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Modelling the collaborative forecasting decision-making process in decentralised supply chains. Towards a reference model

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1. Introduction

Decision system technologies have strongly supported modelling and have solved planning complexities in supply chains in a collaborative context. Moreover, the development of supply chains are increasingly oriented to shape relationships among the firms, companies or nodes involved, generally in manufacturing and logistic processes. In addition, these relationships tend to be more cooperative and collaborative, which is a determining factor to create value in supply chains (Mitra and Sanghal, 2008). Furthermore, in the forecasting process context, Holweg et al. (2003) consider the fact that information sharing not only helps to create more visible and predictable demand in the system, but also allows the easier implement and complete customer-specific control processes. In addition, Aviv (2001) considers a supply chain in which each member maintains its own forecasting process, and is also capable of incorporating forecast updates into the replenishment process. Indeed, the collaborative forecasting process applies supply chain management concepts to the forecasting process, and uses the information and technology available to force a shift from independent to dependent forecasted demand, known as demand (Rodriguez et al., 2008). Poler et al. (2008) states that the collaborative forecasting process is based on the fact that each interrelated company has relevant information available to forecast what the rest do not have. This supports the implementation of the collaboration model and the progressive spreading across the non-collaborative firms. Moreover, Stubbings et al. (2008) establishes that in order to arrive at some kind of shared forecasts, the individual collaborator forecast must be driven by some data source in order to conduct a collaborative forecasting process, mainly when such data sources are distinct and influence the current outcomes. Therefore, this paper proposes a collaborative decision-making model that supports collaborative forecasting which considers and supports collaboration from a decentralised viewpoint among the supply chain nodes.

To doing so, and according to the methodology proposed by Hernández et al. (2007), the exchange of information is considered among each supply chain node, which not only consider the firm orders, but also the customers (or clients) that facilitate the demand plan to their supplier nodes. Thus, each supplier node will carry on their own forecasting demand processes, this with the information that comes from the related supply chain networks and with that information for which has no demand plan information even. Thereafter, the main idea will be that, to the last forecasting process the demand plans will be added as a good collaborative practice in order to promote a more accurate forecasting process. Indeed, the result of this collaboration allows the consecution of a more accurate demand forecasting process, which will imply, for example, the reduction of the safety stock levels in every supply chain element or node which, in addition, will support (at the end) the decision-making process in the supply chain node. Thus, in order to cover and present the subject related to this work, this paper is set out as follows. In the first place a briefly review shows the relevant concepts related to the collaborative forecasting model in generic supply chain network and and to the GRAI concepts. Then, the following section, establish the decisional GRAI modelling process by considering the main decisional centres related to collaborative forecasting process. After that, the decisional GRAI model is presented by highlighting the related informational and constrains flows which shows, from a global supply chain point of view, these relationships (in many cases hierarchical). Finally, the main conclusions and further research are given.

2. Background

2.1. The collaborative forecasting process in supply chain networks

The collaborative forecasting has been applied for many important companies such as Wal-Mart and Warner-Lambed. The main idea of this kind of supply chain process is that the companies collaborate extensively on developing joint demand forecast and production schedules through internet and EDI networks (Raghunathan, 1999). Furthermore, in the context of the forecasting process, Holweg et al. (2003) consider the fact that information sharing not only helps to create more visible and predictable demand in the system, but is also easier to implement than complete customer specific control processes. In this context, McCarthy and Golicic (2001) establish that ones the company is able to develop their own forecasting process, the next step is to exchange this information to all supply chain levels in the development of a single forecasting process, which will imply that the collaborative forecasting will generate benefits greater in magnitude than those that come from a single-firm. In addition, Aviv (2001) consider a supply chain in where each member maintains his own forecasting process, but also they are capable to incorporate the forecast updates into the replenishment process. In a fact, the collaborative forecasting process applies supply chain management concepts to the forecasting process and uses available information and technology to force a shift from independent, forecasted demand to dependent, known demand Rodriguez et al. (2008). Thus, in order to carry on a collaborative forecasting process in the supply chain, Aviv (2001) consider that each member are able to jointly maintain a single forecasting process in the system and also are capable to integrate this joint forecasting process into their individual replenishment process. Moreover, collaborative forecasting makes possible to take advantage of the expertise of all, or at least several, supply chain members, then, a company or department can get access to better information on important drivers of future demand, such as promotions (Småros, 2003). Actually, through vendor managed inventory and collaborative forecasting in product introductions, the company must be able to prioritize production requirements according to the availability situation at the distributors (Holweg et al, 2005). Thereafter, the development and deployment of private forecasting technologies could allow supply chain collaborations to take place without revealing any participants' data to the others, reaping the benefits of collaboration while avoiding the drawbacks (Xie et al., 2007), thus collaborative forecasting will allow to different entities to jointly perform business forecasting where each entity contributes its own data.

Regarding to Poler et al. (2008), the collaborative forecasting process is based on the fact that each inter-related company has relevant information available to forecast what the rest do not have, which facilitates the implementation of the collaboration model and the progressive spreading across the non-collaborative firms. Moreover, Stubbings et al. (2008) establish that in order to arrive at some kind of shared forecast, the individual collaborator forecast must be driven by some data-source in order to conduct a collaborative forecasting process, mainly when these data sources are distinct and influential to the actual outcome. Therefore, the authors set up that a collaborative forecasting process is to combine these data sources into a single superset, which may then be used to generate a single forecast in a collaborative way as has been already mentioned in this section.

2.2. The decisional GRAI-based models. Concepts

Doumeingts (1984) introduces a scheme that encompasses the production system decisional view from the GRAI perspective. The GRAI model is divided into two components: the grid and the net GRAI. The grid shows a macro view about how the decisions and information flow through the system (i.e. productive) regarding the functions that are performed and the decisions that are made, in where a conceptual application of this can be seen in Hernández et al. (2008). Thus, the net provides a micro view of the decisions and activities from the perspective of the inputs, supports and resources where the decisions are described with high level detail. In this context, the GRAI nets were developed to provide a schematic view of the decision-making process and the information flows related to the control system. These decisions can be classified in relation to the related function and the corresponding time scale. Chen et al. (1997) present the basic concepts of GERAM (Generic Enterprise Reference Architecture and Methodology) that addresses architectural enterprises integration and the integrated GRAI methodology (GIM). As far as Doumeingts (1984) is concerned, the GRAI grid is only a modelling formalism that considers the explicit view of the decision-making and communication process. Moreover, Aranguren et al. (1992) consider a number of aspects to build the decision model in an enterprise modelling context. These aspects establish that the GRAI method must consider the establishment of an ontology that is oriented to the generation and utilization of templates at both a macro-structure level to acquire the conceptualization of the global structure of a decision centre (DC) architecture, and at a micro-structure level that will provide a DC architecture-type conceptualization (these templates are supported by the hierarchical theory of multi-level systems (Mesarovic et al. 1970), the complex systems theory (Simon, 1984), and the *Walrasian* production model (Doumeingts et al., 1994)). Moreover, knowledge formalism representations will consider both grid macro (global view representation) and net micro views (detection of activities). In light of this, Doumeingts et al. (1992) establish that the GRAI methodology covers the phases of analysis, inconsistency detection and the system configuration design. In addition Poler et al. (1998), Poler et al. (2002) and Aguilar-Sommar and Poler (2006) the GRAI models propose a hierarchical structure that helps the enterprise decisional system definition. Furthermore, the high level of the structure is the GRAI grid in where the DCs are situated. At this level is where the links between the decision and information's at any DC is established. The low level will be the GRAI net in where the actions related to each DC and the links between them can be seen (Figure 4). In this context the support of each net will be linked to the actions, and depending on the modeller those could be different or the same (i.e. the human resource, the input information, etc.)

3. A collaborative forecasting model in generic supply chain network supported by the GRAI decisional modelling approach

The GRAI method (Doumeingts, 1985) is used to represent the proposed decision-making model of collaborative forecasting processes in decentralised supply chains. The DGRAI method (Poler et al., 2002) has been particularly selected to perform simulations for the purpose of observing the impact of the collaborative forecasting model from a dynamic perspective. This impact is measured in terms of the proper indicators definition (Gentil et al., 2002). Thus, the collaborative forecasting model (based on Hernández et al. (2007) and Hernández et al. (2009)) considers not only collaborative and non-collaborative supply chain customers as its main components, but also the node that carries out the forecasting process. In addition, the nodes exchange information among themselves to support collaboration at a decision-making level. The model identifies the main aspects that support collaboration in the forecasting aspects represented at the aggregated (GRAI grid, Figure 1) and detailed (GRAI nets) levels to identify information and decisional flows (in both cases). Finally with the DGRAI 3.0 tool, a reference decision-making model related with the main decision involved in the collaborative forecasting is presented. Furthermore, a simulation experiment is run to analyse the impact that arises from collaborative forecasting in terms of the decentralised supply chain decisional process.

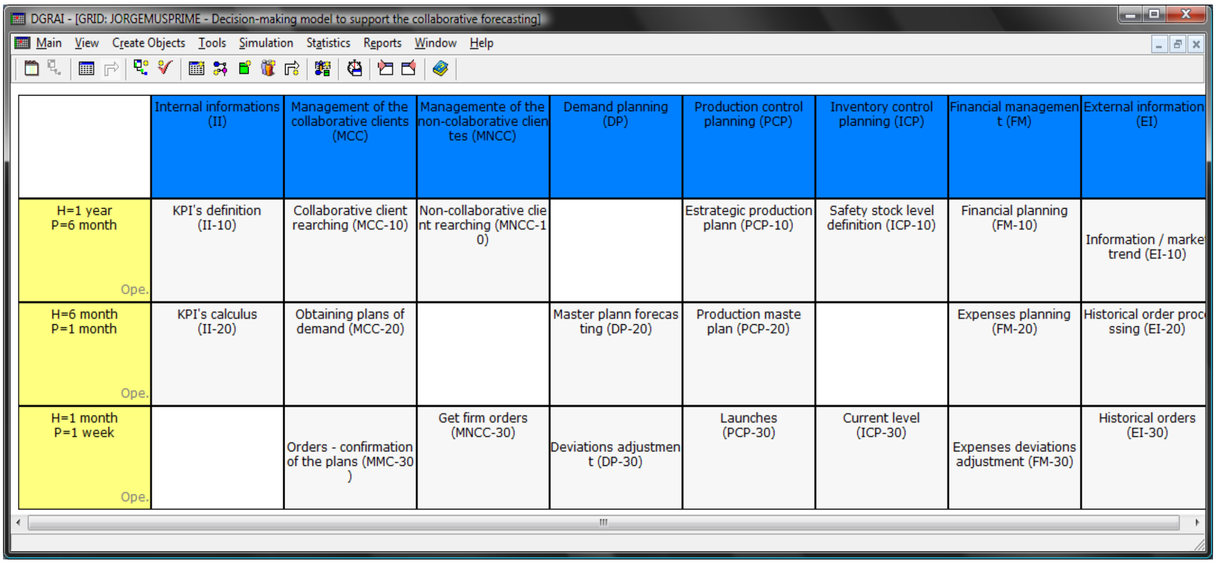
3.1. The decision-making process related with the decentralized collaborative forecasting

The decision-making process related with the collaborative forecasting process, in supply chain networks under a decentralized approach, it's about to define which processes are oriented to obtain the properly information in order to carry on a collaborative process. In addition, to support this, three decisional level gas been considered. The first one is the strategic level which is oriented to define the main goals and acceptance ranges in order to promote validity of the information, constrains and, hence, the decision-making process. The second one is the tactical level, which is oriented to promote the collaborative process related to the forecasting process. In this context, this process will consider the information that come from a collaborative nodes and the information which belongs to the non-collaborative nodes as well. Finally, the operational level which is oriented to consider those information's that support the decisions, and process, at the short term level. This level, mainly, is related with the non-collaborative component of the collaborative forecasting process such as the firm orders sent by the non-collaborative nodes and also with the calculus that need to be processed more frequently in order to identify the deviations and errors in the forecasting calculus process. Hence, the main decisions considered to favour the decentralized collaborative forecasting are to be distinguish at the already mentioned three decisional levels. Then, at the strategic level, it is possible to say that the main decisions are related with the definition of the strategic plans. This plans are concerning to define which information, customers, levels and finance matters will suite better the collaboration process in the supply chain forecasting process. Next, the tactical level considers mainly what to do with the result of the collaboration process. In this case (regarded to the demand visibility) the forecasting process takes place at this decisional level. Moreover, the forecasting process, in order to promote the decentralized collaboration among the supply chain nodes, consider as a main component the demand plan that the collaborative node is accomplished to share and, on the other hand, the firm orders which, at the short term level, are collected from the non-collaborative nodes. Thereafter, the collaborative forecasting (supported by the collaborative decision making-process) consider the main information related to the collaborative and non-collaborative nodes in where information and constrains related to each DC are handled. Each DC with their own orientation is briefly summarized in Table 1.

Table 1. Decision-making GRAI model – Overview

DC	Name	HHRR	Purpose
II-10	KPI's definition	NRS	Generate the KPI's performance by considering the studies and requirements from the environment.
II-20	KPI's Calculus	NRS	Calculate the related KPI's regarded to the deviations, inventory level, KPI's performance and related range of the incomings and expenses.
MCC-10	Collaborative client searching	NRS-Manager NRS	By considering the strategic plan and the customer information's, this DC is oriented to define the requirements in order to consider a customer/client as collaborative.
MCC-20	Obtaining plans of demand	Collaborative - NRS	Collect the demand plans from the collaborative nodes.
MCC-30	Orders-Confirmation of the plans	Collaborative - NRS	Send the confirmed plans
MNCC-10	Non-collaborative client searching	NRS	Regarding to the strategic plan and to the information of the customers, the non-collaborative search criteria is defined
MNCC-30	Get firm orders	Non- Collaborative - NRS	Regarding to the non-collaborative search criteria, the firm order are obtained.
DP-20	Master plan forecasting	NRS	Regarding to the demand plans obtained from the collaborative node and the firm order from the non-collaborative, the collaborative demand forecasting is obtained by the conjuntion of this two parts.
DP-30	Deviation adjustment	NRS	Collect the error of the related forecasting process.
PCP-10	Estrategic production plan	NRS-Manager	Strategic decisions related with the strategic plan are obtained. This is in order to support the launching and production program processes.
PCP-20	Production master plan	NRS - Area managers	The main decisions regarded to the program and quantities to produce of the related products are to be taken.
PCP-30	Launches	NRS NRS - Finance	Regarding to the production program, the deviations adjustments and to related internation information also, the launches processes with their related costs and revenues.
ICP-10	Safety stock level definition	NRS-manager	Regarding to support the error in the demand forecastin process this DC is oriented to define inventory goal level by considering the related external information from the market and expenses planning.
ICP-30	Current level	NRS	By considering the products and purchase orders, the product level is defined.
FM-10	Financial planning	NRS - Finance manager NRS - Manager	The main decisions related with the financial planning are taken in this DC, this by considering the KPI's, deviations, market trends and estrategic planning. The decision will support the finnacial planning and the expenses forecasting.
FM-20	Expenses planning	NRS - Manager	The decision related to this DC is oriented to obtain an acceptable expenses and revenue range realated with the productive process.
FM-30	Expenses deviations adjustments	NRS - Finance	By considering the KPI's evolution values and the expenses and revenue range, the deviations of the expenses and revenues are obtained.
EI-10	Information/Market trend	External entitie	Support the consecution of the right external information which will support, for example, the forecasting process at the strategic level.
EI-20	Historical order processing	External entitie	By considering the historical data, the historical data process is carry out.
EI-30	Historical orders	External entitie	By considering every informational out put from every DC, the total historical data is generated.

As can be seen from the Table 1, the resource which are involved in the collaborative forecasting process are the supply chain nodes (NRS) which has their own supplier and customer which can be considered as collaborative and non-collaborative as well, this depending on which kind of information they are about share. Thereafter, through the DGRAI TOOLS 3.0, each decisional centre is represented in the GRAI grid. This representation allows to observe the hierarchical allocation of every DC.



	Internal informations (II)	Management of the collaborative clients (MCC)	Managemente of the non-colaborative clientes (MNCC)	Demand planning (DP)	Production control planning (PCP)	Inventory control planning (ICP)	Financial management (FM)	External information (EI)
H=1 year P=6 month Ope.	KPI's definition (II-10)	Collaborative client rearching (MCC-10)	Non-collaborative client rearching (MNCC-10)		Estrategic production plann (PCP-10)	Safety stock level definition (ICP-10)	Financial planning (FM-10)	Information / market trend (EI-10)
H=6 month P=1 month Ope.	KPI's calculus (II-20)	Obtaining plans of demand (MCC-20)		Master plann forecasting (DP-20)	Production master plan (PCP-20)		Expenses planning (FM-20)	Historical order processing (EI-20)
H=1 month P=1 week Ope.		Orders - confirmation of the plans (MMC-30)	Get firm orders (MNCC-30)	Deviations adjustment (DP-30)	Launches (PCP-30)	Current level (ICP-30)	Expenses deviations adjustment (FM-30)	Historical orders (EI-30)

Figure 1. GRAI grid-based model for the collaborative forecasting decision-making process (DGRAI 3.0 tool).

As can be seen in the Figure 1, there are functions to manage the process related with the collaborative nodes and with the non-collaborative nodes as well. In addition, it is possible to observe that the collaborative forecasting process consider just the tactic and operative decisional level. This is due the fact that the collaborative forecasting, which is mainly a calculus that considered the best property of both types of nodes (the collaborative and non-collaborative), is oriented to obtain a more accurate forecast result by considering not the all visibility of the demand plans, but also the visibility related with mid term information. This mid term information is which this proposal of the reference model to support the decision-making process of the collaborative forecasting in decentralized supply chain considers. In a fact, as can be seen, the demand planning function is the one of the most critical in order support the decision-making process at almost any level, hence this function is presented at the net level in the following sub-section.

3.2. The demand planning function under a collaborative context

This function considers the forecasting calculus. In this way, the forecasting process in the supply chain will be oriented to support the related node in order to forecast the order request that every customer gives to their supplier. As has been already mentioned, the forecasting process will imply a tactical and operative process. Because the collaboration means share the right in formation, but not only the right one, but also the properly amount of it, the tactical information is related with those information that is oriented to support de collaboration among the nodes. More details of this, under a decision-making process, can be seen in the Figure 2.

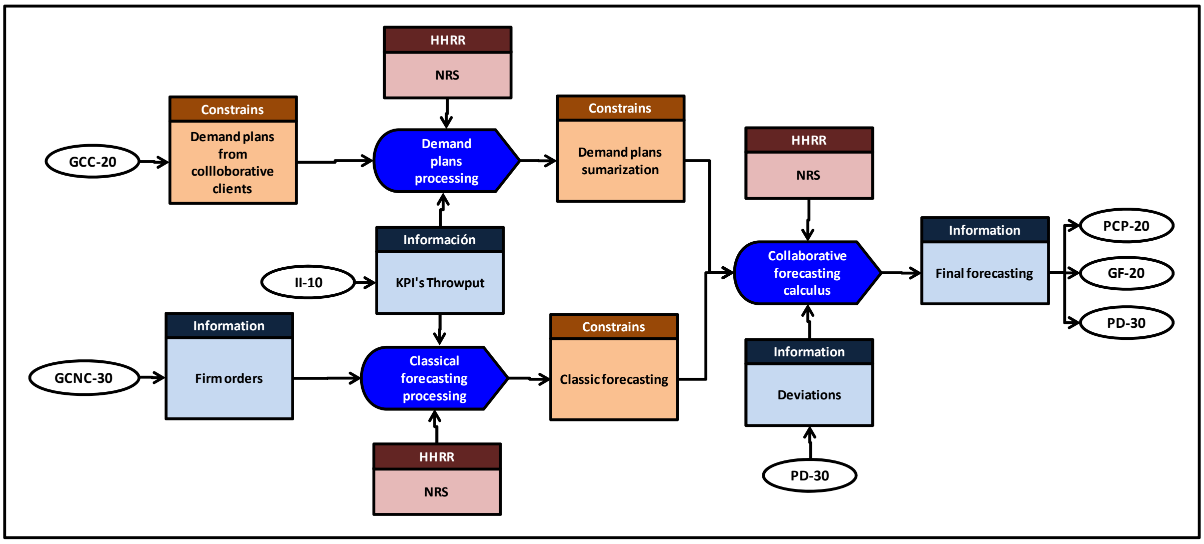


Figure 2. GRAI-net-based model, Master plan forecasting DC (DP-20).

From the Figure 2, it is possible to observe that the decision-making process realted with the collaborative forecasting considers two aspects, the demand plans and the firm order. Thus, the forecasting process will consider a final forecasting process that will cover medium and short term decisional level information. In order to see what happens with the collaborative forecasting at the short level, the reades is suggested to observe the Figure 3.

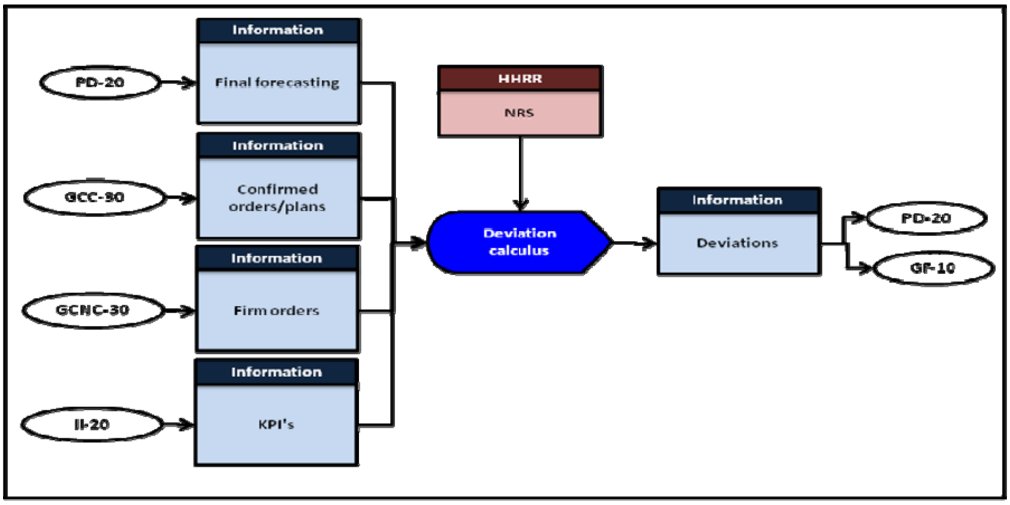


Figure 3. GRAI grid-based model. Deviation adjustment DC (DP-30)

As can be seen in the Figure 3, the collaborative forecasting, at the operational level, is oriented to considering the related deviation in the forecasting process by, in many cases, considering information such us the final forecasting (from the tactical level), the confirmed plans (from the non-collaborative nodes), the firm order and the related KPI's (this by considering the Gentil et al. (2002) definition).

4. Applying the GRAI modelling approach in order to model the relationships among the supply chain decisional centres according to the related constrains and information flows

Finally, the GRAI decisional model is summarized in the Figure 4. As can be seen from this figure, it represents the proposed reference model in order to support, and identify as well, the decision-making process in the collaborative forecasting process. The red thick lines represent the constrain flows, which highlight the hierarchical behaviours of the decision-making process. The green and dotted lines, represents the information flows, in where it is possible the multidirectional flow is allowed due to the fact that any DC needs some information in order to carry on their decisional process in order to support, in example, the collaborative forecasting process.

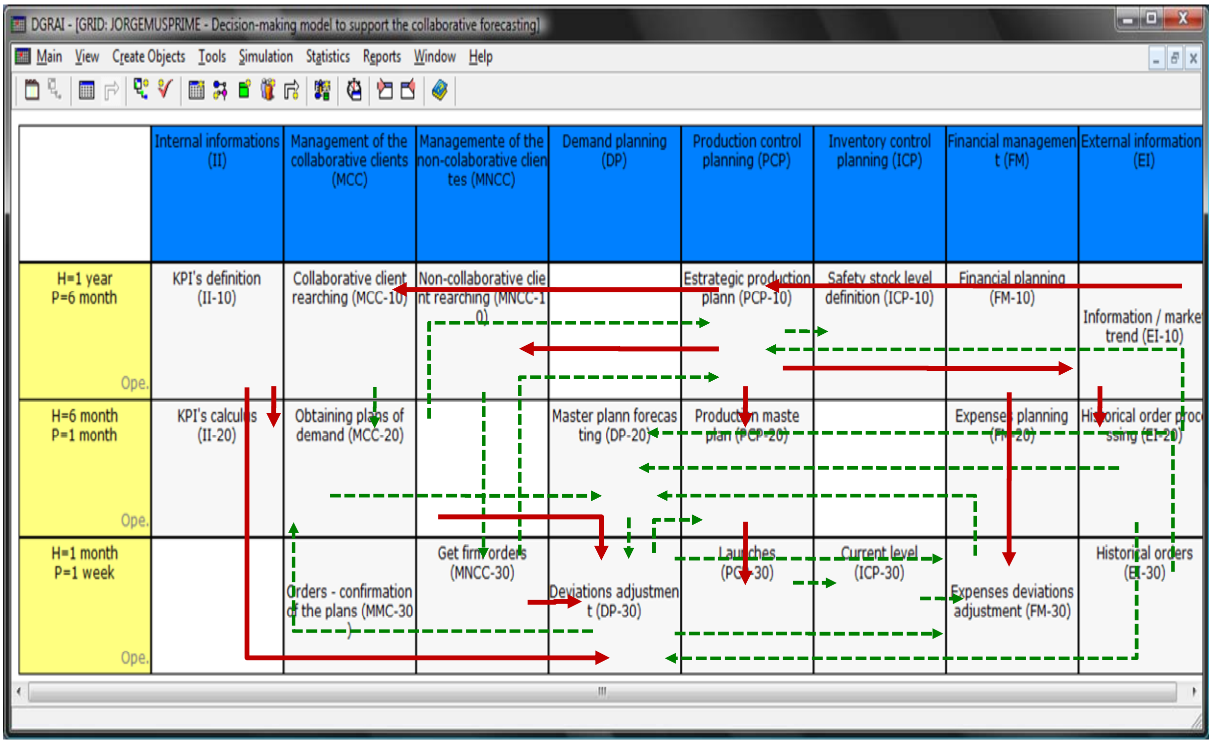


Figure 4. Constrains and information flows regarded to the model for the collaborative forecasting decision-making process (DGRAI 3.0 tool).

5. Conclusions and further research

The objective of collaborative forecasting is not only to improve the accuracy of forecasts, but to also establish links between the internal and external information to improve the performance of supply chains. Thus, collaborative forecasting helps improve control and management by swiftly responding to changes, reducing inventories and, ultimately, by improving service levels. In this context, the decision-making model supports the identification of the main function, information and constraints in terms of the collaborative forecasting process. Therefore, it is possible to identify the main decisions to be considered at any decisional level in order to execute the impact at any decisional centre of the decision-making model. In future research, the proposed model will be applied to a real supply chain network in the automobile supply chain sector, and will consider real demand data.

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