types of multivariate statistical analyses that could be

carried out. The collaborative activities were planned and executed in the supply chain of one large system integrator and the survey was conducted with all supply chain partners that play an important role in the development of this supply chain. Hence, the specific profiles of the responding firms improve the accuracy of the information on a specific subject, and thus have high internal validity.

Another impediment to the maximization of the response rate is the use of a new method of data collection. The availability of the survey through the Web was perceived by some companies as an interesting and easy way to respond to the questionnaire. Others had difficulties answering through the Web since the questionnaire needed the input of several persons. The dual nature of the questionnaire, which required the input of both procurement and sales departments, increased its complexity. However, this fact also establishes the originality of this study in that it analyzed perceptions of both upstream and downstream activities within the supply chain.

As in the field study, multiple respondents are also a key feature of the electronic survey. Questions related to upstream and downstream activities required the involvement of different respondents within one company and sometimes within one department (for example, the purchasing department for questions related to upstream activities and the sales department for those related to downstream activities). In fact, some questions were more appropriate for managers to answer and others for technical personnel.

According to the follow-up discussions with some respondents, in some cases they answered the questions as a group while others passed it from one person to the next to

confirm and complement the answers provided by their peers. Knowing the exact source of information becomes difficult. However, with at least two respondents per company, it is assumed that the data is more reliable then it would have been with a single informant (Bowman and Ambrosini, 1997).

The limited number of participating firms could have hindered this study, but the high response rate (40.8%) strengthens this research initiative as the most frequent users of electronic collaboration tools (suppliers of the OEM) were identified and contacted to answer the electronic survey first.

6.2.3 Supply chain metrics

An integrated supply chain involves the participation of both suppliers and customers in supply-chain-related activities. The initiatives of several large firms to implement a demand-driven strategy in their supply chains (Lummus and Vokurka, 1999; Frohlich and Westbrook, 2002) make the analysis of collaborative supply chain initiatives quite complex.

However, the complexity of analyzing both upstream and downstream activities strengthens this study, since these activities can be monitored and compared using identical criteria. Nonetheless, in dealing with both sides of the supply chain, we forgo the level of detail that could be attained by analyzing only one side of a supply chain. For example, further details (type and amount of data exchanged) on the collaboration tools might have been interesting but the number of collaboration tools (8) used in the supply chain makes this issue very complex to assess with a survey instrument.

Assessing the performance of a complete supply chain is not an easy task in itself. One question comes to mind: How are the supply chain activities of each member of the chain interconnected? One way to answer this question is to follow the supply chain path of a particular product and measure the performance at each node of the chain. However, this methodology requires each member of the supply chain to agree to participate in a field research and to provide detailed information on a particular product. This approach would have been not only time-consuming but also very difficult because of the reluctance of several firms in the telecommunications industry to give out information on highly innovative short-life-cycled products. We opted for another approach, where supply chain interconnections were based on collaborative tools that allowed for the exchange and sharing of data. In order to assist in the design of the supply chain and improve the use of the collaboration tools, collaborative planning activities were used simultaneously, which confirmed different issues related to collaborative activities in the supply chain (e.g. demand-driven strategy). However, with this approach, the supply chain performance measures are those perceived by the respondents and indicate how collaboration planning has affected their performance of supply-chain-related activities.

Few firms are engaged in an integrated supply chain that involves the supplier's suppliers and the customer's customers (Akkermans et al., 1999; Whippel et al., 1999; Harps and Hansen, 2000). To our knowledge, this is one of the few studies of supply chain collaboration that take both upstream and downstream activities into account. Other studies, such as Fawcett and Magnan's (2002), analyze both sides of the supply chain but

do not cover all the different layers. This particular feature contributes largely to the originality of our study.

6.2.4 Number of research variables and conceptual model

The conceptual model was developed with the knowledge that more than 400 firms in the telecommunications equipment industry could be contacted to complete the survey (versus the 130 firms that were actually contacted). Therefore, in order to cover and assess a large portion of the collaborative activities encountered in the industry, the number of research variables (items and questions) was rather large.

The number of variables was especially large for the field study, which allowed us to limit the number for the second phase of the study by eliminating variables that did not play a major role during the field survey (e.g. product innovation) and by creating constructs that facilitated the statistical analysis of the electronic survey.

6.2.5 Contextual factors

Several contextual factors influenced the course of this study, and particularly the sudden and unexpected slowdown in the telecommunications equipment industry in 2001. This slowdown affected the relationships between the large system integrator and its suppliers. The already highly competitive environment gave way to even tenser manufacturer-supplier relationships, with huge amounts of inventories left in the hands of each member of the supply chain.

These contextual factors favor internal validity but the results may not be generalizable to other industries. On the other hand, the content validity is difficult to establish since performance measures are those perceived by each member of the supply chain and are oriented towards manufacturing-related issues. For example, the financial performance of the supply chain partners is not covered in the conceptual model of this study. This may be explained by the fact that more economically oriented performance measures are not directly linked to collaboration tools, unlike more operational performance measures. The link between replenishment/ forecasting tools and the level of inventory is quite straightforward. However, the association between revenue increases or market fluctuations (stock prices) and collaborative initiatives in the supply chain is quite difficult to tease out.

With the recent interest in e-commerce tools to support collaborative actions in a supply chain, several issues have emerged. The use of very specific measures adapted from the literature review, from previous studies and from more professional methods (such as CPFR) allows for the face validity to be high in this research context.

6.3 Theoretical and practical contributions

This section describes the theoretical and practical contributions made by this research initiative. Due to the exploratory nature of this study, these contributions are mainly oriented towards a clearer understanding of different electronic collaborative initiatives within a supply chain. This study analyzes a very important topic that will shape the future of certain industries. It deals with the increasing range of business processes that

used to be mainly internal to firms but that now reach out to key members of the supply chain, either by outsourcing or joint activities or simply by the exchange of critical information (i.e. externalization of activities to business partners). A number of theoretical and practical initiatives are exploring the concept of supply chain collaboration, either through detailed analyses of industries with integrated supply chains or by marketing collaboration-oriented technologies such as the second wave of ERPs with complementary modules such as Advanced Planning and Scheduling (APS), Collaborative planning, forecasting and replenishment (CPFR), supply chain execution (SCE) and supply chain planning (SCP).

6.3.1 Theoretical contributions

The definition of a supply chain is multifaceted and covers a variety of issues. One of the objectives of this study was to shed some light on this under-investigated research area. Various authors have worked on related concepts but very few have been able to conduct research initiatives using empirical data. Both phases of this study (field research and electronic survey) improve our understanding of supply chain collaboration and the role of collaborative planning in determining the performance of a supply chain.

Collaborative planning and the use of methods such as CPFR to support supply chain activities are in the early stages. E-commerce and supply chain research initiatives have focused on the technology and competencies required to carry out collaborative projects in a supply chain. Few (if any) have focused on the preparatory phases of electronic collaboration. Studies on supply chains rarely focus on specific subjects that may

influence their role in an industry. In order to understand the collaborative initiatives undertaken by a supply chain, and eventually analyze supply chains in different industries, this study tries to identify the impact of specific actions (collaboration planning) on the performance of a specific supply chain (telecommunications industry) that uses collaboration tools.

Very few studies deal with different types of innovations. With some exceptions, product and process innovations are usually the targets, and we could not find in the literature a single study that involved relational innovations, although some studies deal with individual aspects of relationship improvement such as trust, commitment or loyalty.

A new conceptual model has been proposed. Variables such as collaborative planning and innovativeness may now be associated with each other as companies not only need to have access to electronic channels such as the Internet to collaborate with supply chain partners but also need to use innovative methods to exchange critical information with business partners. This conceptual model is an attempt to define the possible impact of structuring supply chain actions in order to obtain optimal results. The conceptual model may help researchers in fields such as management of technology, operations management or industrial engineering understand the role of and issues related to collaboration planning with the support of electronic collaboration tools.

The most interesting theoretical contribution is certainly in the approach taken to examine the entire length of the supply chain. Until now, research relating to supply chains has tented to be limited to studies involving only two levels of the chain (Vachon and

Klassen, 2002; Khouja, 2003). Some studies deal with a single-supplier, single-retailer relationship (Goyal, 1995; Hill, 1997; Ertek and Griffin, 2002); others focus on single-supplier, multiple-retailer relationships (Viswanathan and Piplani, 2001; Klastorin et al., 2002). The proposed model covers all levels of the supply chain and addresses both upstream and downstream perspectives.

6.3.2 Practical contributions

As mentioned earlier, externalizing activities while ensuring security and confidentiality is on every company's action list. The continuous increase in outsourcing has forced companies to involve outsiders in the design, development and manufacturing of products, in their ongoing quest for competitive advantage. This is particularly true for the telecommunications industry, given the critical role of electronic manufacturing specialists (EMSs) in that sector. Nonstop technological changes accompany the need for optimal supply chain processes and relationships. Therefore, e-commerce-oriented companies and software vendors (in particular ERPs) may be interested in the following implications of the study:

(i) It may help companies understand the role of CPFR in their supply chain and, more importantly, the role of collaboration planning (first two steps of CPFR) in developing their network.

(ii) This study also identifies and indicates the importance of some collaboration variables in the success of supply chain implementations. Both tactical and strategic

collaborative actions must be carried out during supply chain relationships and the efficiency of collaboration tools is critical to the success of the supply chain information sharing along the supply chain.

(iii) Identifying the right performance indicators is a difficult task. The complexity of performance monitoring is amplified when information is obtained from business partners. The performance measures in this study may now be assessed according to the collaborative actions and strategies suggested by supply chain managers.

(iv) The results of this study should be of interest to prime contractors and their business partners. The impact of collaborative planning on their business is relatively hard to assess and this study proposes some interesting opportunities for the development of collaborative activities with supply chain partners and, most of all, identifies the potential benefits of such initiatives.

(v) Collaborative methods such as CPFR are at the forefront of new enterprise applications. Solution providers such as ERP or SCM vendors are seeking ways to illustrate the advantages of implementing such collaborative applications within a supply chain environment. This study will interest solution providers for two reasons:

- it demonstrates the benefits of applying collaborative initiatives in a competitive supply chain environment;
- it suggests new features and collaboration tool applications that could be developed.

6.4 Future research initiatives

Research initiatives on the impact of collaboration on supply chains are only beginning to emerge in the literature. This study represents one of the first steps towards the evaluation of a supply chain using a complete set of supply chain performance measures as it enabled the relevant performance measures to be identified. According to Lambert and Pohlen (2001), no meaningful performance measures currently exist that span the entire supply chain. They go onto say that each member of a supply chain must develop the best metrics to fit its context and situation. Therefore, a larger field study based on the development and use of context-specific supply metrics could be relevant to enrich our knowledge of topics related to supply chain performance measures. A field study would be an appropriate method for examining the use of the performance measures proposed in this study to assess one specific collaboration tool used by all members of the supply chain (e.g.: forecasting tool).

The ability to carry out collaborative planning activities with several partners is critical in the quest for an efficient supply chain. According to Hoover et al. (2001), planning collaboration generates significant benefits when the collaboration is on a large scale. This "mass collaboration" approach requires a large number of business partners to plan and execute CPFR methods within the supply chain (Holmström et al., 2002). In this study, we focused on the initial steps of CPFR. It would be interesting to look out the later stages, which are more focused on the execution of collaboration actions. By this

means, one could assess the impact of executing a complete cycle of CPFR on a manufacturing supply chain.

Some of our results tend to show that collaboration planning enhances supply chain performance more in terms of intangible benefits (flexibility measures) than tangible benefits (output measures). A focused analysis of the role of intangible benefits in the efficiency of the supply chain rather than of more traditional performance measures (costs, inventory, etc.) should interest many in the field.

Supply chains and the various partnerships formed along them are shaped around products and families of products. Furthermore, collaborative activities are carried out from the earliest phases of product design to the last stages of recycling and re-use. An interesting approach would be to analyze the impact of these collaborative initiatives on the management of the entire product life cycle. Joint collaborative design or procurement activities probably influence the manufacturing or logistical activities carried out later on. This approach could interest more proactive sectors such as the automobile or telecommunications industries.

This study involved companies from the telecommunications equipment industry. Their widespread adoption of collaborative tools is what led to carry out this type of analysis in this industry, more specifically the use of collaborative methods and tools in the relationships between a large OEM and its supplier base. It would be interesting to identify a similar supply chain environment in another industry in order to analyze it and compare it to the telecommunications equipment supply chain examined here. An

industry with short product life cycles and short lead times in which partners are engaged in collaborative planning using electronic collaboration tools could be measured against the telecommunications equipment industry. For example, the computer industry could be comparable; another interesting sector that is proactive in CPFR-related activities is the food industry, which may have the required characteristics to be compared to the telecommunications equipment industry.

Finally, one under-investigated aspect of supply chain studies is the combined analysis of upstream and downstream activities in a multi-stage supply chain. Few studies deal with the multi-stage issue (Muson and Rosenblatt, 2001; Khouja, 2003), and even fewer analyze the supply chain from both supplier and customer perspectives (for example, see Fawcett and Magnan, 2002). This study made the most of these issues within a collaborative planning approach. It would be interesting to work out other supply chain research initiatives, using the same two issues, but for the entire collaboration life cycle (from planning to the termination of the supply chain relationship)

6.5 Concluding remarks

Several important issues were tackled in this study. The complexity of measuring supply chain performance is undeniable, as performance metrics need to be developed and customized (Lambert and. Pohlen, 2001). The telecommunications equipment industry, which was selected, has some experience in supply chain collaboration through the use of collaboration tools. Lambert and Pohlen (2001) also mention that supply chain metrics must be developed case by case, using clear supply chain objectives defined in the first

phases of the collaboration initiatives. This issue was tackled through the first phases of the CPFR method with critical activities related to the definition of joint objectives. A field research in the telecommunications equipment industry was carried out to understand how the partners in this supply chain collaborate but also to identify the right performance metrics to operationalize for a larger electronic survey. The field research built on Beamon's work (1999), which served as a cornerstone in the identification of supply chain performance measures. It also helped define different types of innovations, namely process and relational innovations, which contributed to the beneficial effects of collaboration planning on the supply chain performance. Several avenues were explored in this thesis, but the results clearly indicate that many issues need to be studied in more detail. Visibility is often seen as a critical element in maintaining an efficient supply chain, but the only way to obtain visibility is to plan and execute collaborative actions with both upstream and downstream partners. This study represents an attempt to identify and compare the different activities required in a two-way collaborative supply chain.

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APPENDIX A :

PERFORMANCE OF THE SUPPLY CHAIN

Table A.1 – Supply chain performance constructs

Constructs	Items	Alpha Cronbach	Mean[1]	Std dev
Resource measures	1 to 5	.8893	3.95	1.00
	1. inventory levels 2. inventory costs 3. operational costs 4. personnel requirements 5. equipment utilization energy usage and cost			
Output measures	6 to 14	.6944	4.74	0.58
	6. the number of items produced 7. the time required to produce a product 8. the number of on-time deliveries 9. improvement in customer satisfaction 10. lead times 11. stock-outs 12. fill rates 13. product quality 14. time being utilize to offer a product or service			
Flexibility measures	15 to 18	.7860	4.94	0.87
	15. sales volume 16. the flexibility to deliver the product 17. product variety and product mix 18. new product introductions			

1: Based on Likert scales where 1 = significant decrease in and 7 = significant increase in

Table A.2 – Mean scores of supply chain performance items

Items	Mean [1]	Std dev	Median	Maxi-mum	Mini-mum
1. inventory levels	3.84	1.33	4	7	1
2. inventory costs	3.98	1.25	4	7	1
3. operational costs	3.96	1.16	4	7	1
4. personnel requirements	4.02	1.09	4	7	1
5. equipment utilization energy usage and cost	3.88	1.12	4	7	1
6. the number of items produced	4.30	1.25	4	6	1
7. the time required to produce a product	4.42	1.00	4	7	2
8. the number of on-time deliveries	5.27	1.05	5	7	2
9. improvement in customer satisfaction	5.40	1.07	6	7	3
10. lead times	4.49	1.20	5	7	1
11. stock-outs	4.84	1.19	5	7	2
12. fill rates	4.61	1.16	5	7	1
13. product quality	5.19	1.02	5	7	3
14. time being utilize to offer a product or service	4.02	1.04	4	6	2
15. sales volume	4.84	1.28	5	7	1
16. the flexibility to deliver the product	5.07	1.03	5	7	2
17. product variety and product mix	4.86	1.06	5	7	3
18. new product introductions	5.00	1.13	5	7	2

1: Based on Likert scales where 1 = significant decrease in and 7 = significant increase in

APPENDIX B :

COLLABORATIVE PLANNING – DEVELOPING A FRONT-END AGREEMENT

Table B.1 – Front-end agreement constructs

Constructs	**Items**	**Alpha Cronbach** *When dealing with a supplier*	**Alpha Cronbach** *When dealing with a customer*
Collaboration agreement	1-2-3-13-14	.747	.702
	1. have common objectives of collaboration? 2. have common objectives of confidentiality? 3. determine each party's competencies and resources? 13. define opportunities and impacts on each trading partners? 14. use common means of measurement (metrics) ?		
Collaboration process mapping	4-5-6-7-8-9	.918	.822
	4. Identify systems and their functionalities that contribute to the process? 5. map collaboration points to partner competencies and establish business functions? 6. outline information to be shared (frequency of updates, forecast methodology, data elements, technology, recovery time and response time)? 7. define the service and ordering commitment parameters? 8. determine the staffing involvement and time commitment? 9. assign resources to the process?		
Continuous improvement	10-11-12	.836	.836
	10. establish ground rules for handling disagreements? 11. design an evaluation and benchmark the success of the relationship? 12. exchange a written agreement of the collaboration parameters?		

Table B.2 – Mean scores of front-end agreement constructs

Constructs	Mean [1]	Std dev	Median	Maxi-mum	Mini-mum
When dealing with a supplier					
Collaboration agreement	5.59	0.81	5.6	7	3.8
Collaboration process mapping	5.39	1.09	5.42	7	2.67
Continuous improvement	4.85	1.40	5.0	7	2
When dealing with a customer					
Collaboration agreement	5.51	0.78	5.4	7	4
Collaboration process mapping	5.34	1.01	5.33	7	2.83
Continuous improvement	4.90	1.38	5.0	7	1.67

1: Based on Likert scales where 1 = does not execute these activities in the supply chain and 7 = executes these activities in the supply chain

Table B.3 – Mean scores of front-end agreement items

Items	*When dealing with a supplier*		*When dealing with a customer*	
	Mean[1]	**Std dev**	**Mean[1]**	**Std dev**
1. have common objectives of collaboration?	5.78	0.93	5.65	0.993
2. have common objectives of confidentiality?	6.43	0.74	6.50	0.63
3. determine each party's competencies and resources?	5.86	0.90	5.44	1.06
4. Identify systems and their functionalities that contribute to the process?	5.26	1.33	5.04	1.45
5. map collaboration points to partner competencies and establish business functions?	4.88	1.50	4.81	1.62
6. outline information to be shared (frequency of updates, forecast methodology, data elements, technology, recovery time and response time)?	5.69	1.20	5.65	1.21
7. define the service and ordering commitment parameters?	5.98	1.16	5.74	1.12
8. determine the staffing involvement and time commitment?	5.03	1.49	5.13	1.60
9. assign resources to the process?	5.38	1.20	5.73	1.25
10. establish ground rules for handling disagreements?	5.17	1.47	5.31	1.28
11. design an evaluation and benchmark the success of the relationship?	4.65	1.55	4.48	1.72
12. exchange a written agreement of the collaboration parameters?	4.72	1.78	4.76	1.75
13. define opportunities and impacts on each trading partners?	4.67	1.51	4.98	1.47
14. use common means of measurement (metrics) ?	5.12	1.50	4.91	1.54

1: Based on Likert scales where 1 = does not execute these activities in the supply chain and 7 = executes these activities in the supply chain

APPENDIX C :

COLLABORATIVE PLANNING – CREATE A JOINT BUSINESS PLAN

Table C.1 – Joint business plan constructs

Constructs	**Items**	**Alpha Cronbach** *When dealing with a supplier*	**Alpha Cronbach** *When dealing with a customer*
Strategic collaborative actions	1-2-6	.8852	.7982
	1. develop an agreed-on partnership strategy? 2. share information about periodic business goals and objectives? 6. compare business plans and agree on a joint business plan?		
Tactical collaborative actions	3-4-5	.7188	.7494
	3. discuss roles, objectives, and goals for specific categories of items? 4. identify and develop the appropriate pricing actions? 5. develop individual plans based on previously shared information between partners?		
Collaborative information systems	7.a to 7.h	.9175	.8998
	7. are the systems in place efficient to exchange information for : a. direct procurement b. replenishment c. shortages d. delivery and tracking e. design (CAD) f. forecasting g. capacity planning h. business strategy		

Table C.2 – Mean scores of joint business plan constructs

Constructs	Mean [1]	Std dev	Median	Maxi-mum	Mini-mum
When dealing with a supplier					
Strategic collaborative actions	5.14	1.26	5.0	7	1.67
Tactical collaborative actions	5.46	0.95	5.33	7	2.67
Information systems	5.12	1.15	5.0	7	2
When dealing with a customer					
Strategic collaborative actions	4.83	1.29	5.0	7	2
Tactical collaborative actions	5.40	1.03	5.5	7	2.67
Information systems	4.85	1.26	4.88	7	2

1: Based on Likert scales where 1 = does not execute these activities in the supply chain and 7 = executes these activities in the supply chain

Table C.3 – Mean scores of joint business plan items

	When dealing with a supplier		*When dealing with a customer*	
Items	**Mean[1]**	**Std dev**	**Mean[1]**	**Std dev**
1. develop an agreed-on partnership strategy?	5.32	1.11	5.16	1.41
2. share information about periodic business goals and objectives?	5.39	1.34	5.09	1.33
3. discuss roles, objectives, and goals for specific categories of items?	5.30	1.27	5.26	1.29
4. identify and develop the appropriate pricing actions?	5.90	0.99	5.73	1.21
5. develop individual plans based on previously shared information between partners?	5.15	1.28	5.21	1.36
6. compare business plans and agree on a joint business plan?	4.62	1.66	4.21	1.90
7. are the systems in place efficient to exchange information for :				
a. direct procurement	5.33	1.69	4.76	1.74
b. replenishment	5.33	1.49	4.88	1.74
c. shortages	5.28	1.38	4.86	1.66
d. delivery and tracking	5.34	1.46	5.50	1.46
e. design (CAD)	5.48	1.35	5.22	1.80
f. forecasting	5.10	1.55	4.78	1.66
g. capacity planning	4.89	1.45	4.57	1.84
h. business strategy	4.65	1.51	4.34	1.78

1: Based on Likert scales where 1 = does not execute these activities in the supply chain and 7 = executes these activities in the supply chain

APPENDIX D :

PROCESS INNOVATIONS

Table D.1 – Process innovations constructs

Constructs	**Items**	**Alpha Cronbach** *When dealing with a supplier*	**Alpha Cronbach** *When dealing with a customer*
Process creation	1-2	.905	.668
	1. generate new design processes 2. gear processes to customer requirements		
Logistical processes	3-4-5	.909	.909
	3. improve logistic processes 4. increase flexibility of distribution 5. enhance responsiveness of distribution chains		
Production processes	6-7	.841	.840
	6. design new production processes 7. increase production flexibility		

Table D.2 – Mean scores of process innovations constructs

Constructs	**Mean** [1]	**Std dev**	**Median**	**Maxi-mum**	**Mini-mum**
When dealing with a supplier					
Process creation	5.24	1.28	5.5	7	2
Logistical processes	5.44	1.11	5.67	7	3
Production processes	5.25	1.10	5.0	7	2.5
When dealing with a customer					
Process creation	5.43	1.21	5.5	7	3
Logistical processes	5.45	1.08	5.67	7	2.67
Production processes	5.15	1.27	5.0	7	1.5

1: Based on Likert scales which measure the extent to which collaborative planning allows for the improvement of process innovations: 1 = disagrees that collaboration planning has a positive impact on... and 7 = agrees that collaboration planning has a positive impact on ...

Table D.3 – Mean scores of process innovations items

Items	*When dealing with a supplier*		*When dealing with a customer*	
	Mean[1]	**Std dev**	**Mean[1]**	**Std dev**
1. generate new design processes	5.08	1.50	5.17	1.53
2. gear processes to customer requirements	5.38	1.14	5.65	1.23
3. improve logistic processes	5.44	1.16	5.40	1.03
4. increase flexibility of distribution	5.32	1.29	5.21	1.39
5. enhance responsiveness of distribution chains	5.50	1.61	5.60	1.13
6. design new production processes	5.21	1.32	4.93	1.58
7. increase production flexibility	5.26	1.04	4.98	1.42

1: Based on Likert scales which measure the extent to which collaborative planning allows for the improvement of process innovations: 1 = disagrees that collaboration planning helps and 7 = agrees that collaboration planning helps…

APPENDIX E :

RELATIONAL INNOVATIONS

Table E.1 – Relational innovations constructs

Constructs	**Items**	**Alpha Cronbach** *When dealing with suppliers*	**Alpha Cronbach** *When dealing with a customers*
Partnership development	1-5	.733	.777
	1. target new groups 5. retain partners, customers and suppliers		
Relationship improvement	2-3-4	.972	.916
	2. build or improve trust with customers and suppliers 3. enrich quality of relations 4. improve loyalty		

Table E.2 – Mean scores of relational innovations constructs

Constructs	**Mean** [1]	**Std dev**	**Median**	**Maxi-mum**	**Mini-mum**
When dealing with suppliers					
Partnership development	5.15	1.27	5	7	2.5
Relationship improvements	5.63	1.07	6	7	2.67
When dealing with customers					
Partnership development	5.50	1.08	5.5	7	2.5
Relationship improvements	5.61	1.07	5.67	7	2.67

1: Based on Likert scales which measure the extent to which collaborative planning allows for the improvement of relational innovations: 1 = disagrees that collaboration planning has a positive impact on... and 7 = agrees that collaboration planning has a positive impact on ...

Table E.3 – Mean scores of relational innovations items

	When dealing with a supplier		*When dealing with a customer*	
Items	**Mean[1]**	**Std dev**	**Mean[1]**	**Std dev**
1. target new groups	4.72	1.67	5.34	1.29
2. build or improve trust with customers and suppliers	5.63	1.09	5.61	1.21
3. enrich quality of relations	5.68	1.01	5.73	1.15
4. improve loyalty	5.57	1.20	5.50	1.11
5. retain partners, customers and suppliers	5.60	1.17	5.61	1.08

1: Based on Likert scales which measure the extent to which collaborative planning allows for the improvement of relational innovations: 1 = disagrees that collaboration planning helps and 7 = agrees that collaboration planning helps…

APPENDIX F :

INFLUENCE OF CONTROL VARIABLES

Evaluating P1 and P4.1 for upstream activities

Table F.1– Strength of the relationships between collaborative planning and innovativeness when dealing with suppliers controlling for product demand/customization

Controlling for product demand/customization		Innovativeness when dealing with suppliers				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relation. Improv.
Collaborative planning		PCS	LPS	PPS	PDS	RIS
Develop front-end agreement						
- Collaboration agreement	CAS	0.5255	0.5105	0.4536	0.5708	0.4630
- Collaboration process mapping	CPMS	0.4194	0.6016	0.2810	0.5402	0.5296
- Continuous improvement	CIS	0.2705	0.3863	0.2966	0.2861	0.2029
Create joint business plan						
- Strategic collabo. actions	SCAS	0.3455	0.8197	0.3033	0.7064	0.7101
- Tactical collabo. actions	TCAS	0.5649	0.8554	0.4988	0.7899	0.7705
- Collaboration tools efficiency	CTES	0.4558	0.6596	0.2620	0.7664	0.6634

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table F.2– Strength of the relationships between collaborative planning and innovativeness when dealing with suppliers controlling for position held in supply chain

Controlling for position held in supply chain		Innovativeness when dealing with suppliers				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relation. Improv.
Collaborative planning		PCS	LPS	PPS	PDS	RIS
Develop front-end agreement						
- Collaboration agreement	CAS	0.5549	0.5217	0.4723	0.5779	0.4649
- Collaboration process mapping	CPMS	0.4341	0.5629	0.2848	0.4870	0.4772
- Continuous improvement	CIS	0.3266	0.4135	0.3223	0.3251	0.2170
Create joint business plan						
- Strategic collabo. actions	SCAS	0.4485	0.8369	0.3479	0.7445	0.7158
- Tactical collabo. actions	TCAS	0.6428	0.8710	0.5238	0.8276	0.7744
- Collaboration tools efficiency	CTES	0.4999	0.6743	0.2909	0.7715	0.6741

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Evaluating P1 and P4.1 for downstream activities

Table F.3– Strength of the relationships between collaborative planning and innovativeness when dealing with customers controlling for product demand/customization

Controlling for product demand/customization		Innovativeness when dealing with customers				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
Collaborative planning		PCC	LPC	PPC	PDC	RIC
Develop front-end agreement						
- Collaboration agreement	CAC	0.3949	0.2619	0.5493	0.6092	0.5249
- Collaboration process mapping	CPMC	0.3510	0.2953	0.3760	0.4666	0.3786
- Continuous improvement	CIC	0.2485	0.3863	0.3045	0.5060	0.3658
Create joint business plan						
- Strategic collabo. actions	SCAC	0.1568	0.3220	0.5548	0.5700	0.6370
- Tactical collabo. actions	TCAC	0.4050	0.4104	0.7230	0.7307	0.6456
- Collaboration tools efficiency	CTEC	0.4626	0.4905	0.5209	0.4236	0.475

Pearson correlation coefficients

Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table F.4– Strength of the relationships between collaborative planning and innovativeness when dealing with customers controlling for position held in supply chain

Controlling for position held in supply chain		Innovativeness when dealing with customers				
		Process innovations			Relational innovations	
		Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
Collaborative planning		PCC	LPC	PPC	PDC	RIC
Develop front-end agreement						
- Collaboration agreement	CAC	0.4033	0.2354	0.5521	0.5739	0.4606
- Collaboration process mapping	CPMC	0.4079	0.2272	0.4072	0.3657	0.1181
- Continuous improvement	CIC	0.2534	0.3909	0.3047	0.4902	0.3311
Create joint business plan						
- Strategic collabo. actions	SCAC	0.1670	0.3026	0.5839	0.5014	0.5121
- Tactical collabo. actions	TCAC	0.4186	0.4117	0.7322	0.6891	0.5650
- Collaboration tools efficiency	CTEC	0.464	0.4665	0.5167	0.3959	0.4531

Pearson correlation coefficients

Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Evaluating P2 and P4.2 for upstream activities

Table F.5– Strength of the relationships between collaborative planning and supply chain performance when dealing with suppliers controlling for product demand/customization

Controlling for product demand/customization		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Collaborative planning		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAS	0.1797	0.1518	0.2545
- Collaboration process mapping	CPMS	0.1121	0.1477	0.1689
- Continuous improvement	CIS	0.2802	0.3745	0.2327
Create joint business plan				
- Strategic collaborative actions	SCAS	0.0090	0.0648	0.1818
- Tactical collaborative actions	TCAS	0.1155	0.1710	0.3310
- Collaboration tools efficiency	CTES	0.4083	0.2722	0.4303

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table F.6– Strength of the relationships between collaborative planning and supply chain performance when dealing with suppliers controlling for position held in supply chain

Controlling for position held in supply chain		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Collaborative planning		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAS	0.1513	0.1401	0.2745
- Collaboration process mapping	CPMS	0.0345	0.1073	0.1833
- Continuous improvement	CIS	0.2550	0.3680	0.2552
Create joint business plan				
- Strategic collaborative actions	SCAS	0.0379	0.1012	0.2358
- Tactical collaborative actions	TCAS	0.1544	0.2109	0.3752
- Collaboration tools efficiency	CTES	0.4175	0.2845	0.4497

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Evaluating P2 and P4.2 for downstream activities

Table F.7– Strength of the relationships between collaborative planning and supply chain performance when dealing with customers controlling for product demand/customization

Controlling for product demand/customization		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Collaborative planning		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAC	0.1907	0.1805	0.1591
- Collaboration process mapping	CPMC	0.3230	0.1054	0.2265
- Continuous improvement	CIC	0.1240	0.1034	0.0261
Create joint business plan				
- Strategic collaborative actions	SCAC	0.1166	0.4518	0.3586
- Tactical collaborative actions	TCAC	0.1099	0.2606	0.3651
- Collaboration tools efficiency	CTEC	0.1576	0.0066	0.3753

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table F.8– Strength of the relationships between collaborative planning and supply chain performance when dealing with customers controlling for position held in supply chain

Controlling for position held in supply chain		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Collaborative planning		OM	RM	FM
Develop front-end agreement				
- Collaboration agreement	CAC	0.1773	0.1666	0.1626
- Collaboration process mapping	CPMC	0.2827	0.0102	0.2524
- Continuous improvement	CIC	0.1305	0.1302	0.0456
Create joint business plan				
- Strategic collaborative actions	SCAC	0.0580	0.4073	0.3810
- Tactical collaborative actions	TCAC	0.0802	0.2384	0.3809
- Collaboration tools efficiency	CTEC	0.1391	-0.0218	0.3719

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Evaluating P3 and P4.3 for upstream activities

Table F.9– Strength of the relationships between innovativeness and supply chain performance when dealing with suppliers controlling for product demand/customization

Controlling for product demand/customization		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Innovativeness		OM	RM	FM
Process innovations				
- Process creation	PCS	0.3232	0.0855	0.3731
- Logistical processes	LPS	0.2860	0.2136	0.4523
- Production processes	PPS	0.5125	0.2277	0.6234
Relational innovations				
- Partnership development	PDS	0.3112	0.1380	0.4353
- Relationship improvements	RIS	0.3386	0.0622	0.3653

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table F.10– Strength of the relationships between innovativeness and supply chain performance when dealing with suppliers controlling for position held in supply chain

Controlling for position held in supply chain		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Innovativeness		OM	RM	FM
Process innovations				
- Process creation	PCS	0.3999	0.2282	0.4342
- Logistical processes	LPS	0.3010	0.2809	0.4902
- Production processes	PPS	0.5440	0.2733	0.6378
Relational innovations				
- Partnership development	PDS	0.3341	0.2385	0.4828
- Relationship improvements	RIS	0.3211	0.0864	0.3870

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Evaluating P3 and P4.3 for downstream activities

Table F.11– Strength of the relationships between innovativeness and supply chain performance when dealing with customers controlling for product demand/customization

Controlling for product demand/customization		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Innovativeness		OM	RM	FM
Process innovations				
- Process creation	PCC	0.4212	0.0773	0.5411
- Logistical processes	LPC	0.3027	0.0753	0.6346
- Production processes	PPC	0.2934	0.1115	0.5987
Relational innovations				
- Partnership development	PDC	0.4481	0.2316	0.4503
- Relationship improvements	RIC	0.4180	0.3055	0.3913

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table F.12– Strength of the relationships between innovativeness and supply chain performance when dealing with customers controlling for position held in supply chain

Controlling for position held in supply chain		Supply chain performance		
		Output measures	Resource measures	Flexibility measures
Innovativeness		OM	RM	FM
Process innovations				
- Process creation	PCC	0.4261	0.0859	0.542
- Logistical processes	LPC	0.3050	0.0915	0.6608
- Production processes	PPC	0.2938	0.1135	0.5982
Relational innovations				
- Partnership development	PDC	0.4188	0.1674	0.4573
- Relationship improvements	RIC	0.3705	0.1898	0.4056

Pearson correlation coefficients Level of significance one-tailed p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

APPENDIX G :

STEPS TO TEST MEDIATION FOR UPSTREAM ACTIVITIES

Table G.1 – Summary of the results of the first three steps for upstream activities

First step – relationships between collaborative planning and supply chain performance

	Supply chain performance ⇔		
⇐ Collaborative planning	Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.1903	0.1325	0.2626*
- Collaboration process mapping	0.1955	0.3220**	0.2332*
- Continuous improvement	0.2654*	0.2960**	0.2325*
Create joint business plan			
- Strategic collaborative actions	0.0634	0.1007	0.1440
- Tactical collaborative actions	0.1351	0.1744	0.2595*
- Collaboration tools efficiency	0.4288***	0.3185**	0.4538***

Second step – relationships between collaborative planning and innovativeness

	⇐ Innovativeness				
	Process innovations			Relational innovations	
⇐ Collaborative planning	Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
Develop front-end agreement					
- Collaboration agreement	0.5716****	0.4207***	0.4804***	0.5687****	0.4088***
- Collaboration process mapping	0.3880**	0.4250***	0.2506*	0.4533***	0.4008***
- Continuous improvement	0.3183**	0.3065**	0.3752**	0.3171**	0.1786
Create joint business plan					
- Strategic collaborative actions	0.4317***	0.7561****	0.2842**	0.6877****	0.6873****
- Tactical collaborative actions	0.6208****	0.7486****	0.4417***	0.7587****	0.7272****
- Collaboration tools efficiency	0.5055***	0.7169****	0.3441**	0.8113****	0.6525****

Third step – relationships between innovativeness and supply chain performance

	Supply chain performance ⇔		
⇐ Innovativeness	Output measures	Resource measures	Flexibility measures
Process innovations			
- Process creation	0.3489**	0.2228	0.3479**
- Logistical processes	0.4480***	0.4479***	0.5279****
- Production processes	0.5335****	0.4116***	0.6421****
Relational innovations			
- Partnership development	0.4296***	0.3769**	0.5592****
- Relationship improvements	0.3602***	0.2036	0.3341**

Pearson correlation coefficients *(unilateral tests)*:
Level of significance p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table G.2 – Relationship between the collaboration planning and supply chain performance when controlling for process innovation (upstream)

Fourth step – partial correlation between the independent variable and the dependent variable, when controlling by the mediator variable

Independent variables ⇐ **Collaborative planning**	Dependent variables ⇐**Controlling for process creation** Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.033	-0.030	0.151
- Collaboration process mapping	0.213	0.394 **	0.219
- Continuous improvement	0.140	0.134	0.159
Create joint business plan			
- Strategic collaborative actions	-0.005	0.206	0.153
- Tactical collaborative actions	0.062	0.258 *	0.290 *
- Collaboration tools efficiency	0.216	0.142	0.273 *

	⇐ **Controlling for production processes** Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	-0.065	-0.009	-0.004
- Collaboration process mapping	0.094	0.280 *	0.122
- Continuous improvement	0.104	0.222	0.039
Create joint business plan			
- Strategic collaborative actions	-0.161	-0.077	-0.096
- Tactical collaborative actions	-0.128	-0.035	-0.074
- Collaboration tools efficiency	0.311 **	0.200	0.318 **

	⇐ **Controlling for logistical processes** Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.129	-0.018	0.175
- Collaboration process mapping	0.053	0.219	0.054
- Continuous improvement	0.214	0.226	0.178
Create joint business plan			
- Strategic collaborative actions	-0.471 ***	-0.438 ***	-0.480 ***
- Tactical collaborative actions	-0.319 **	-0.315 **	-0.300 **
- Collaboration tools efficiency	0.203	-0.029	0.098

Pearson correlation coefficients *(unilateral tests)*

Level of significance of partial correlation coefficients where $r_{ijk} = \frac{r_{ij} - r_{ki} r_{kj}}{\sqrt{(1 - r_{ki}^2)(1 - r_{kj}^2)}}$

p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table G.3 – Relationship between the collaboration planning and supply chain performance when controlling for relational innovation (upstream)

Fourth step – partial correlation between the independent variable and the dependent variable, when controlling by the mediator variable

Independent variables ⇐ **Collaborative planning**	Dependent variables ⇐ **Controlling for partnership development**		
	Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.100	-0.010	0.163
- Collaboration process mapping	0.112	0.233 *	0.111
- Continuous improvement	0.268 *	0.255 *	0.206
Create joint business plan			
- Strategic collaborative actions	-0.287 *	-0.157	-0.177
- Tactical collaborative actions	-0.203	-0.070	0.019
- Collaboration tools efficiency	0.199	0.049	0.146

	⇐Controlling for relationship improvements		
	Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.043	0.070	0.118
- Collaboration process mapping	0.052	0.282 **	0.086
- Continuous improvement	0.217 *	0.274 *	0.179
Create joint business plan			
- Strategic collaborative actions	-0.272 **	-0.055	-0.125
- Tactical collaborative actions	-0.198	0.039	0.026
- Collaboration tools efficiency	0.274 **	0.250 *	0.330 **

Pearson correlation coefficients *(unilateral tests)*
Level of significance of partial correlation coefficients where p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

$$r_{ijk} = \frac{r_{ij} - r_{ki} r_{kj}}{\sqrt{(1 - r_{ki}^2)(1 - r_{kj}^2)}}$$

APPENDIX H :

STEPS TO TEST MEDIATION FOR DOWNSTREAM ACTIVITIES

Table H.1 – Summary of the results of the first three steps for downstream activities

First step – relationships between collaborative planning and supply chain performance

	Supply chain performance ⇔		
Collaborative planning ⇒	Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.2264*	0.2260*	0.1819
- Collaboration process mapping	0.3457**	0.1674	0.2472*
- Continuous improvement	0.1336	0.1420	0.0429
Create joint business plan			
- Strategic collaborative actions	0.1625	0.4879****	0.3696***
- Tactical collaborative actions	0.1606	0.3354**	0.3853***
- Collaboration tools efficiency	0.1865	0.0470	0.4029***

Second step – relationships between collaborative planning and innovativeness

	Innovativeness ⇒				
	Process innovations			Relational innovations	
Collaborative planning ⇒	Process creation	Logistical processes	Production processes	Partnership development	Relationship improvements
Develop front-end agreement					
- Collaboration agreement	0.3421**	0.2521*	0.5204****	0.5126****	0.4353***
- Collaboration process mapping	0.3173**	0.2569*	0.2995**	0.4219***	0.3070**
- Continuous improvement	0.2294*	0.2336*	0.2118*	0.4064***	0.2352*
Create joint business plan					
- Strategic collaborative actions	0.1941	0.4398***	0.5905****	0.5517****	0.6057****
- Tactical collaborative actions	0.4136***	0.4541***	0.6998****	0.6971****	0.6356****
- Collaboration tools efficiency	0.4246***	0.3628**	0.4663***	0.3084**	0.3937***

Third step – relationships between innovativeness and supply chain performance

	Supply chain performance ⇔		
Innovativeness ⇒	Output measures	Resource measures	Flexibility measures
Process innovations			
- Process creation	0.3868***	0.0936	0.4487***
- Logistical processes	0.3457**	0.2157*	0.6417****
- Production processes	0.2934**	0.1441	0.5497****
Relational innovations			
- Partnership development	0.4387***	0.2506*	0.4572***
- Relationship improvements	0.4105***	0.3310**	0.4054***

Pearson correlation coefficients *(unilateral tests)*:
Level of significance p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table H.2 – Relationship between the collaboration planning and supply chain performance when controlling for process innovation (downstream)

Fourth step – partial correlation between the independent variable and the dependent variable, when controlling by the mediator variable

Independent variables / **Collaborative planning ⇒**	Dependent variables: **Controlling for process creation ⇒** Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.2237 *	0.2654 *	0.1730
- Collaboration process mapping	0.2956 **	0.1561	0.1681
- Continuous improvement	0.1094	0.1469	-0.0064
Create joint business plan			
- Strategic collaborative actions	0.1275	0.5031 ***	0.3779 ***
- Tactical collaborative actions	0.0331	0.3452 **	0.3037 **
- Collaboration tools efficiency	0.0439	0.0131	0.3002 **

	Controlling for production processes ⇒ Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.1731	0.1292	0.0232
- Collaboration process mapping	0.2483 *	0.1191	0.0875
- Continuous improvement	0.0801	0.0875	-0.1163
Create joint business plan			
- Strategic collaborative actions	0.0149	0.4539 ***	0.1432
- Tactical collaborative actions	0.0088	0.2638 *	0.1368
- Collaboration tools efficiency	0.0725	-0.0318	0.2378 *

	Controlling for logistical processes ⇒ Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.0582	0.1486	-0.1864
- Collaboration process mapping	0.2806 **	0.1264	0.0912
- Continuous improvement	0.0978	0.1395	-0.0915
Create joint business plan			
- Strategic collaborative actions	-0.0381	0.4879 ***	0.0683
- Tactical collaborative actions	-0.0801	0.3064 **	0.0200
- Collaboration tools efficiency	0.0204	-0.0480	0.1733

Pearson correlation coefficients *(unilateral tests)*
Level of significance of partial correlation coefficients where $r_{ijk} = \frac{r_{ij} - r_{ki} r_{kj}}{\sqrt{(1 - r_{ki}^2)(1 - r_{kj}^2)}}$
p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001

Table H.3 – Relationship between the collaboration planning and supply chain performance when controlling for relational innovation (downstream)

Fourth step – partial correlation between the independent variable and the dependent variable, when controlling by the mediator variable

Independent variables / **Collaborative planning ⇒**	Dependent variables: **Controlling for partnership development ⇒** Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.0609	0.1535	0.0127
- Collaboration process mapping	0.2320 *	0.0984	0.1553
- Continuous improvement	-0.0001	0.0960	-0.0561
Create joint business plan			
- Strategic collaborative actions	-0.1093	0.4422 ***	0.1585
- Tactical collaborative actions	-0.2094	0.2373 *	0.1482
- Collaboration tools efficiency	0.0666	-0.0435	0.3374 **

	Controlling for relationship improvements ⇒ Output measures	Resource measures	Flexibility measures
Develop front-end agreement			
- Collaboration agreement	0.0546	0.1008	0.0185
- Collaboration process mapping	0.2515 *	0.0761	0.1476
- Continuous improvement	0.0401	0.0721	-0.0524
Create joint business plan			
- Strategic collaborative actions	-0.1187	0.3827 ***	0.1705
- Tactical collaborative actions	-0.1426	0.1716	0.1808
- Collaboration tools efficiency	0.0297	-0.0960	0.2895 **

Pearson correlation coefficients *(unilateral tests)*

Level of significance of partial correlation coefficients where $r_{ij_k} = \frac{r_{ij} - r_{ki} r_{kj}}{\sqrt{(1 - r_{ki}^2)(1 - r_{kj}^2)}}$

p= * < 0.1 **< 0.05 *** < 0.01 **** < 0.001