MAGISTERARBEIT

Titel der Magisterarbeit

„Global production under duties, duty drawbacks and local content trade barriers in Mercosul"

Verfasser

Georg Maier

angestrebter akademischer Grad

Magister der Sozial- und Wirtschaftswissenschaften (Mag. rer. soc. oec.)

Wien, im Mai 2011

Studienkennzahl lt. Studienblatt:	A 066 915
Studienrichtung lt. Studienblatt:	Magister-Studium Betriebswirtschaft
Betreuer:	Univ.-Prof. Dr. Stefan Minner

Contents

List of Figures

List of Tables

List of Abbreviations

AR	Argentina
BNDES	O banco nacional do desenvolvimento
BOM	Bill of material
BR	Brazil
CAM	Código aduaneiro do Mercosul
CET	Common external tariff
CIF	Cost, insurance and freight
CMC	Conselho de Mercado Comum
CMC/DEC	Decisãos do Conselho de Mercado Comum
EU	European Union
FOB	Free on board
FTA	Free trade agreement
GATT	General Agreement on Tariffs and Trade
ICR	Indíce de Conteúdo Regional
IN	Indíce de nacionalização
INCOTERMS	International set of trade terms
LC	Local content
Mercosul	Mercado Comum do Sul
MIP	Mixed integer program
NPV	Net present value
PTA	Preferential trade agreement
ROO	Rules of origin
TA	Tratado de Asuncíon
VNM	Value of non-originating material
WTO	World Trade Organization

List of Variables

Indices and sets

$i \in I$	set of all component and product variations
$p \in P$	set of all production lines
$q \in Q$	set of all product or component types
$t \in T$	set of all periods
$n \in N$	set of all nations
$u \in U$	set of all PTA's
$k \in K$	set of all production stages
$l \in L$	set of all possible capacity levels
$i \in I_p$	subsets of components and products i allocated to production line p
$i \in I_q$	subsets of components and products i allocated to product or component type q
$i \in I_k$	subsets of components and products i allocated to production stage k
$i \in A_{i'}$	subset of direct antecessors i to component or product variation $i^{'}$
$m \in M, M_u, M_B$	set of all markets, markets per PTA and markets located in Brazil

$f \in F, F_n, F_u, F_i$	set of all production plants, plants per nation, plants per PTA and plants able to produce component or product i
$m \in MP_f$	subset of markets m placed in different nations compared to plant f
$f^* \in FP_f$	subset of plants f^* placed in different nations compared to plant f

Parameter

D_{qmt}	demand of product type q at market m in period t
K_{pfl}	capacity level l of production line p at plant f (in units)
$B_{ii'}$	amount of components i required for the production of product $i^{'}$
C_{if}^{var}	variable production costs of component or product i at plant f
$C_{iff'}^{shipF}$	transport costs of component or product i from plant f to plant $f^{'}$
C_{ifm}^{shipM}	transport costs of component or product i from plant f to market m
C_{pfl}^{invK}	investment for capacity level l at production line p in plant f
$C_{pfll'}^{swK}$	costs for switching from capacity level l to capacity level $l^{'}$ of production line p in plant f
C_{pflt}^{fixK}	fixed costs for capacity level l of production line p in plant f per period t
C_{qf}^{setup}	setup costs for product or component type q in plant f

α_{in}	dutyrate for the import of component or product i into nation n
ρ_u^{lc}	necessary local content requirement in PTA u
V_{ifu}^{nor}	aggregated VNM for a component or product i in plant f relating to PTA u
ω_{ifu}^{lc}	local content fulfillment of a component or product variant i in plant f relating to PTA u (1: fulfilled, 0: not fulfilled)
ρ_n^{Fin}	necessary local content requirement for Finame purpose in Brazil
V_{if}^{norFin}	aggregated VNM for a component or product i in plant f relating to the Brazilian market and its Finame calculation method
W_i	weight of a component or product i
W_{if}^{norFin}	aggregated weight of non-originating materials for component or product i in plant f relating to the Brazilian market and its Finame calculation method
ω_{if}^{Fin}	Finame fulfillment of a component or product i in plant f relating to the Brazilian market in value and weight (1: fulfilled, 0: not fulfilled)
$C_t^{penalty}$	Penalty payment in period t per delivered item, if Finame requirement is not fulfilled
P_{im}^{lc}	relevant reference price at market m for LC calculation, for product or component i
P_{im}^{Fin}	intern market price in Brazil for product or component i without taxes
R_t	discount factor in period t

$BigM$	sufficient big number

Decision variables

$z_{ifmt} \geq 0$	production quantity of component or product i at plant f shipped to market m in period t
$y^{shipF}_{ii'ff'mt} \geq 0$	flow of component or product i for successor i' from plant f to plant f' shipped to market m in period t
$y^{shipM}_{ifmt} \geq 0$	flow of product i from plant f shipped to market m in period t
$d^{shipF}_{iff't} \geq 0$	total customs value of components or products i, shipped from plant f to plant f', relevant for duty payments in period t
$dd^{shipF}_{iff't} \geq 0$	total customs value for all duty drawbacks on components or products i, shipped from plant f to plant f', in period t
$d^{shipM}_{ifmt} \geq 0$	total customs value of all products i from plant f shipped to market m, relevant for duty payments in period t
$\psi^{activeK}_{pflt} \in \{0,1\}$	binary decision variable for the active capacity level l, of production line p in plant f at period t (1: active levels, 0: inactive levels)
$\psi^{swK}_{pfll't} \in \{0,1\}$	binary decision variable for a capacity switch from level l to level l', for production line p in plant f at period t (1: switch occurred, 0: no switch)
$\psi^{link}_{qf} \in \{0,1\}$	binary decision variable for assigning product or component type q to plant f
$\psi^{penalty}_{qt} \in \{0,1\}$	binary decision variable for Finame fulfillment of all products from type q shipped to the Brazilian market (1: fulfilled, 0: not fulfilled)

1 Introduction

In today's economic environment multinational companies face more than ever the urge for globalization (Meixell and Gargeya 2005, p. 532). Indeed, globalization is a well-known phenomenon, since international trade already has been existing for centuries. Silk, spices or porcelain have been traded between Asia and Europe more than two thousand years ago. In fact, the speed of international cross linking is new and especially the world's economy development (Jacob and Strube 2008, p. 2).

However, most of the corporation's production networks are historically grown and need to be adopted, renewed and enlarged, to further enable competition on an international level. Sourcing and production decisions for industrial products make up a large share of total costs; in the automotive industry, this proportion amounts to around 60%. Thus, optimizing the global production footprint can save up to 20% of total costs in the long term (Stolle, Näher, Frank, Reinecke, Hexter and Dervisopoulos 2008, p. 325).

In order to achieve this, an integrated perspective on the value chain has to be applied. It is no longer sufficient to use conventional location planning techniques; instead a holistic approach has to be pursued to cover a company's entire production and supply chain network. Within classical cost factors, regional value added requirements (local content), duties, duty drawbacks and further trade barriers should be integrated, to account for the globalized world (Meyer and Jacob 2008, p. 141).

Based on the General Agreement on Tariffs and Trade (GATT) the reduction of tariffs began. Today a total of 283 regional trade agreements, among other the Mercado Comum do Sul (Mercosul), are registered within the World Trade Organization (WTO 2010a). However, some industries are still under special protection through non-tariff trade barriers and high customs duties. This special protection applies amongst others for the Mercosul automotive industry. The

Mercosul legal framework requires for a product specific value-based local content (Mercosul 1991, annex II), while a further Brazilian non-tariff barrier asks for a minimum local value and weight added (BNDES 2006, Article 4). These differences in calculation schemes assign additional complexity to the supply chain design process.
Duty drawbacks are a refund on paid duties for goods designated for further exportation and can be used to economize duty payments (Oh and Karimi 2006, p. 595). The availability of duty drawback schemes and their incorporation in the planning process leads to different supply chain configurations in order to minimize total duty load.
It can be stated that global aspects have an incremental influence on the design process of supply chains and need therefore be considered when determining optimal production networks.

1.1 Motivation and objectives

The following thesis deals with global production decisions under duties, duty drawbacks and local content trade barriers with particular focus on Mercosul's automotive industry. It points out how these aspects interact and affect production decisions in international supply chains of multinational companies.
To study the impact of global aspects on production decisions within Mercosul, a mathematical model is formulated, which reflects the legal framework of the Mercosul automotive industry. Due to its importance, the automotive sector was excluded of the Mercosul creation process from the very beginning in 1991. Politicians installed a technical Committee, which was instructed to harmonize the automotive sector with regard to local content regulations and decomposition of tariff barriers (IDB-INTAL 1997, pp. 30).
The developed model deals with the production network of a global acting truck manufacturer. Local content as well as duty and duty drawback calculations are modelled as constraints in a linear program. Existing mixed integer models like Arntzen et al. (1995) or Oh and Karimi (2006) have already designed production-distribution models considering duties and duty drawbacks in a general manner. This work; in particular, extends the existing literature by providing a model able, to calculate the local content on a product specific level for

a multi-product, multi-period environment. Further, detailed inward and outward processing schemes are implemented to determine duty drawback claims and necessary duty payments in detail, on basis of the specific product.

1.2 Structure

The introductory chapter presented the key elements of interests and gave a methodological overview on the topic and its main aspects incorporated through the developed mixed integer program. The remainder of the thesis is organized as follows:

Chapter 2 introduces the theoretical fundamentals of this thesis. It provides a summary on external factors, influencing global production decisions. Different forms of regional cooperation between countries and their motives are presented and an overview on non-tariff trade barriers is given. Finally, common customs regimes are introduced and a literature review is given.

Chapter 3 introduces the Mercosul trade area and its legal framework. It describes Mercosul's history and its legislative organs. Furthermore, particular Mercosul local content calculation methods with focus on the automotive industry are presented as well as specific duty regulations for the territory.

In chapter 4 the mixed integer model is formulated. Two extensions to the model are adopted. First, a specific Brazilian non-tariff trade barrier and second, capacity planning decisions are included.

Chapter 5 develops numerical studies for the Mercosul automotive industry, to highlight the interactions between the different global aspects on a truck manufacturer's production network design and capacity planning decisions.

Chapter 6 concludes and summarizes the main results of this thesis. Furthermore, is given an outlook on future research topics of interest.

2 Theoretical Fundamentals

The following chapter provides a theoretical overview on challenges, which arise in an international environment for corporations. Necessary terms and definitions are given and particular aspects affecting global supply chain and production networks are introduced. Finally, a literature review is given.

2.1 Supply chain definition

The focus of this thesis is on the supply chain of a multinational automotive manufacturer. In a first step, it has to be clarified what exactly is meant by the term and how it is used in the context of the following thesis. Coyle et al. (2008) define a supply chain as:

> *"An extended enterprise that crosses the boundaries of individual firms to span the related activities of all the companies involved in the total supply chain. This extended enterprise should attempt to execute or implement a coordinated, two-way flow of goods/services, information and financials."*

(Coyle, Langley, Bardi, Gibson and Novack 2008, p. 20).
Although, this definition clearly incorporates various firms, when speaking of supply chains, in this thesis the concept is used as a synonym for an intra-organizational process.
Vidal and Goetschalckx (1997) refer to the term of supply chains as strategic production-distribution models and distinguish between domestic and international approaches (Vidal and Goetschalckx 1997, p. 2). To derive an optimal design for the supply chain the authors suggest incorporating decisions on:

- Amount of locations and characteristic capacities

- Sourcing
- Transportation methods
- Optimal flow of materials
- Inventories

However, Meixell and Gargeya (2005) point out that global supply chains, compared to domestic networks, are more challenging to manage, due to additional factors that need to be attended to; tariff and non-tariff trade barriers, duty drawbacks, exchange rates, transfer prices, different cultures and political backgrounds (Meixell and Gargeya 2005, p. 533).
Subsequently, the thesis gives a more detailed overview on trade factors influencing international supply chains and how they are motivated. Regional cooperation and their categories are described, to obtain an understanding on legal frameworks. This is followed by an introduction into tariff and non-tariff trade barriers.

2.2 Regional cooperation

A regional cooperation describes the association of different countries in Preferential Trade Agreements (PTA) consolidated under the World Trade Organization (WTO). Motives and specifications are various and presented subsequently.

2.2.1 Motivation for regional cooperation

Currently, 283 PTAs are registered within the WTO (WTO 2010a). This number is expected to rise significantly within the following years, due to the increasing competition of countries on the world market (Richard 2010, p. 227). The current trend of a growing number of PTAs during the last two decades is known as “new Regionalism”(Guerrieri and Dimon 2006). The authors cluster regionalism into three waves. Beginning in the 1930s with the first wave, of highly protected and discriminatory trade areas. As second wave they define the years between 1950 and 1970, where emerging countries focused on the progress of their national industries, while discouraging imports. The current third wave differs, since liberalization and deregulation are in the focus of PTAs (Guerrieri and Dimon 2006,

pp. 86). Political governments use PTAs as an instrument to face globalization challenges (Bouzas 2007, p. 334).
Moreover, an increasing number of North-South agreements is notable, which is interesting, because of the national economical differences (Bouzas 2007, pp. 334). Free trade agreements between the European Union (EU) and Cameroon, EU and Cote d'Ivoire or EU and South Africa are examples for this development (WTO 2010b). The less developed country is granted a preferential access to attractive large markets. As a consequence, exports increase and the economy can be further developed. The counterpart is able to execute influence on policy towards improving investment conditions for international companies (Bouzas 2007, pp. 335).
But how are PTAs motivated? Beyond static welfare effects additional benefit can be identified in larger markets. As static welfare effects are defined trade-diverting; replacing an efficient supplier from the outside through a less efficient from inside and trade-creation; generating trade through a more efficient member (Bhagwati 1993, p. 33). What was not taken into consideration by this concept is the deeper integration of today's PTAs. Intellectual property rights, free transfer of resources, investment and competition policies as well as environmental and labor standards are often implemented, and generate welfare beyond the static effect (Guerrieri and Dimon 2006, pp. 87).
Schirm (1999) identifies an additional motive for regionalism. Economies try to improve their competitive situation on the world markets through cooperation and liberalization. International corporations started decades ago building up a worldwide production and distribution network and therefore became independent from one single country and its scope of action. A delimitation and concentration on domestic politics is no longer the answer to global competition. (Schirm 1999, pp. 20).
Nevertheless, problems arise through building PTAs all over the world. The participation of one country in various PTAs and the applying of trade barriers lead to a shift in the worldwide power-relations, not always to their best (Guerrieri and Dimon 2006, pp. 91). The GATT, signed on 30th October 1947, was designed to face these problems. Article I of the agreement demands for non-discrimination:

> *"Any advantage, favor, privilege or immunity granted by any contracting party to any product originating in or destined for any other*

country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties."

(GATT 1947, article I).
This general most favored nation treatment has one exception. Article XXIV GATT permits customs unions and free trade agreements among WTO members as long as they guarantee themselves a 100% preference. This clear rule is compatible with non-discrimination and multinationalism, the long term goal of the WTO. However, most agreements do not fulfill this strong constraint, but even though they are accepted by the WTO. Lawyers and government representatives succeeded to wash out the article, resulting in its today's practice (Bhagwati 1993, pp. 25).

2.2.2 Types of preferential trade agreements

There can be identified five international integration categories, listed by increasing degree of cooperation and therefore, loss of national sovereignty:

- **Preferential trade agreement**, represents the weakest form of integration. The signing members allow each other to import and export several goods at a preferred tariff rate, compared to third party countries (Krueger 1997, p. 173).
- **Free trade agreements** (FTA), are the next higher form of integration. Internal tariff rates are set to zero, whereas, external tariffs still differ in the member countries. This leads to the hazard of trade deflection. Goods are imported through the country with the most favorable import tariffs and passed on to the country of destination. A problem adjustable by implementing rules of origin (Mesa 2009, pp. 9).
- **Customs unions**, establish a common external tariff and have a zero tariff for internal trade. Rules of origin, to prevent trade deflections are therefore not necessary. National governments lose sovereignty through the higher form of integration and increased need of coordination (Mesa 2009, pp. 10).

- **Common market**, is the next step of integration. Services and production factors, such as capital and human resources are allowed to move freely. National governments have to shift power to a supranational organization, in order to harmonize economical politics and the legal framework for the market. (Mesa 2009, pp. 11)
- **Single market**, is the highest form of integration. Physical, technical and economical barriers are completely harmonized. This form is also known as economic and monetary union (Krueger 1997, p. 174).

2.3 Non-tariff trade barriers

Despite, strong liberalization on worldwide trade concerning the diminishment of tariffs, non-tariff trade barriers were installed to compensate the loss of protection. Under non-tariff trade barriers can be summarized all interferences on trade, except for tariffs. Three different types of non-tariff trade barriers can be distinguished. First, import quota, only a limited amount of a certain product category may be imported per period. Second, product standards, e.g. technical or environmental requirements are used to seal against exports from developing countries and finally rules of origin (ROO). They determine the origin of a good, hence, derives a preferential or non-preferential treatment (Petersen 2004, pp. 2).

Non-tariff trade barriers create trade diversion, i.e. imports from outside the trade area are replaced by imports from member countries, to comply with the barriers. Consequently, this limits a company's flexibility and additional costs have to be accepted. Local, less experienced or more expensive suppliers need to be chosen, know-how has to be shared and additional costs, through screening potential partners arise (Krueger 1997, pp. 174). Since, global competition is intense, there is no choice for management, besides, accepting these restrictions and hazards, in order to act successful on an international basis.

In the following, it is taken a closer look on rules of origin. The creation of trade blocks introduced the need for an instrument, capable to determine the originating status of a good (Li, Lim and Rodrigues 2007, p. 425). In a FTA member states stick to their different external tariff schemes, while reducing internal barriers. ROO, are an instrument to inhibit trade deflection, i.e. goods

enter through the member state of the FTA, with the lowest import tariffs and are afterwards shipped forward to their actual destination (Krueger 1997, pp. 178). ROO prevent this action, as they demand an originating status, in order to benefit from the preferential treatment inside the FTA.
Li et al. (2006) distinguish three types of ROO, to designate the originating status:

- **Change in tariff classification**, refers to the harmonized system (HS) of the WTO, which assigns to every good a characteristic position in this framework. Change in tariff classification requires that imported goods are refined to a final product, classified under a higher position in the HS (Vermulst 1994, pp. 449).
- **Process rule** or **technical test**, gives a positive or negative list for processing a good to achieve originating status (Vermulst 1994, p. 450).
- **Value added or percentage criterion**, may occur in three forms. The first method is limiting imported parts through a maximum proportion of total parts. The second form works vice versa and requires a minimum domestic aliquot. Finally, the value-of-parts test evaluates, if originating inputs account for a minimum percentage of total value (Vermulst 1994, p. 436). These methods are known as local content (LC) requirements.

LC usually is defined in terms of volume or value, referring to cost structures. Physical content protection schemes require for a quantitative fraction of parts to be originating, while value based content schemes request for the fulfillment of a certain percentage of value, to count as originating (Munson and Rosenblatt 1997, p. 278). Change in Tariff Classification and Process Rules are easier to implement, whereas the value added criterion is more complicated to define (Li, Lim and Rodrigues 2007, p. 425).
Peterson (2004) describes the LC as:

$$LC = \frac{local\ value\ added}{total\ value\ of\ the\ good} \cdot \% \tag{2.1}$$

LC returns the percentage of an originating proportion of a good and has in most cases to fulfill a minimum requirement. Nevertheless, evaluating the exact cost structures of parts included into a product is difficult, considering the allocation of variable and fixed costs to the particular components (Vermulst 1994, p. 437).

The LC requirement is a powerful instrument for governments to develop foreign investments and increase industry know-how (Petersen 2004, pp. 9).

2.4 Duties and customs regimes

This section deals with duties and associated customs regimes. In a globalized world economy duties and customs regimes have an incremental impact on global supply chains. Companies carry out a significant effort to save duty payments when designing production networks. For example, through shipping semi-knocked down (SKD) or completely-knocked down (CKD) kits of automotive products and an afterwards on-site assembly. Thus, import duties can be economized (Kohler 2008, p. 56). Nevertheless, available customs regimes as duty drawbacks are often not actively managed when designing supply chain networks (Oh and Karimi 2006, p. 597). Even though, national customs laws are under steady change an active management can reveal significant financial advantages (Grainger 2000, p. 43).

2.4.1 Duties

Duties are a classical instrument of foreign trade policy, reflecting import taxes (Mah 2007, p. 967). Nowadays, duties have more a protective function, which can no longer be compared to the initial purpose of tariffs, the simple increase of public revenues. The WTO further acknowledges e.g. "educational tariffs" to protect certain industries or "anti-dumping tariffs" to seal against subsidized products or dumping prices from third party countries (Mesa 2009, pp. 6). Tariffs on imported commodities may not hinder that foreign products enter the country, but they install a barrier, protecting domestic goods by increasing market prices for third party products. Potential price disadvantages of local products are balanced (Mesa 2009, pp. 4).
It can be stated that developing countries have considerable higher import tariffs to protect their industries and increase revenues, compared to already developed countries (Mah 2007, p. 968). In general, tariffs range between 0% and 15% on top of the customs value of a good, so called ad valorem duties. In extreme cases

tariff rates up to 30% and higher are possible, as they can be found for example for automotive goods imported into Mercosul territory. (Hübner 2007, p. 83). The customs value of a good is defined for WTO members under Article VII GATT (GATT 1947). According to this article the customs value of an imported commodity is calculated on a cost plus insurance and freight (CIF) basis. It has to be noted that the applicable tariff rate is not equal for all trade partners and may also depend on the country of origin and if, any preferential trade agreements are valid (Hübner 2007, p. 83).

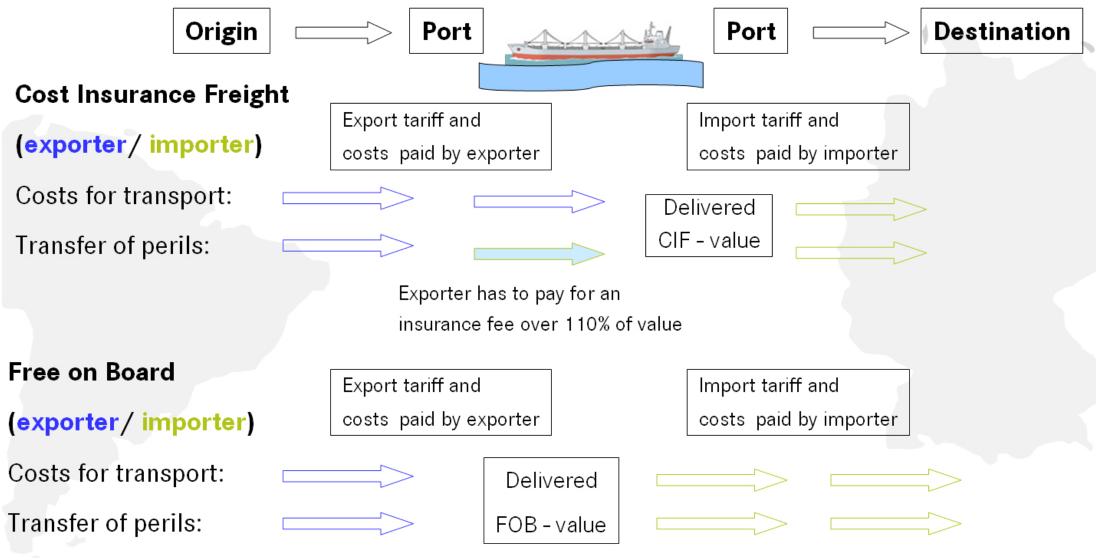


Figure 2.1: CIF and FOB value illustration (Bernstorff 2010, pp. 129)

Figure 2.1 presents the definitions of CIF and FOB values of a good, according to International Commercial Terms (Incoterms). These concepts were introduced by the International Chamber of Commerce and are frequently used in worldwide trade contracting as well as for LC determinations.
The CIF-value includes the costs of a product plus additional expenses for freight and an insurance fee over at least 110% of the underlying asset's value until the port of destination, covered by the exporter. On the opposite, the transfer of perils from the exporter to the importer is already realized at the port of origin (Bernstorff 2010, pp. 144). The FOB-value on the contrary, contains the costs for the product itself, plus transport to the port of destination. For the remaining transport the importer is held responsible. However, the transfer of peril is similar to the CIF-value concept (Bernstorff 2010, pp. 129).

2.4.2 Customs regimes

Tariff payments for international trade flows are operated through customs regimes (Kohler 2008, p. 49). Particular customs regimes of a country are various and depend on national law or stipulations in PTA's. Grainger (2000) outlines common regimes in use; import into free circulation, it is applied, if the imported good's destination is inside the customs territory. The imported factor is subject to the tariff payment and thereafter moves freely inside the area. Another available customs regime is the customs warehousing, it is used, if the final destination of the good is not yet known at the moment of importation. No duties have to be paid until the good is registered for a different customs regime. Temporary importation is a further common customs regime. It liberates from duty payments, if the commodity is re-exported in the same state as imported after a certain time interval (Grainger 2000, p. 42).

Customs regimes with a greater importance for designing supply chain networks are the inward processing relief and outward processing relief. Through an appropriate supply chain network configuration these schemes can be used to diminish the overall duty load throughout the production network.

The inward processing relief, is also known as suspension or drawback. Input factors from outside the customs territory are imported, in order to refine them inside the territory into a good designated for export. Two methods are possible for handling the import duties concerning a drawback. Imported input factors are suspended from being charged with tariffs or on the contrary, already paid tariffs are rebated (Kohler 2008, p. 50). Figure 2.2 illustrates this process, a shortblock from the European Union (EU) is imported by Brazil, in order to be part of an inward processing for a truck engine in Brazil, designated for the EU sales market. The importation of the shortblock is applicable under the inward processing relief and Mercosul import duties on the EU shortblock may be suspended or rebated.

The outward processing relief on the opposite, describes the same procedure discussed under inward processing. However, the point of view is different. Input factors are refined outside the alliance territory and afterwards re-imported. Therefore, import duties have to be paid on the ad valorem of a product, i.e. the value added outside the customs territory (Kohler 2008, pp. 49). It is the same process, as illustrated under figure 2.2, however, considered from the European's

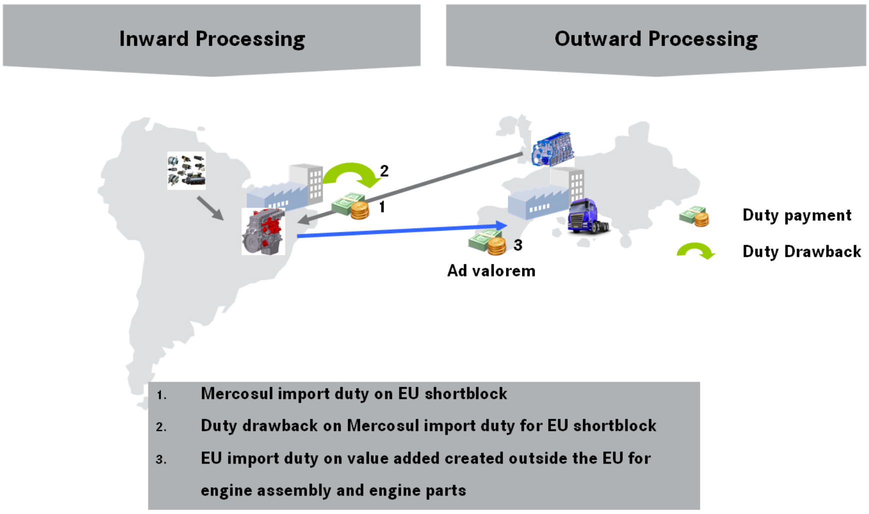


Figure 2.2: Inward and outward processing

angle. The EU shortblock is processed in Brazil, outside the EU customs territory. Hence, at the re-importation of the truck engine, incorporating the EU shortblock, duties have to be paid on the ad valorem. Thus, the engine assembly process in Brazil and the engine parts from the Mercosul territory are liable to EU import duties.

It can be summarized that a single production process can be seen as inward and outward processing, depending on the point of view. Duty drawbacks on paid import duties only can be claimed under the inward processing scheme from the nation occupying the active part at the processing.

Duty Drawback schemes in all existing kinds have one primary goal: promoting exports (Chao, YU and YU 2006, p. 432). These redemptions are especially interesting in countries with high import tariffs, where else wise producing for export, with imported input factors would be non-competitive with world market prices (Panagariya 1992, pp. 131). Companies gain duty free access to resources and can develop their export business, which should enhance welfare of the exporting economy.

In Brazil, for instance, the automotive industry is highly protected by import tariffs. The government motivates manufacturer to claim duty drawbacks on imported inputs, in order to develop their export business (Panagariya 1992, p. 132)

WTO members are allowed to offer these forms of redemption as export supporting instrument, inside the limits of a defined legal framework. Article VI GATT (GATT 1947) limits duty drawbacks to an upper bound, namely the tariffs levied for import (Mah 2007, p. 968). Even though, duty drawbacks bear a high cost savings potential for a worldwide manufacturing company, Oh and Karimi (2006) state that duty drawbacks are often not claimed or taken into account, while designing the supply chain network. In the United States every year about 1,5 - 10 billion *$ US* of possible duty drawbacks stay unvalued (Oh and Karimi 2006, pp. 595). Hence, the customs regimes inward and outward processing are included in the following model formulation as key elements, to examine their impact on supply chain network design.

2.5 Literature review

The following literature review provides an overview on research works linked to the context of this thesis. However, especially relevant works incorporating capacity planning and global aspects as local content restrictions, duties and duty drawbacks are reviewed. A more detailed list on global supply chain models is given by Melo, Nickel and Saldanha-da-Gama (2009), Meixell and Gargey (2005) or Vidal and Goetschalckx (1997).
At first the literature review presents research works focusing on LC requirements under PTAs, duties and capacity planning problems. This is followed by a review on relevant papers concerning duty drawbacks, the special focus of interest.

Munson and Rosenblatt (1997)
Munson and Rosenblatt (1997) examine the effect of LC rules on global sourcing decisions. In a first step a single plant model is formulated under the assumption that LC restrictions have to be met, otherwise, penalties are sufficiently high. The objective function minimizes sourcing costs over all possible local or global suppliers. This deterministic single plant model is extended in a second step to a multi-plant model. Munson and Rosenblatt (1997) cover additionally the impact of different LC quota in local industries on a macroeconomic level.

Bhutta et al. (2003)

The developed model by Bhutta et al. (2003) attends to production, distribution and investment decisions of a global acting corporation. The formulated mixed integer program addresses the problem, where plants should be opened and how their configuration in terms of chosen capacity volumes should look like to maximize profit. The formulated model considers necessary investments, capacity adjustment costs and inventory decisions. Further, global aspects as tariff and exchange rates are included. However, the exchange rate is assumed as a linear function and reflects therefore a strong simplification. LC decision are not taken into account.

Chakravarty (2005)

Chakravarty (2005) provides a model for optimizing plant investment decisions, while simultaneously determining the necessary selling prices for the products at its designated markets. The model assumes that manufacturers are not price takers and therefore this aspect needs to be attended to, while optimizing investment decisions. Hence, demand is modelled as a price sensitive function, depending on the manufacturers cost. In order to determine the most beneficial plant configurations the occurring investments are allocated as overheads to the variable production costs of a product at each plant, whereof the particular selling price is derived from. Further, global aspects as taxes, LC, tariffs, exchange rates and market sizes are taken into account, while maximizing the after tax profit of a manufacturer.

Wilhelm et al. (2005)

Wilhelm et al. (2005) develop for the free trade area NAFTA a strategic model for designing the production network of a manufacturer. The authors intend to develop a decision support model with practical relevance for managers and conclude therefore with an exemplary application. However, the model maximizes after tax profits, while taking taxes, transfer prices and LC requirements from the NAFTA region as global aspects into consideration. The LC constraint is modelled as a hard constraint limiting the non-originating value of every good to a upper limit. The LC is always fulfilled. Their model works under the premise of a deterministic business environment.

Li, Lim and Rodrigues (2007)
Li, Lim and Rodrigues (2007) examine sourcing decisions for multinational corporations, especially concerning the Japan-Singapore Economic Partnership Agreement. This agreement forms a free trade area between Japan and Singapore. Rules of origin were implemented to prevent transshipment. Their developed optimization model considers LC decisions and duties as global aspects. Firstly, described as non-linear integer program, it is consequently remodelled into a linear integer program for easier solving. The LC restriction is defined as soft constraint, i.e. a fulfillment of LC for inner area trade is not required. If the minimum LC on the contrary is met, duty payments are eliminated.

Guo et al. (2008)
Guo et al. (2008) model a multi-stage facility location problem under free trade agreements. They implement LC decisions through cumulating the particular value added over all stages of a specific country and contrast it to the related LC requirement. As further global aspect duties are incorporated. In order to solve their problem the authors develop a multi-exchange heuristic, based on the very large-scale neighborhood search and investigate it with an experimental analysis.

Stephan (2008)
Stephan (2008) develops a strategic network design model under the influence of LC requirements in Free trade agreements, especially considering the automotive industry. The author therefore, presents a non-linear planning model for the North American Free Trade Area (NAFTA) and its specific automotive requirements. LC fulfillment is modelled as soft constraint and costs are determined accurately to the NAFTA legal framework. The objective function minimizes total costs.

Bihlmaier, Koberstein and Obst (2009)
Bihlmaier, Koberstein and Obst (2009) present a two-stage, stochastic mixed integer model for capacity planning and analyzing strategic flexibilities for uncertain demands in the automotive industry. Further, a detailed work force planning via shift models is included. Global aspects are not taken into account, while

minimizing total costs. In order to solve this stochastic formulation the authors develop an accelerated decomposition approach based on Benders decomposition. They conclude their work with a performance study, followed by a numerical case study.

The following research papers deal with facility location problems and account in addition for possible duty payments and the opportunity of **duty drawbacks**, while optimizing the supply chain:

Arntzen et al. (1995)

Arntzen et al. (1995) developed a global supply chain model (GSCM) for the Digital Equipment Corporation, considering their production and distribution network. Therefore, they created a large deterministic mixed integer program with a split objective function. It is a composition of minimizing costs, as well as time. Operative attributes taken into account are variable and fixed costs as well as capacity and demand fulfillment constraints. Time however, is considered in the objective function by a weighted factor of cumulative production and distribution times.
In order to fulfill the claim of a global supply chain model, Arntzen et al. further include LC, tax, duty payment and duty drawback decisions. The LC constraint is modelled as a so called hard constraint, i.e. LC must be fulfilled. Hence, no decision is possible, on whether fulfilling LC or paying the related penalty duties. Duty drawbacks are granted for products and components imported to a production site, designated for further exportation.

Oh and Karimi (2006)

Oh and Karimi (2006) develop an international production-distribution model for the chemical industry. Their focus of interest is on duties and duty drawbacks. The authors state that duty drawbacks have an incremental influence on international supply chains. However, drawbacks are not taken into account to this extend in existing production-distribution models.
The implemented objective function maximizes total after tax profit, accounting for variable and fixed production costs. Duty drawback regulations are modelled in detail. Thereto, the bill of material for a chemical product is used to trace

back imported input factors. The sum of all paid import duties returns an upper bound for drawback claims. To obtain the amount of claims, the model calculates the export quota of a final product and multiplies it with the predetermined upper bound for drawbacks.
All these calculations are executed in a multi- supplier, multiperiod environment, which complicates the problem, concerning inventory tracking and different import tariff payments.
The authors test their model for the chemical industry and conclude that import and export profiles change, whether or not, duty drawback constraints are respected. The allowance of duty drawbacks results in production-distribution networks with higher after tax profits.

Villegas and Quenniche (2008)

Villegas and Quenniche (2008) develop a general multinational supply chain model. They claim for their work to include previous research factors, like transport cost and duty drawbacks, in a more generalized and comprehensive manner than existing literature.
Their model maximizes earnings, whilst, calculating the optimal transfer prices between interdivisional profit center. In order to reproduce a realistic environment, the model includes production and transportation costs, import tariffs, exchange rate risks and corporate taxes. Duty drawbacks can be claimed for products imported, previously treated by the importing division (outward processing) or products for export previously processed abroad (inward processing). Villegas and Quenniche concentrate on the relations inside a company and exclude supplier selection as well as LC restrictions. Their model never was tested.

Kohler (2008)

Kohler (2008) develops a deterministic mixed integer program for supply chain design. He focuses on the modelling of material flows between different production sites and derives thereof information on global aspects influencing the supply chain design. Global aspects taken into account are taxes, duties, duty drawbacks, LC-requirements and exchange rates. The objective function maximizes profits and is further extended into a multi-objective function through additionally considering delivery times. Due to the holistic approach the author has to cope with various premises, therefore, legal frameworks cannot be incorporated accurately.

Table 2.3 provides an concluding overview on the presented literature respectively the most important attributes. Incorporated characteristics with regard to global aspects and capacity planning are summarized.

Attributes	**Authors**											
	Arntzen et al. (1995)	Munson and Rosenblatt (1997)	Bhutta (2003)	Wilhelm et al. (2005)	Chakravarty (2005)	Oh and Karimi (2006)	Li; Lim and Rodrigues (2007)	Guo et al. (2008)	Villegas and Quenniche (2008)	Stephan (2008)	Kohler (2008)	Bihlmaier, Koberstein and Obst (2009)
Local content	x	x	-	x	x	-	x	x	-	x	x	-
Duties	x	-	-	-	x	x	x	x	x	x	x	-
Duty drawbacks	x	-	-	-	-	x	-	-	x	-	x	-
Exchange rates	-	-	x	x	x	-	-	-	x	-	x	-
Stochastic parameters	-	-	-	-	-	-	-	-	-	-	-	x
Facility location	x	x	x	x	x	x	-	x	x	x	x	x
Capacity planning	x	-	x	-	x	x	-	-	-	x	x	x
Inventory level	x	-	x	-	-	-	-	-	-	-	-	-
Objective	multi-objective	min. costs	max. profit	max. profit	max. profit	max. profit	min. costs	min. costs	max. profit	min. costs	multi-objective	min. costs

Figure 2.3: Literature overview

Although, the examination of the non-tariff trade barrier LC is purpose to a various number of research papers its implementation in mathematical modelling is very general and often not applicable for an operative application. LC calculation schemes are as various as the number of PTAs in force and report often different specification for industries of special interest, e.g. the Brazilian automotive sector. The same difficulties can be stated for duty and duty drawback calculations. Research works incorporating duty drawbacks are not very widespread and consider drawbacks in a very generalized way. Therefore, in order to properly examine the interactions of LC requirements, duties and duty drawbacks a mathematical model has to be formulated in such a way that represents actual effective legal frameworks for the PTA and the industrial sector of interest.

This gap is closed by this thesis. It is presented a mixed integer program to optimize the production network of a truck manufacturer acting on Mercosul territory. The model incorporates effective legal frameworks for Mercosul automotive LC calculations, duty regulations and applicable customs regimes. Therefore, valid disclosures on their interactions can be concluded, whereby, the production network and capacity decisions of the manufacturer are optimized.

3 Mercosul

After having introduced global trade barriers as well as duties and duty drawbacks from a methodological point of view, this chapter focuses on the legal framework of the Mercosul territory. The following section deals with a brief introduction into the trade area Mercosul, its history of origins and decision making institutions. Furthermore, the legal framework with regard to global production network design is presented in detail. In particular, Mercosul LC requirements, duties and Mercosul customs regimes are provided respectively to the automotive industry. Finally, a characteristic Brazilian non-tariff trade barrier is introduced with special focus on the automotive sector.

3.1 History and organization

The regional integration process in South America was already in progress before the establishment of Mercosul. In the following, a brief overview on the history is provided. In addition, the organization and legislation process of the Mercosul territory is described.

3.1.1 Integration projects in South America

Asociación Lationamericana de Libre Comercio (ALAC)
The ALAC was founded in 1960 in Montevideo and was the first South American attempt for a regional integration project. The eleven member states Argentina, Brazil, Chile, Mexico, Paraguay, Peru, Uruguay, Columbia, Ecuador, Venezuela and Bolivia declared the establishment of a free trade area within twelve years as their common goal. Their long term ambition was the creation of a common

market. Supranational institutions with decision making rights were not established, instead, consulting and support giving organizations were installed. As the negotiation process stumbled, their goals never were realized. During the 1970s the contract was formally still in force, but agreed meetings never were held (Wehner 1999, pp. 30).

Asociación Lationamericana de Integración (ALADI)

In 1980 the ALADI was founded by the same eleven member states allied under the ALAC and is therefore its direct successor organization. Long term objective is again the creation of a common market. Since, the member states learned from their previous mistakes, this goal was declared without a determined deadline. The ALADI allows member states to sign with each other bilateral preferential trade agreements, free trade agreements and customs unions. These contracts have to be registered with the ALADI and are called "acuerdos de Alcance regional". Thus, the ALADI can be seen as a framework for an integration process within the South American continent (Wehner 1999, pp. 31).

Mercado Comum do Sul (Mercosul)

Figure 3.1: Mercosul member countries

Acuerdo de Alcance Parcial de Complementação Econômica No. 18 (ACE) is the "Tratado de Asuncíon (TA)", the foundation contract of the Mercado Comúm del Sur (Mercosur), in Spanish or in Portuguese, Mercado Comum do Sul (Mercosul).

The TA was signed on March 26th 1991 from the founding countries illustrated under figure 3.1, Argentina, Brazil, Paraguay and Uruguay with following objectives:

- Free transit of goods, services and production factors
- Establishment of a common external tariff
- Establishment of a common trade policy
- Macroeconomic coordination of politics

Their intention was to realize these goals within a transition period of three years, until the 31st of December 1994. Their expectation was to increase economic growth, efficiency and competitive ability for the region, along with, granting an increased social justice (Basedof and Jürgen 2000, pp. 19).
Mercosul is after the US, the European Union and Japan the fourth biggest economy, accounting for 70% of the South American area with about 240 million inhabitants (Funders 2007, pp. 18). The European Union represents the biggest importer to Mercosul and is therefore one of its most important trade partners. Mercosul and the European Union signed the "Interregional Framework Cooperation Agreement" in 1995 with the long term intention of creating an interregional association (Funders 2007, pp. 18).
In the following years, the TA was widely revised and completed by protocols. The member countries stated later that the contract has to be understood as basic agreement for the initialization of the integration process. At the beginning two institutions, the "Conselho de Mercado comum (CMC)" and the "Grupo de Mercado comum (GMC)", were meant to be installed. However, this framework was later extended by the "Protocol de Ouro Preto", establishing further institutions and a more relaxed time framework to realize the Mercosul goals (Rocha de Mello Martins 2001, pp. 23).

3.1.2 Decision-making institutions

The TA and its amendment protocols are considered as primary law on which the Mercosul was founded. Thus, secondary law are all legal acts legislated by the Mercosul institutions (Wehner 1999, pp. 77). These regulations are passed continuously. Due to their enumeration it is defined, which institution legislated

them at which date. For example, CMC/DEC 10/94, is the 10th decision of the CMC in 1994. As a result, the legal framework of the Mercosul is in a steady dynamic extension, to realize the goals defined by the TA.
Mesa (2009) gives an overview on the most important institutions and their composition:

- **Conselho de Mercado Comum (CMC)**, is the superior council of Mercosul and consists of the External Relations and Economics Ministers from all member states. Its presidency changes every sixth month. The CMC decrees "decisãos (CMC/DEC)", which aim at the fulfillment of the TA goals. All CMC/DEC are agreed on concordant and binding for all members (Mesa 2009, pp. 46).
- **Grupo Mercado Comum (GMC)**, is the executive institution. Its task is the realization of the CMC/DEC. The GMC consists of 32 members. Every member state is allowed to appoint four permanent as well as four changing representatives. The GMC legislates so called "resoluções (GMC/RES)" that are binding for all members. In addition, eleven sub-working groups for particular industries, like the sub group automotive, were installed (Mesa 2009, pp. 49).
- **Comissão de Comercio do Mercosul (CCM)**, was introduced by the "Protocol de Ouro Preto". Its task is to support the GMC concerning economical questions. Members are four permanent as well as four changing representatives from each country, meeting at least once per month. They legislate binding "Directivas" or suppose non-binding "Propuestas" (Mesa 2009, pp. 51).
- **Parlamento do Mercosul**, the 90 delegates elected by their home parliaments have no decision making competencies so far. They consult installed institutions and represent their home parliaments. However, this should change as well as the fact that in the future delegates are elected directly (Mesa 2009, pp. 55).
- **Tribunal Permanenete de Revision**, this court of justice is responsible for litigations in correlation with the Mercosul legal framework. Its permanent residence is stationed in Asunción, Paraguay (Mesa 2009, pp. 54).

3.1.3 Classification of Mercosul

The overall goal of the TA was the creation of a common market. This was meant to be achieved in less than five years until the end of 1994. A very ambitious intention that could not yet be realized. Nevertheless, some significant processes were made towards it. Internal free trade and a common external tariff for imports are realized at a great deal, besides some still existing exclusion. Their abolishment is one of the most important projects on the current agenda (Mercosul/CMC 2010a).
The Mercosul agreement can be ranked between a FTA and a customs union. The main difference between both is that a customs union applies a common external tariff, which makes LC rules to avoid trade deflections unnecessary.
The Mercosul legal framework recently focuses very strong on building up a common external tariff and disposing the last exceptions to it. However, LC regulations are still applied and a double levying of duty payments is possible, while crossing a border inside the Mercosul. Concluding can be said that the Mercosul integration process is beyond the classification of a Free Trade Agreement and can be seen as an incomplete customs union or a customs union under development.

3.2 Mercosul tariff regulations

Under this section the implementation process for the two major goals from the TA is presented. Free transit of goods inside the Mercosul territory and establishing a common external tariff opposite third party countries. The following section includes the intentions stated in the TA and contrasts them to the actual effective application.

3.2.1 Intra-Mercosul trade

Article 1 of the TA defines that until December 31st 1994 all intra-Mercosul tariff payments should be abolished to achieve free trade for goods inside Mercosul (Mercosul 1991, Article 1). Annex one of the TA gives a detailed scheme for the incremental cutback on inner trade area tariffs until the end of 1994. For Paraguay and Uruguay an extension of one year to this deadline was designated.

Nevertheless, every country was allowed to introduce exceptions to this preferential treatment. These exclusion lists were meant to be reduced by 20% each year (Mercosul 1991, Article 7, Anexo I). By the end of 1994 all exceptions should have vanished. Brazil was allowed to except 324 items, Argentina 394, Paraguay 439 and Uruguay 960 (Mercosul 1991, Article 6, Anexo I). Most of them could be found in the textile, steel or agricultural sector, which are protected industries and therefore have special needs for the liberalization process (IDB-INTAL 1996, p. l8).
Later CMC/DEC 5/94 and CMC/DEC 24/94 allowed exceptions to the free trade for products of sensible industries beyond the original deadline. CMC/DEC 29/94 installs another arrangement, going beyond simple excluding. It demands for the Mercosul automotive industry the installation of a special committee, dealing with the liberalization of the intra-Mercosul automotive market as well as the handling of a common external tariff (Mercosul/CMC 1994e).
The automotive as well as the sugar sector are industries of special interest with a strong lobby in Mercosul countries. Through their influence on national governments, lobbyists try to impair decisions towards their advantage, ending up in higher protection of national interests (Malcher 2004, p. 129).
A complete free trade within the Mercosul territory has not been established. Despite its original intention, there is still the need for rules of origin to determine the derivation of a good. These rules of origin, applying on Mercosul territory are explained under section 3.3.

3.2.2 Common external tariff

A common external tariff (CET) was designated from the very beginning. Article 1 of the TA refers to a "tarifa externa comum" opposite all third party countries outside Mercosul. In order to build up free trade for goods, a CET possesses an essential role to achieve it. The CET assures that imported goods, after paying the Mercosul import duty can freely move inside Mercosul (Funders 2007, pp. 229), representing the customs regime "import into free circulation" (Grainger 2000, p. 42).
For the CET the TA contains less detailed proceeding instructions. It is mentioned that until the end of December 1994, when the Mercosul officially should

start, a CET should be agreed on. CMC/DEC 22/94 introduces therefore, a Harmonized Nomenclature System for all goods. It resembles to the Harmonized System of the WTO and contains for about 85% of all Mercosul goods a common tariff. Article three of the CMC/DEC 22/94 allows the member countries to exclude certain goods from the CET, accordingly, to the exceptions available for inner Mercosul trade. However, for the automotive industry the responsible committee also deals with the regulation of an automotive CET. Until today, there are still items excluded from the CET. These items have to be documented on lists for every country. CMC/DEC 28/09 is the most recent decision dealing with the exceptions. It schedules that until the end of 2011 all of the up to 100 exceptions still assigned to every country, should be abolished (Mercosul/CMC 2009c). It has to be mentioned that these deadlines were continuously postponed over the last years and therefore, the expire dates have to be referred to very carefully (IDB-INTAL 2009, p. 79).

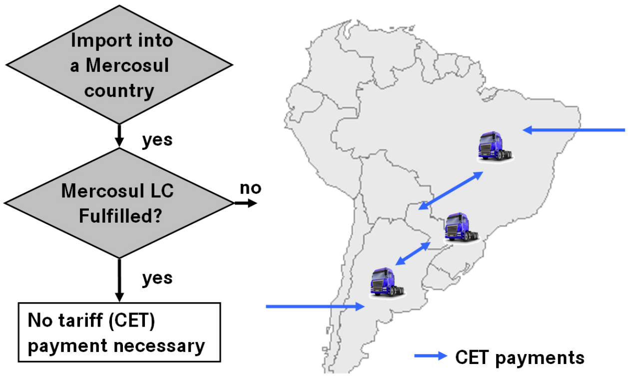


Figure 3.2: Common external tariff (CET)

Another problem yet unsolved is the double levying of tariffs. Since, the Mercosul intends to set up a customs union this phenomenon is unusual. It is justified by the member states through the exclusion lists and the lack of a distribution mechanisms on tariff revenues (IDB-INTAL 2009, p. 75). For example, a commodity (non-compliant with Mercosul LC) entering the Mercosul customs territory through Brazil with destination Argentina has to pay the CET twice, on the Brazilian as well as the Argentinean border. Figure 3.2 illustrates this situation. Every time a good not compliant with Mercosul LC crosses a border the CET has to be paid. CMC/DEC 54/04 explicitly addresses this problem and defines following guidelines to further develop the customs area:

- Imported goods, after paying the CET, are seen as originating in the Mercosul territory
- Legislation of a common customs code
- Online system for the customs administration
- Distribution mechanism for the customs revenue

Most of the topics are still on Mercosul's agenda, whereas CMC/DEC 27/10 legislated finally, the "Código aduaneiro do Mercosul" (CAM) - the common Mercosul customs code. In addition, CMC/DEC 10/10 provides a timetable divided into three stages with the final deadline in January 2019 for achieving the presented aims of CMC/DEC 54/04. Article 158 CAM defines the modalities of possible duty payments in the Mercosul territory:

- **Ad Valorem duties** are expressed in a percentage and calculated on the basis of the customs value of a good. The CET is an Ad Valorem duty.
- **Special tariffs** are fixed values and charged per imported unit.
- **Mixture of both** duty types

Article 163 CAM specifies the Mercosul custom's value. It refers explicitly to the article VII GATT, where the WTO defines its draft of the customs value, the CIF value of a good (GATT 1947, article VII). Article 164 CAM, declares the properties of the Mercosul customs value. It includes costs for producing the good plus costs for transport and an insurance fee until it reaches the customs territory of destination (Mercosul 2010, article 163,164). This definition equals the CIF value, according to the Incoterms as well as the the WTO customs value definition.

3.2.3 Mercosul customs regimes

Beneath, the customs regime "import into free circulation" through paying the CET on the customs value, the CAM describes amongst others the possibility for inward as well as outward processing of input factors:

- Article 56 CAM refers to **inward processing**, if a good is imported and refined for further export purpose inside Mercosul, it can be liberated from customs duties and duty drawbacks can be claimed.
- Article 86 CAM refers to **outward processing**, goods temporary exported and refined outside the Mercosul territory only have to pay duties on the value added outside Mercosul.

Free trade areas and customs unions normally ban the possibility of duty drawbacks on trade flows between member states, as the North American Free trade agreement did. In general, duty drawback schemes may exclusively be available for imports on goods, consequently exported to third party countries from outside the trade area, in order to prevent bypassing the originating criteria established within the preferential trade area (Cadot, de Melo and Olarreaga 2003, pp. 1).
The abolishment of intra-Mercosul duty drawbacks was meant to be realized for the Mercosul territory as well. Article 12 of the CMC/DEC 10/94 stipulates that intra-regional trade should not benefit from duty drawbacks. CMC/DEC 31/00 introduces for the first time a concrete deadline considering the abolishment of intra-Mercosul duty drawbacks: the 31st of December 2000. Furthermore, the decision asks the GMC to provide an overview on all additionally applied national non-tariff trade barriers and suggest therefore harmonization possibilities until January 1st 2006. These deadlines were postponed constantly, compare CMC/DEC 69/00, CMC/DEC 32/03, CMC/DEC 33/05, CMC/DEC 02/06 and CMC/DEC 57/08. A common regulation is not yet agreed on.
Intra-Mercosul duty drawbacks are still possible, due to CMC/DEC 20/09 until December 31st 2016. This decision indicates that in terms of legal certainty, a binding framework has to be found. Simple postponement is no longer an appropriate solution (Mercosul/CMC 2009b).
Duty drawback regulations are national law and administrated in Brazil by Porteria SECEX no. 10 and Decreto no. 6.759, distinguishing two general types of drawbacks:

1. **Drawback Suspensão:** in this case duty payments are suspended, while importing input factors for inward processing.
2. **Drawback Isenção:** imported goods, meant for further export, are liberated from duty payments.

These two laws explicitly allude on their export developing purpose, a domestic excess supply should be avoided by all means. The overall goal is to strengthen the national export industry and enable companies to compete with world market prices. Possible drawbacks have to be claimed within a specified period of time. Article 62 SECEX refers to the processes available for duty drawbacks. Input factors need to be transformed, improved, assembled or refurbished in order to acquire duty drawbacks through the customs regime of inward processing in Brazil.

3.3 Mercosul non-tariff trade barriers

As presented before, neither a complete intra-Mercosul free trade is in place, nor is the CET fully harmonized. Rules of origin are necessary to cope with these conditions. In the following section these non-tariff trade barriers are introduced. First, the general rule of origin for the Mercosul territory is presented followed by its equivalent for the automotive industry. Finally, information on a special non-tariff trade barrier are provided, which is from special interest at the Brazilian market.

3.3.1 General rules of origin in Mercosul

Rules of origin are used in the Mercosul territory to avoid trade deflections. Since, the Mercosul member states have not yet established a CET for all goods, there is the need for rules to define, if a product or good is originating from Mercosul and receives therefore a preferential treatment. These rules are summarized for the Mercosul territory under the "Régime de Origem" and mentioned in the TA (Mercosul 1991, annex II).
CMC/DEC 01/09 is their most recent legal version. The decision defines originating criteria, the emission process for Mercosul LC certificates, control mechanisms and sanctions in cases of irregularities. Goods originating from Mercosul have to fulfill at least one of the following criteria, compare also figure 3.3:

- All input factors for the product are totally obtained in one member country
- All input factors originate exclusively from Mercosul territory

- Products containing input factors from third party countries have to comply with:
  1. The change in tariff heading criteria. That is, if the transition process of the good ends in a higher class of the harmonized system compared to its input factors or
  2. if there is no change in heading, a good accounts as originating from Mercosul, in case more than 60% of its input factors derive from Mercosul territory. This can be summarized under the value added or local content criterion.

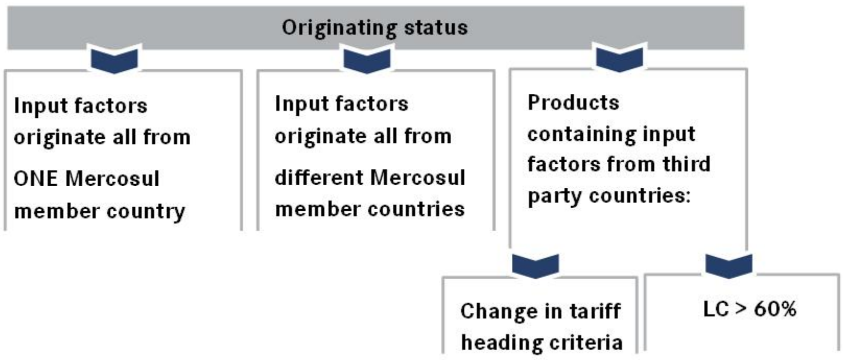


Figure 3.3: Mercosul originating status

Article 6 from the CMC/DEC 01/09 provides the calculation formula for Mercosul local content compliance:

$$LC = 1 - \frac{CIF\ value\ of\ imported\ goods}{FOB\ value\ of\ exported\ product} \cdot 100 \geq 60\% \tag{3.1}$$

The LC proportion of a good, remains after subtracting third party input factors, evaluated on basis of CIF values compared to the FOB value of the exported good. To account as originating from Mercosul this value has to be superior 60% (Mercosul/CMC 2009a, Articles 1 - 6).
The Mercosul LC certificate can be issued for all commodities, compliant with LC requirements, crossing a Mercosul customs border. The document asks for detailed information on contracting partners, means of transport and a bill of material of the specific good. Input factors have to be listed with their value,

country of origin and its dedicated code from the harmonized system. However, after issuing a LC certificate, the good accounts as 100% originating from Mercosul (Mercosul/CMC 2009a, Articles 18 - 21).

3.3.2 Automotive sector regulations

The automotive sector in Mercosul represents 25% of interregional trade on Mercosul territory (Malcher 2004, p. 129). The two most important nations in this industry are Brazil and Argentina, whereof the Argentinean industry relies more on Mercosul trade than the Brazilian. This is the fundament for ongoing conflicts. The Argentinean government accuses Brazil to distort competition by granting subsidies to multinational companies and hinder development of the interregional free trade. Climax of the conflict was in 1999 when Brazil granted to the Ford concern a 100 million *$ US* tax advantage, in exchange for the construction of a production site in Bahia, Brazil (Malcher 2004, pp. 129).
A Technical Committee for the automotive industry was installed from the very beginning and asked to submit a proposal for a common Mercosul automotive regime (IDB-INTAL 1997, pp. 30). Their proposal should point out, how free trade in the automotive market can be established and how the CET should be designed. This proposal was meant to be brought in, with the end of 1997 and realized by end of 2000 (Mercosul/CMC 1994e, Articles 1 - 3).
This ambitious objective could not yet be accomplished. CMC/DEC 70/00 postponed the deadline for free trade until January 1st 2006. For the transition period CET harmonization schemes and calculation methods for the LC were specified (Mercosul/CMC 2000c).
In 2004 the economical situation changed. Argentina's automotive products suffered a significant market loss on the Brazilian sales market, due to import substitution by third party countries. On the opposite, the Brazilian market share in Argentina rose up to 62%. This imbalance in trade flows lead to a change in mind of the Argentinean government, requesting for a review on the Mercosul automotive policy (IDB-INTAL 2006, pp. 61). Hence, negotiations in the sector went back on a bilateral level between Brazil and Argentina.
The recent valid framework for the two biggest members in Mercosul, Argentina and Brazil, is their bilateral contract registered in the ALADI as ACE 14 with

its 39 additional protocols. The latest protocol validates the ACE 14 until June 30th 2014 and administrates:

- **The common external tariff** is set to 35% for final products like cars, omnibuses, trucks and tractors. For automotive parts, the Mercosul CET applies. All automotive goods are clustered into categories, the membership to a specific category can be seen through consulting the Harmonized System table, where every item is attached to a specific category, compare figure 3.4 (ALADI 2010, Article 3, Annex).

Classification of automotive goods		Applied tariff
Cars	a)	
Omnibus	b)	
Trucks	c)	Mercosul CET 35 %
Tractor	d)	
Chassis with engine	e)	
Trailer	f)	
...		Mercosul CET Average: 14%
Automotive parts	j)	

Figure 3.4: Classification of automotive goods (ALADI 2010, Article 7)

- **Parts non-receivable** in Mercosul can be imported to a preferential tariff of 2% (ALADI 2010, Article 6).
- **Trade volume limits** were introduced to restrict free trade between both countries, due to Argentina's described trade deficit. Thereto, a coefficient is used. The so called "flex", limits maximum exportation amounts. For every *$ US* exported from Argentina to Brazil, Brazil may import up to *$ US* 1.95 to Argentina. On the contrary, Argentina's "flex" was set to 2.5, for every *$ US* imported from Brazil, Argentina is allowed to export up to the factor 2.5 of this value (ALADI 2010, Article 11).
- In order to determine the originating status of a good, a LC calculation method for the automotive sector, the "índice de Conteúdo Regional (ICR)" was legislated (ALADI 2010, Article 16).

$$ICR = 1 - \frac{CIF\ value\ of\ imported\ goods}{ex\ factory\ value\ without\ taxes} \cdot 100 \geq 60\% \qquad (3.2)$$

Latter formula is valid for the categories of final products, and refers to letters a - f, from figure 3.4. For automotive parts the general Mercosul LC formula as explained under formula 3.1 applies (ALADI 2010, Article 16). Furthermore, article 18 of the agreement refers to a special case of interest, the introduction of new models. The requested ICR raises step by step beginning with 40% in the first year, 50% in the second and 60% from the third year on, in order to consider the start-up phase of these products (ALADI 2010, Article 17).

3.3.3 Special Brazilian non-tariff trade barrier: Finame

This section presents a specific non-tariff trade barrier from Brazil. The Brazilian development bank (Banco nacional de desenvolvimento - BNDES) grants for investments in new national machinery and equipment, produced in Brazil favorable development loans (BNDES 2006, bullet 4.1). Objective is the progression and support of the Brazilian economy opposite increasing competition.

Fundable are assets registered at the “credenciamento de Fabricantes informatizado (CFI)”, a data base accessible via the Internet. For the admission into the CFI a product or equipment has to fulfill the “indíce de nacionalização (IN)”. The IN is comparable to a LC requirement with one additional specific characteristic. In addition, to a certain value added request, there is a further requirement for a minimum weight added. An asset accounts as originating, if in both cases the aliquot of local input added is superior 60% (BNDES 2006, Article 4).

Formula 3.3 refers to the calculation of local value added. In addition to the CIF value of an imported good, paid customs duties are included into the enumerator and account therefore as non-originating. Denominator is the intern market price of the asset without taxes (BNDES 2010, Article 13 No. 1).

Formula 3.4 presents the calculation of local weight added. Imported input factors of a product are assessed by their weight and subsequently contrasted with the total weight of the final product (BNDES 2010, Article 13 No. 2). In both cases a minimum proportion of 60% has to be fulfilled.

1. **IN by value**

$$In_v = 1 - \frac{CIF\ value\ of\ imported\ goods\ +\ customs\ duties}{intern\ market\ price\ without\ taxes} \cdot 100 \geq 60\% \tag{3.3}$$

2. **IN by weight**

$$In_w = 1 - \frac{summarized\ weight\ of\ imported\ goods}{total\ weight\ of\ product} \cdot 100 \geq 60\% \tag{3.4}$$

Figure 3.5 illustrates the application process for the development loan. If, a Brazilian carrier plans to buy a new truck financed through a BNDES development loan, he needs to choose an approved product from the CFI register. Thereon, he can insert his application for the loan concerning the specific truck with a contract bank, equally approved through the BNDES. Applicants never have direct contact to the BNDES. After verifying the request in terms of compliance, the development loan is granted and disbursed through the contract bank.

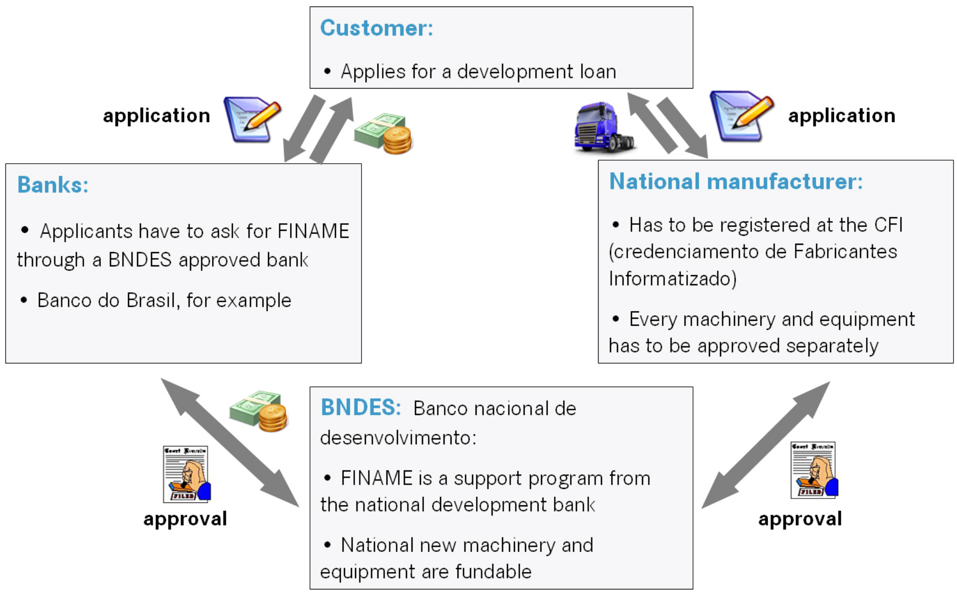


Figure 3.5: Finame application and approval process

3.3.4 Summary and application of non-tariff trade barriers

In the following is given a summary for the beforehand introduced Mercosul non-tariff trade barriers, especially on the LC and Finame calculation methods. Priority is put on the concrete application for the automotive industry and how these requirements can be implemented into the optimization process of a global production network of a truck manufacturer. Therefore, five different cases are introduced, which need to be distinguished during the calculation process. At first, the calculation of Mercosul LC is presented, based on the five cases, followed by the description for the Finame characteristics.

3.3.4.1 Mercosul LC

The Mercosul legal framework for the automotive industry pinpoints two different calculation methods for local content purpose. One for automotive parts, compare formula 3.1 and additionally, another for final products presented under formula 3.2. Both have in common their enumerator, the CIF-value of imported goods. Furthermore, described as the value of non-originating material (VNM). The identification of the VNM is, consequently, the focus of interest.

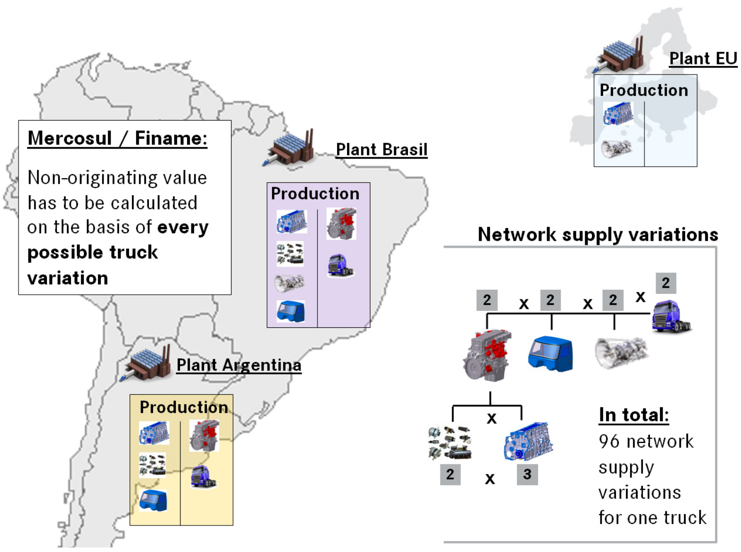


Figure 3.6: Network supply variations

For the Mercosul LC, the VNM is calculated on basis of every possible network

supply variation of a product. By network supply variation, a set of all possible production options for one product is described, which is available throughout the global production network of the truck manufacturer. Figure 3.6 gives an example on the determination of all possible variations inside a given network. In the set-up three production plants are available, each of them able to produce specific components. Given the assumption, the three-staged bill of material looks as illustrated, 96 different network supply variations for the truck are generated, composing through: three possibilities for producing the shortblock, multiplied by two possibilities for producing the engine parts, multiplied by two possible engine production sites and so on, ending up in 96 network supply variations for the particular truck type. However, for each of them a different VNM, relating to Mercosul LC and Finame regulations, has to be determined. Thus, different LC and Finame characteristics are possible for every truck variation. It needs to be pinpointed for every iteration in the production process, where its specific value was generated and if the value accounts as local added.
Consequently, five different cases for the VNM calculation are provided, respectively to the location of producing plants as well as LC fulfillment of antecessors components. As antecessor components are labeled all parts necessary, for assembling a product variation, defined by the subordinated stages from the bill of material. The classification into the cases is necessary, to enable an exact tracing of the VNM of every product or component throughout the global production network. Indeed, every case ends up in different summing of antecessor components and VNM calculation.

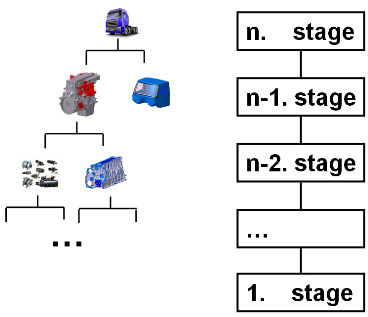


Figure 3.7: Stages of the production process

Figure 3.7 illustrates the stages of a generalized production process for an exemplary final product. It describes a bottom up approach, defining the subcomponents of the lowest level as first stage with an ascending enumeration to the top. Consequently, these stages are referred to when it comes to the VNM calculation via the five cases presented in the following.

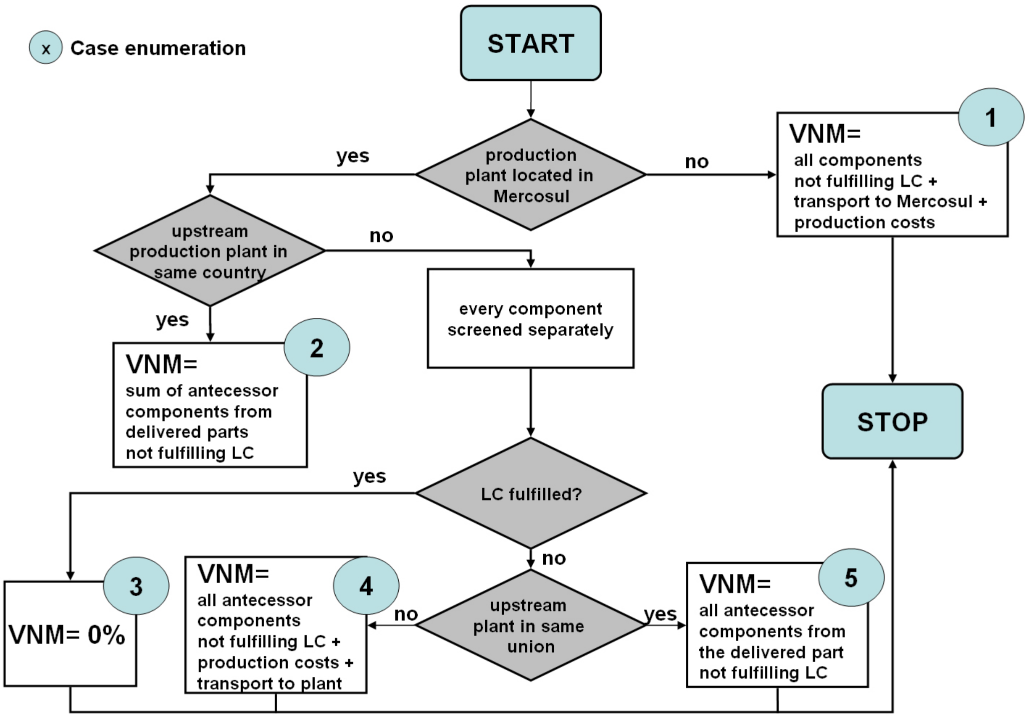


Figure 3.8: Process chart Mercosul local content

The process chart 3.8 illustrates the five cases and the conditions leading to them. The decision for the appropriate formula is at first dependent on the location of the particular production plant. Is it based on Mercosul territory or not? In case the plant can be found on Mercosul territory, the next information needed is: Is the upstream plant located in the same country or not? In case these two countries differ, every component has to be screened separately in terms of Mercosul LC compliance and location of the upstream plant, with regard to the union of interest.

When determining the VNM of a product, it is essential to strictly follow the bottom up principle. VNM calculation and therefore Mercosul LC stipulations always start on the lowest level of the production process, working its way through the scheme. This is caused by the fact that for the VNM calculation at every stage, the data concerning antecessor components are needed. With exception to the first stage, where input data on the VNM are necessary, for every consequent stage the VNM calculation process starts with identifying the proper case. This is followed by determining the VNM and therefore the Mercosul LC compliance of the component. This proceeding is repeated step by step for every stage of the production process, until the final level is achieved.

$$\omega_{ifu}^{lc} = \begin{cases} 1 & \text{if } \sum\limits_{\tilde{i} \in I} B_{\tilde{i}i} \ = \ 0 \text{ and } \tilde{i} \neq i \\ 0 & \text{else} \end{cases}$$

$$\forall i \in I, u \in U, f \in F_i \cap F_u \tag{3.5}$$

Formula 3.5 allocates to every component without any antecessors, $\sum\limits_{\tilde{i} \in I} B_{\tilde{i}i} \ = \ 0$, originating on Mercosul territory a LC of 100%. This reflects the necessary input data for the first stage of the production process in order to enable the following VNM calculation proceeding for the subsequent stages.

In the following, the methodology for Mercosul LC determination is presented. Figure 3.9 illustrates this procedure. In a first step necessary parameters need to be initialized. Consequently, strictly tracking the bottom up approach, the VNM for components and products of each stage is calculated. The calculation is dependent on the applicable case. In a last step, to every product or component is allocated its specific LC characteristic, the binary parameter ω_{ifu}^{lc}. This process is repeated for all components and products until the final production stage is achieved.

Subsequently, the algorithm is described. Line one and two initialize the necessary control parameters and activate the loop for the bottom up approach of VNM calculation for Mercosul LC purpose. Along with lines four to eight comes the summing of the particular component or product variation's VNM, with regard to the detected case. Hereby, the values of all components and assemblies of non-originating materials as well as their transport (CIF) are summarized. The

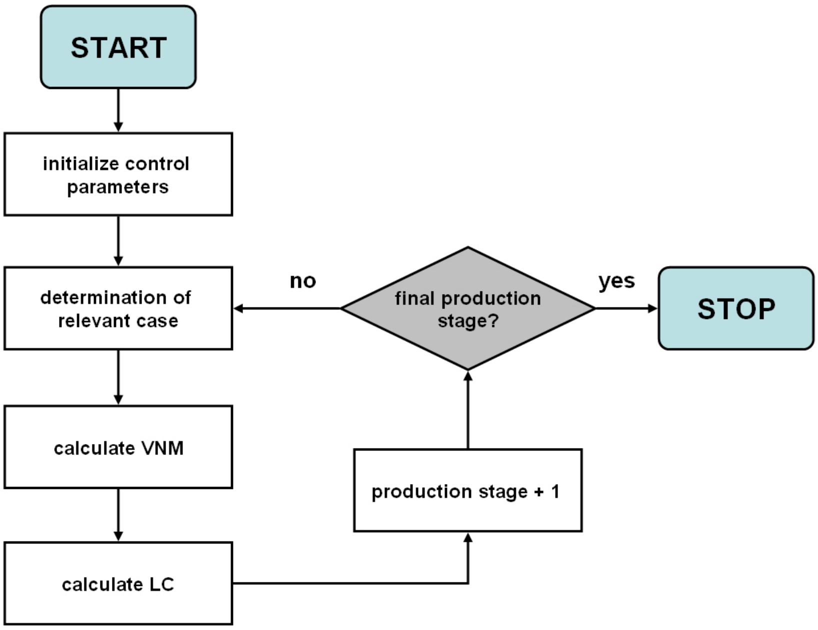


Figure 3.9: Outline algorithm for Mercosul LC calculation

algorithm concludes with the assignment of the Mercosul LC characteristic for the component or product variant. If the good exceeds the necessary LC request ρ_u^{lc} it is classified as LC fulfilling and the binary parameter ω_{ifu}^{lc} approves the value one. In a last step the algorithm increases the count for the production stage and as long as the final stage of the production process is not yet obtained, the proceeding is repeated.

Algorithm for Mercosul LC determination

1: initialize control parameters

2: forall k = 2,...,n do

3: forall $i \in I_k, u \in U, n \in N, f \in F_n, m \in M_u$ do

4: **if** case 1 then

$$V_{ifu}^{nor} = C_{ifm}^{shipM} + \sum_{\tilde{i}\in I}\sum_{\tilde{f}\in F_{\tilde{i}}} (\ 1\ -\ \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot (C_{\tilde{i}\tilde{f}}^{var} + C_{\tilde{i}\tilde{f}f}^{shipF})$$

elseif case 2 then

$$V^{nor}_{ifu} = \sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_i \setminus F_n} (\ 1\ -\ \omega^{lc}_{\tilde{i}\tilde{f}u}) \cdot B_{\tilde{i}i} \cdot (C^{var}_{\tilde{i}\tilde{f}} + C^{shipF}_{\tilde{i}\tilde{f}f})$$

elseif case 3 then

$$V^{nor}_{ifu} = \sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_{\tilde{i}} \cap F_u} (\ 1\ -\ \omega^{lc}_{\tilde{i}\tilde{f}u}) \cdot B_{\tilde{i}i} \cdot (C^{var}_{\tilde{i}\tilde{f}} + C^{shipF}_{\tilde{i}\tilde{f}f})\ \ =\ 0$$

elseif case 4 then

$$V^{nor}_{ifu} = \sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_{\tilde{i}}} (\ 1\ -\ \omega^{lc}_{\tilde{i}\tilde{f}u}) \cdot B_{\tilde{i}i} \cdot (C^{var}_{\tilde{i}\tilde{f}} + C^{shipF}_{\tilde{i}\tilde{f}f})$$

elseif case 5 then

$$V^{nor}_{ifu} = \sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_{\tilde{i}} \setminus F_u} (\ 1\ -\ \omega^{lc}_{\tilde{i}\tilde{f}u}) \cdot B_{\tilde{i}i} \cdot (C^{var}_{\tilde{i}\tilde{f}} + C^{shipF}_{\tilde{i}\tilde{f}f})$$

end if

if $(\ 1 - \frac{V^{nor}_{ifu}}{P^{lc}_{im}} \geq \rho^{lc}_u\ )$ then

$\omega^{lc}_{ifu} = 1$

else

$\omega^{lc}_{ifu} = 0$

end if

$k\ +\ 1$

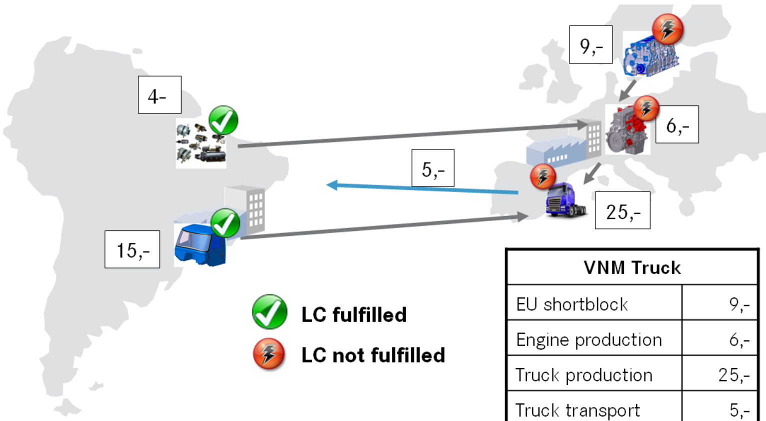
end do

end do

Below, every case is discussed in detail, highlighting their specifications in terms of determining the VNM. Every case is described in a general manner for a n-staged production process, concluding with an illustrative example. For the example a three-staged production process is assumed, hypothesizing that the Mercosul LC characteristics of all antecessor components to the truck are known already.

Case 1:

Under this set-up, the production site is located outside the regarded union. In a first step, all direct antecessor (previous stage to the one regarded) of the product variation and their LC fulfillment are considered. In case of not fulfilling, the VNM is calculated by summing up all antecessor components not possessing a LC certificate by their CIF value. Furthermore, production costs as well as the transport to the designated market account as non-originating.
Figure 3.10 illustrates these circumstances. The truck production is located in the EU, receiving parts from the Mercosul area and the EU. However, as VNM account the 9 (all numbers are given in a generalized monetary unit) for the EU shortblock, plus 6 for producing the engine not fulfilling Mercosul LC. Further have to be added 25 for the truck fabrication as well as the 5 necessary for transporting the truck to its designated sales market Mercosul, all together, the VNM equals 45.

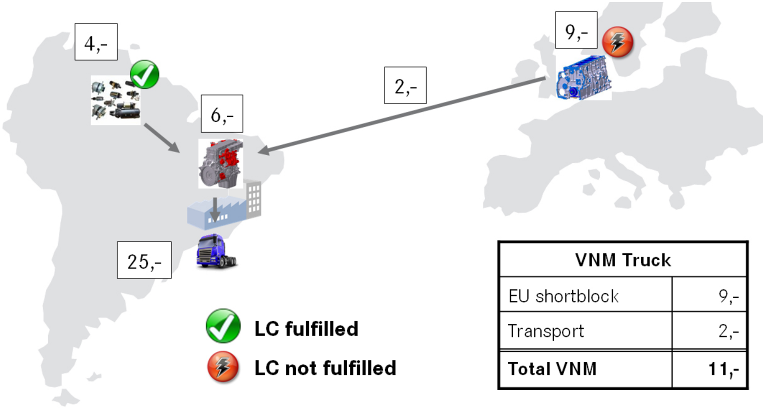


VNM Truck	
EU shortblock	9,-
Engine production	6,-
Truck production	25,-
Truck transport	5,-
Total VNM	**45,-**

Figure 3.10: Case 1

Case 2:

The underlying set-up in case 2 locates the production plant as well as the upstream plant of the direct antecessor in the same country, a Mercosul member. Thus, no LC certificates for components are issued, as no border crossing is realized. The VNM is composed by all antecessor components not fulfilling the Mercosul LC. Figure 3.11 displays the chosen set-up. Truck and engine production are allocated in Brazil. Therefore, as VNM for the truck account the 9 of the EU shortblock plus 2 for its transport, the Argentinean engine parts fulfill LC and are not included into the VNM. All together the VNM equals 11.

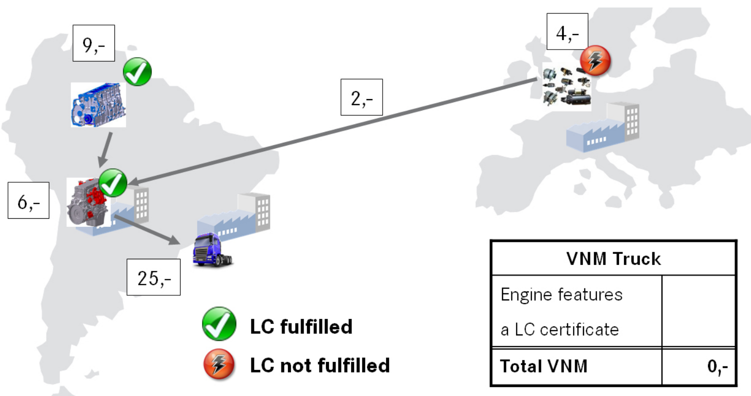


VNM Truck	
EU shortblock	9,-
Transport	2,-
Total VNM	**11,-**

Figure 3.11: Case 2

Case 3:

Case 3 allocates the production plant as well as the upstream plant in different member states of the Mercosul territory. The upstream production site delivers a direct antecessor component, compliant to Mercosul LC. Therefore, a Mercosul LC certificate can be requested and the VNM of the direct antecessor equals 0. In the described case under figure 3.12, an Argentinean production plant delivers a Mercosul LC compliant engine to a Brazilian plant. The VNM of the engine equals 0, even though, EU engine parts were used. The engine itself received a LC certificate and accounts as a 100% originating.



VNM Truck	
Engine features a LC certificate	
Total VNM	**0,-**

Figure 3.12: Case 3

Case 4:

The production plant, located on Mercosul territory, is now served with a direct antecessor, not fulfilling Mercosul LC, by an upstream plant located in a third party country. Hence, account as VNM all antecessors not compliant to Mercosul LC as well as their production and transportation costs. Figure 3.13 gives an example: the Brazilian plant is served with an EU engine, not fulfilling LC. For the production of the engine Mercosul engine parts are used. Hence, the VNM includes only parts obtained outside the Mercosul: 9 for the EU shortblock plus 6 for manufacturing the engine as well as 2 for its transport. Ending up in a total VNM of 17 for the truck.

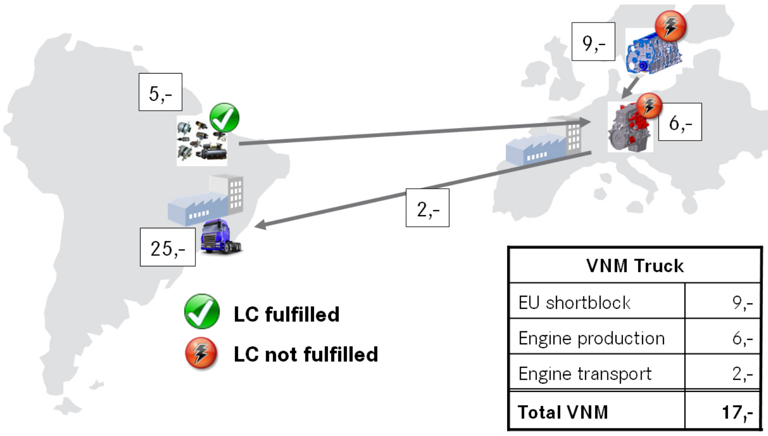


Figure 3.13: Case 4

Case 5:

Case 5 includes a border crossing inside the Mercosul territory. Delivered is a direct antecessor not fulfilling Mercosul LC from the upstream production plant. Therefore, all prior not LC compliant components are considered for the VNM, except the direct antecessors fabrication, which was realized on Mercosul territory. Figure 3.14 illustrates this case. The Brazilian truck production site is equipped with an engine, not compliant with Mercosul LC, from the Argentinean plant. The VNM for the truck includes the 9 for the EU shortblock, plus 2 for its transport. Further engine parts are produced on Mercosul territory, accounting as originating like the production of the engine itself.

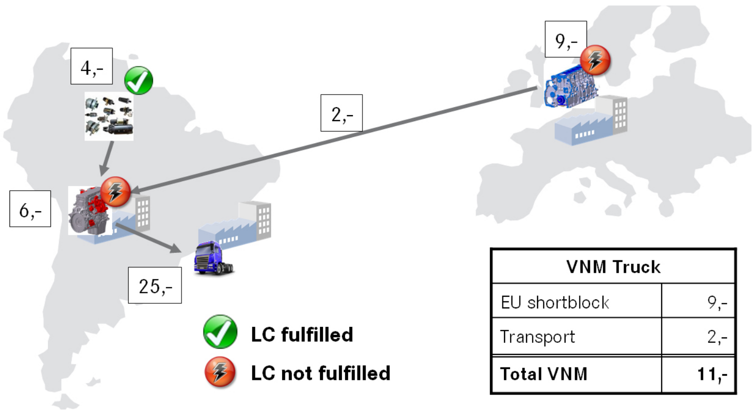


Figure 3.14: Case 5

3.3.4.2 Determination of Finame fulfillment

Section 3.3.3 already introduced the conceptual framework of the Finame requirements. The favorable development loan is only granted, if the prerequisites in value and weight are fulfilled.

In order to calculate the VNM and non-originating weight for the Finame restriction the identical proceeding as explained under Mercosul LC calculation needs to be followed. For every stage of the production process the VNM and non-originating weight has to be identified from the bottom up. Moreover, in general the same cases can be detected, as described under the Mercosul LC calculation, to determine the Finame VNM and the Finame non-originating weight for every network supply variation. Nevertheless, the approach is modified by two items:

- Because the enumerator of the Finame formula includes additional customs duties for calculating the VNM, all determined costs are multiplied by their import duty rate.
- The focus switches from Mercosul to Brazil. Thus, as VNM and non-originating weight account all non-Brazilian materials, or materials not featuring a Mercosul LC certificate. A differentiation between, Mercosul LC cases four and five is no longer necessary, as explained in the follwoing.

Figure 3.15 displays the process chart. It describes the same decisions, necessary for Mercosul LC calculation, leading to the four different cases relevant for Finame calculations. Considered are locations of production plants and upstream production plants as well as Mercosul LC fulfillments of antecessor components.

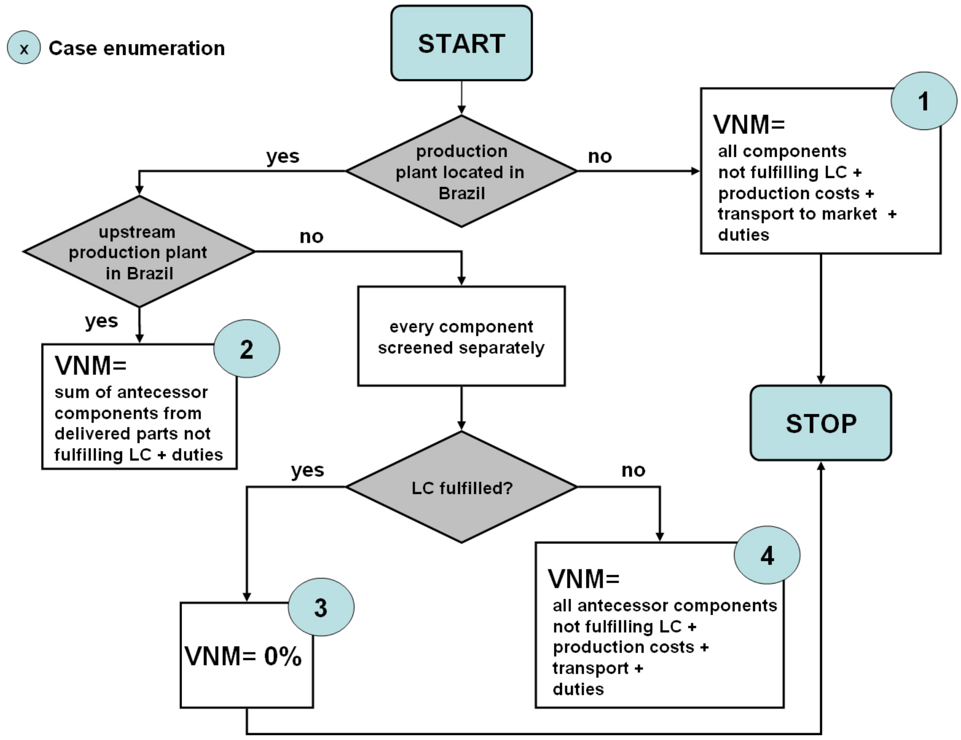


Figure 3.15: Process chart Finame

In the following the methodology for Finame compliance in value and weight is presented. Figure 3.16 displays the approach of the algorithm. The proceeding is similar to the Mercosul LC VNM stipulation. Consequently, the bottom up approach with regard to Finame VNM and non-originating weight calculation is presented. The resulting values are contrasted with the Finame requirements to determine the goods compliance.

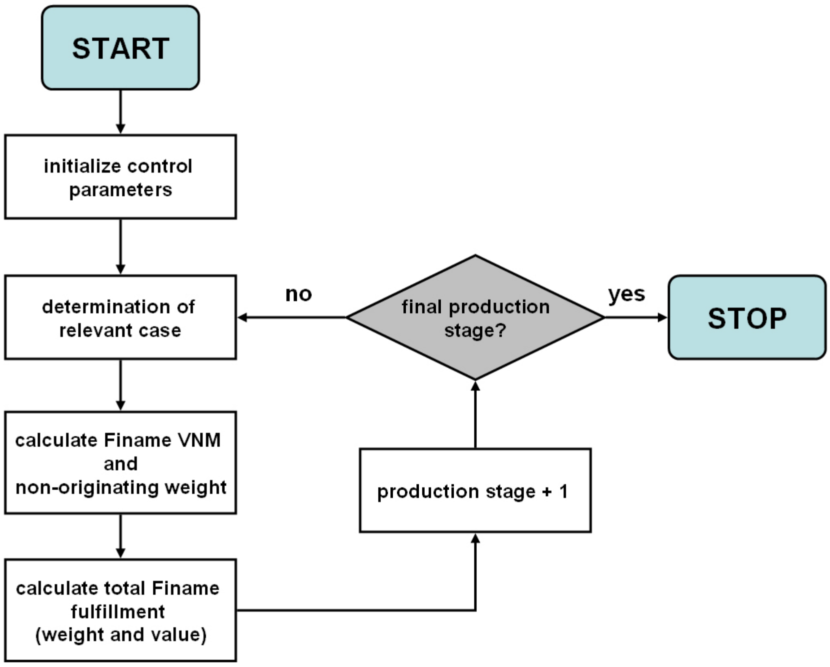


Figure 3.16: Outline algorithm for Finame characteristics calculation

---

Algorithm for Finame determination

1: initialize control parameters

2: forall k = 2,...,n do

3: forall $i \in I_k, f \in F_i, u \in U, m \in M_u, n = Brazil$ do

4: **if** case 1 then

$$V_{if}^{norFin} = \alpha_{in} \cdot (C_{ifm}^{shipM} + \sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_{\tilde{i}}} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot (C_{\tilde{i}\tilde{f}}^{var} + C_{\tilde{i}\tilde{f}f}^{shipF}))$$

$$W_{if}^{norFin} = \sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_{\tilde{i}}} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot W_{\tilde{i}}$$

5: **elseif** case 2 then

$$V_{if}^{norFin} = \alpha_{\tilde{i}n} \cdot (\sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_{\tilde{i}} \setminus F_n} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot (C_{\tilde{i}\tilde{f}}^{var} + C_{\tilde{i}\tilde{f}f}^{shipF}))$$

$$W_{if}^{norFin} = \sum_{\tilde{i}\in I} \sum_{\tilde{f}\in F_{\tilde{i}} \setminus F_n} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot W_{\tilde{i}}$$

6: **elseif** case 3 then

$$V_{if}^{norFin} = \alpha_{\tilde{i}n} \cdot (\sum_{\tilde{i} \in I} \sum_{\tilde{f} \in F_{\tilde{i}} \cap F_u} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot (C_{\tilde{i}\tilde{f}}^{var} + C_{\tilde{i}\tilde{f}f}^{shipF})) = 0$$

$$W_{if}^{norFin} = \sum_{\tilde{i} \in I} \sum_{\tilde{f} \in F_{\tilde{i}} \cap F_u} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot W_{\tilde{i}} = 0$$

7: **elseif** case 4 then

$$V_{if}^{norFin} = \alpha_{\tilde{i}n} \cdot (\sum_{\tilde{i} \in I} \sum_{\tilde{f} \in F_{\tilde{i}}} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot (C_{\tilde{i}\tilde{f}}^{var} + C_{\tilde{i}\tilde{f}f}^{shipF}))$$

$$W_{if}^{norFin} = \sum_{\tilde{i} \in I} \sum_{\tilde{f} \in F_{\tilde{i}}} (1 - \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot B_{\tilde{i}i} \cdot W_{\tilde{i}}$$

8: **end if**

9: **if** $(1 - \frac{V_{if}^{norFin}}{P_{im}^{Fin}} \geq \rho_n^{Fin}$ and $1 - \frac{W_{if}^{norFin}}{W_i} \geq \rho_n^{Fin})$ then

10: $\omega_{if}^{Fin} = 1$

11: **else**

12: $\omega_{if}^{Fin} = 0$

13: **end if**

14: $k + 1$

15: **end do**

16: **end do**

Line one and two initialize again the relevant control parameters and start the loop for the calculation process beginning with stage two. Necessary data for the first stage are obtained the same way as for Mercosul LC determination. Line four to seven return the procedure for Finame VNM and non-originating weight computation, constrained to the particular case applied. Line nine determines, if the product or component is compliant with the Finame requirement in value and weight ρ_n^{Fin}. In case of fulfillment the binary parameter, ω_{if}^{Fin} approves the value one. Line 14 increases the count of the loop and as long as the final production stage is not achieved the procedure is repeated.

Case 4 Finame:
Case 4 determines the VNM, if a production plant is located in Brazil and served with direct antecessors not fulfilling Mercosul LC from outside the country. Since, Finame focuses on Brazil, the VNM accounts for all actions obtained abroad. It does not matter, if the upstream production plant is located inside or outside the Mercosul territory. No further differentiation between cases four and five is necessary. Imported goods are evaluated by their CIF-value, less Mercosul LC compliant antecessors.

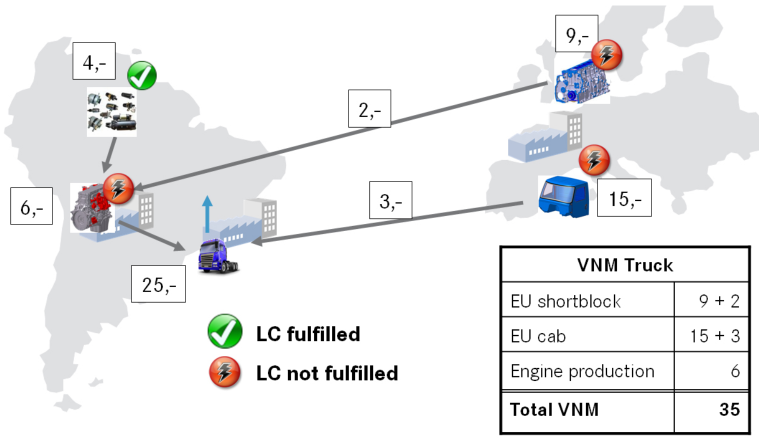


Figure 3.17: Case 4 Finame

In the described example under figure 3.17, a truck production is located in Brazil, serving the Brazilian market. However, an EU cab and an engine from Argentina are included into the truck variant, both without Mercosul LC certificate. Hence, the VNM consists of the 15 for the cab plus 3 for its transport. Further, the Argentinean engine production is added with 6 plus 11 for the EU shortblock. Since, the rest of the engine parts are compliant with Mercosul LC, they are not included. Total VNM under this set-up equals 35.
Beneath the value criterion, Finame requests for a minimum local weight added. Its calculation is done by formula 3.4. To determine the non-originating weight of a component or product, once again is referred to the bottom up calculation proceeding. Throughout the production program every stage is evaluated sepa-

rately, respectively to non-originating weight. The same four cases as under the VNM calculation for Finame purpose need to be distinguished. Instead, of CIF values plus customs duties the non-originating weights are summed up in the enumerator and contrasted with the total weight of the component or product at the production stage currently regarded. If, both criterions, the local value added and local weight added are superior 60% the Finame requirement is fulfilled and the product can be registered with the BNDES.

4 Model Formulation

Part of this chapter is a detailed explanation and formulation for a production network design and capacity planning model. In comparison to already existing models, which take decisions on global aspects as LC, duties and duty drawbacks into consideration, compare e.g. Arntzen et al. (1995) and Oh and Karimi (2006) the subsequent model formulation differs and therefore extends the existing literature in three specifications.
First, the model is capable to calculate LC characteristics on a product specific level. For every product variation of the multi-product environment the specific LC of the network supply variant is considered. Second, a detailed consideration of inward and outward processing schemes is implemented. Especially, the modelling of the customs regime outward processing with its associated ad valorem payment of duty, describes an extension to the existing literature. The model calculates the specific duty load on basis of the single delivered product, regarding every incorporated component and its origin. Therefore, the ad valorem duty load when crossing a customs border can be determined exactly. Third, through the implementation of the Mercosul legal framework with reference to LC, duties, duty drawbacks and the Finame requirement, detailed conclusions for this economic area are possible. This is especially interesting as calculation methods vary a lot between different PTAs and a generalized treatment may lead to suboptimal solutions for the production network configuration.

4.1 Problem statement and assumptions

The following developed model is based on the automotive sector, with special focus on Mercosul. A truck manufacturer holds different production plants placed inside and outside the Mercosul territory. All necessary components for the trucks are produced inside the manufacturer's inbound production network. Hence, the necessary capacity planning for all production lines is incorporated into the model formulation.

Between plants and markets occur component and product deliveries. Components are delivered at CIF values. Final products are shipped to sales markets, where the manufacturer acts as a price taker. All prices and costs are translated into a common currency. For every shipment to a production plant or sales market, various circumstances have to be considered and therefore, be implemented in the model:

- Are components or products shipped cross a border?
- If there has taken place a border crossing concerning Mercosul, are the goods fulfilling Mercosul LC requirements?
- Have duties to be charged?
- Is the underlying shipment a case of inward or outward processing and can therefore duty drawbacks be claimed?
- Are products delivered to the Brazilian market compliant with Finame?

For the Mercosul LC and Finame regulation, VNM is calculated on basis of every possible network supply variation as explained under section 3.3.4. Components without any antecessors originating on Mercosul territory possess a Mercosul LC of 100%.

Thus, it is necessary to be aware of the different variations possible and how they are composed. This is done by a multilevel bill of material matrix (BOM) (Dyckhoff 2006, pp. 279). It is defined for all components and products, underlying the optimization problem. An index can stand for a component as well as a product in its different network supply variation.

Table 4.1 illustrates for a simple example the composition and configuration of the BOM. Thereto, the final product is identified with the index 1. It consists of two times component 2 and one time component 3, whereas component 2 is further split into one time component 4 as well as 5. This mixture is illustrated by the BOM in the following. Columns reflect for the product or component regarded all subcomponents necessary, unrelated to the stages of the production process. Therefore, an overview on the complete composition can be obtained.

Product or component is part of:	Product or component consists of: 1	2	3	4	5
1	1	0	0	0	0
2	2	1	0	0	0
3	1	0	1	0	0
4	2	1	0	1	0
5	2	1	0	0	1

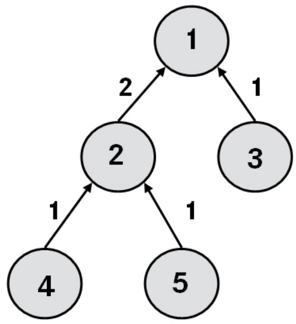


Table 4.1: Composition bill of material matrix

However, rows return information on products or components incorporating the specific part, with its quantity.

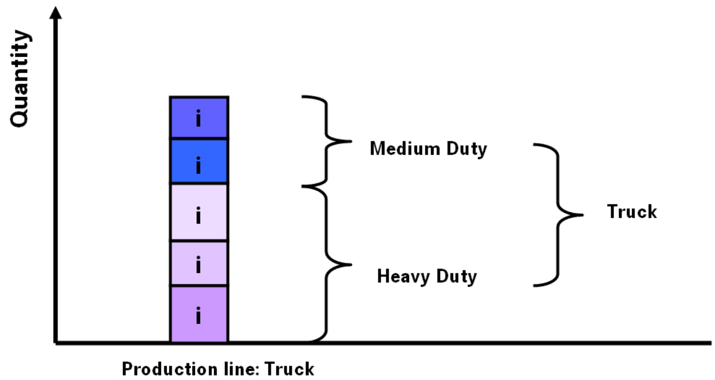


Figure 4.1: Exemplary production line

For capacity planning purpose product and component types are introduced additionally, compare figure 4.1. Thus, products and components can further be distinguished into different types, whereas they consume the same capacity at the associated production line. For example, the product truck can be differentiated into medium duty and heavy duty, both consuming the same capacity units at the production line truck. The model is enabled to decide, which production network configuration and capacity planning decisions are optimal, concerning fulfilling demand, while minimizing fixed costs and investments.
Concluding all assumptions underlying the model formulation are given clustered in an enumeration:

- All data are modelled deterministically
- Demands have to be fulfilled completely
- Product and component flows are based on CIF values
- Components completely produced on Mercosul territory possess a Mercosul LC of 100%
- Mercosul LC calculation is based on the non-originating value of every possible network supply variation
- All costs are translated into a common currency
- The manufacturer acts as price taker at the sales markets
- All types of a component or product consume the same amount of capacity at the specific production line during their production process
- Inventory decisions are not taken into account, products and components cannot be stored

The consequent model development is organized as follows. First, the basic model is introduced. This formulation is further extended by the Brazilian non-tariff trade barrier Finame and a second extension dealing with capacity planning decisions.

4.2 Basic model

This section presents the mathematical formulation of the mixed integer program. To begin with, the basic model is presented, including its key elements demand satisfaction under capacity restrictions, network flows as well as duty and duty drawback calculation constraints. Furthermore, the model is extended, firstly by the Finame fulfillment and secondly by capacity planning decisions.

4.2.1 Objective function

$$min\ NPV\ COSTS = \sum_{t \in T} R_t \cdot \Bigg[\sum_{i \in I} \sum_{f \in F_i} \tag{4.1}$$

$$\Bigg[\sum_{m \in M} z_{ifmt} \cdot C^{var}_{if} + \tag{4.2}$$

$$\sum_{i' \in I} \sum_{f' \in F_{i'}} \sum_{m \in M} y^{shipF}_{ii'ff'mt} \cdot C^{shipF}_{iff'} + \tag{4.3}$$

$$\sum_{m \in M} y^{shipM}_{ifmt} \cdot C^{shipM}_{ifm} + \tag{4.4}$$

$$\sum_{n \in N} \sum_{f' \in F_n} \sum_{f \in F_n} (d^{shipF}_{iff't} - dd^{shipF}_{iff't}) \cdot \alpha_{in} + \tag{4.5}$$

$$\sum_{n \in N} \sum_{m \in M_n} d^{shipM}_{ifmt} \cdot \alpha_{in} \Bigg] \Bigg] \tag{4.6}$$

In order to derive an optimal solution the program minimizes costs. Therefore, costs are summed up and discounted periodically by a factor, i.e. the negative net present value of costs is minimized.

Companies use the net present value (NPV) to evaluate their investments. It is calculated by the difference of the discounted cash flow of sales, less the net present value of costs. Thus, costs are minimized to generate the best possible NPV, a manufacturer acting as a price taker, can achieve.

The objective function may be divided into different formulas. Line 4.1 introduces the discount factor, relevant for all sequent periods. Line 4.2 determines the production costs for the produced quantities of all component and product variations per period, while under 4.3 and 4.4 the costs of their shipments between plants and markets are determined.

Formula 4.5 subtracts the customs value of all duty drawbacks from the total customs value paid per period. Potential duty payments for serving the sales markets with products are calculated under 4.6.

4.2.2 Constraints

Demand constraint

$$\sum_{i \in I_q} \sum_{f \in F} y^{shipM}_{ifmt} = D_{qmt} \tag{4.7}$$
$$\forall q \in Q, m \in M, t \in T$$

Restriction 4.7 ensures that distribution quantities to each market per period fulfill the demand for all requested product types over all periods. Demand has to be fully served.

Capacity constraint

$$\sum_{i \in I_p} \sum_{m \in M} z_{ifmt} \leq K_{pfl} \tag{4.8}$$
$$\forall p \in P, f \in F, t \in T, l \in L$$

Constraint 4.8 ensures that the produced quantities at a production plant do not exceed the available capacities of its production lines.

Network flow constraints

$$\sum_{i' \in I} \sum_{f' \in F_{i'}} y^{shipF}_{ii'ff'mt} + y^{shipM}_{ifmt} = z_{ifmt} \tag{4.9}$$
$$\forall i \in I, f \in F_i, m \in M, t \in T$$

$$\sum_{\tilde{f} \in F_{\tilde{i}}} y^{shipF}_{\tilde{i}i\tilde{f}fmt} = B_{\tilde{i}i} \cdot z_{ifmt} \tag{4.10}$$
$$\forall i \in I, \tilde{i} \in A_i, f \in F_i, m \in M, t \in T$$

The flow constraints assure the harmonization of all component and product flows as well as their production quantities. Under 4.9 is provided that all amounts shipped, either to plants or sales markets, are produced anyhow. Equation 4.10 includes the BOM, thereby, is assured that every component or product variant is supplied by its appropriate quantities of direct needed antecessors. The restrictions imply that no storage of component or product variations take place.

Duty constraints for shipments between production plants

$$d^{shipF}_{iff't} = \sum_{i' \in I} \sum_{m \in M} y^{shipF}_{ii'ff'mt} \cdot (1 - \omega^{lc}_{ifu}) \cdot \left[\sum_{\tilde{i} \in I} \sum_{\tilde{f} \in FP_{f'}} (1 - \omega^{lc}_{\tilde{i}\tilde{f}u}) \cdot B_{\tilde{i}i} \cdot (C^{var}_{\tilde{i}\tilde{f}} + C^{shipF}_{\tilde{i}\tilde{f}f}) + C^{shipF}_{iff'} \right] \quad (4.11)$$

$$\forall u \in U, i \in I, f \in F_i \cap F_n, f' \in F_u \cap FP_f, t \in T$$

Restriction 4.11 calculates for every shipment between two production plants its customs value. However, duties have to be paid every time a good crosses a customs border, expressed by $f' \in FP_f$, the receiving production plant f' is located in a different nation compared to f. By the time, a good is imported into a preferential trade area u, whilst fulfilling the union's specific LC requirement, $\omega^{lc}_{ifu} = 1$, no duty payments are necessary.

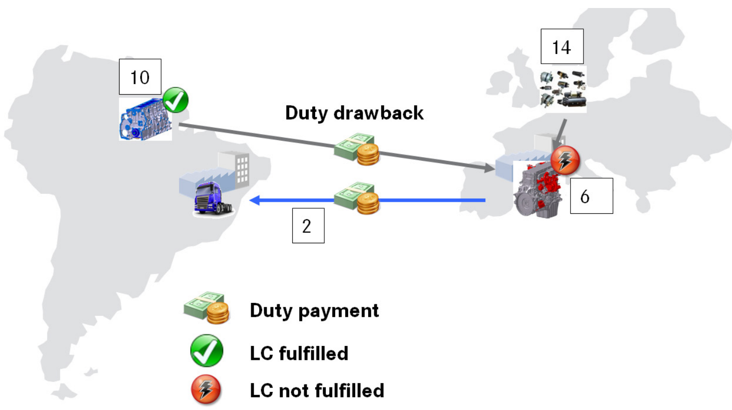


Figure 4.2: Duties and duty drawbacks

The customs value of a good is composed by its CIF value, less obtained antecessor components $\tilde{i}$, fulfilling an originating status, $\omega^{lc}_{\tilde{i}\tilde{f}u} = 1$, at the union of the importing production plant f'. Figure 4.2 gives therefore, an example. At the production plant in Europe a truck engine is produced with parts from Europe as well as Brazil. Assuming, the engine is integrated into a truck assembly in Brazil, import duties for the engine have to be paid as it does not fulfill Mercosul LC. The customs value comprises of the CIF value from the engine less the values of containing antecessor components compliant with Mercosul LC, here, the shortblock. Thus, the customs value of the engine equals 22. For the imported Brazilian shortblock EU, import duties have to be paid as it does not originate from the EU. However, a duty drawback is granted, since the shortblock takes part in the inward processing of the engine at the EU plant.

Duty drawback constraint

$$\begin{aligned} dd^{shipF}_{iff't} = & \sum_{i' \in I} \sum_{m \in MP_{f'}} y^{shipF}_{ii'ff'mt} \cdot (1 - \omega^{lc}_{ifu}) \cdot \\ & \left[\sum_{\tilde{i} \in I} \sum_{\tilde{f} \in FP_{f'}} (1 - \omega^{lc}_{\tilde{i}\tilde{f}u}) \cdot B_{\tilde{i}i} \cdot (C^{var}_{\tilde{i}\tilde{f}} + C^{shipF}_{\tilde{i}\tilde{f}f}) + C^{shipF}_{iff'} \right] \qquad (4.12) \\ & \forall u \in U, i \in I, f \in F_i \cap F_n, f' \in F_u \cap FP_f, t \in T \end{aligned}$$

Duty drawbacks are modelled in constraint 4.12, returning the customs value of drawbacks on shipments between production plants. In contrast, to constraint 4.11, drawbacks on beforehand calculated duties are claimed, if the importing plant is not located in the same nation, as the future aim market of the component or product variant, compare $m \in MP_{f'}$. Hence, is implied that a further border crossing takes place and the good is part of an outward or inward processing, enabling duty drawbacks. The calculation of the customs value for drawbacks is done congruent to 4.11.

Duty constraints for shipments to sales markets

$$d_{ifmt}^{shipM} = y_{ifmt}^{shipM} \cdot (\ 1 \ - \ \omega_{ifu}^{lc}) \cdot$$

$$\left[\sum_{\tilde{i} \in I} \sum_{\tilde{f} \in F_{\tilde{i}}} (\ 1 \ - \ \omega_{\tilde{i}\tilde{f}u}^{lc}) \cdot \ \ B_{\tilde{i}i} \ \cdot (C_{\tilde{i}\tilde{f}}^{var} + C_{\tilde{i}\tilde{f}f}^{shipF}) + C_{ifm}^{shipM} \right] \qquad (4.13)$$

$$\forall u \in U, i \in I, f \in F_i \cap F_n, m \in M_u \cap MP_f, t \in T$$

Constraint 4.13 detects duty payments on shipments for sales markets. The model distinguishes between shipments to plants and shipments to sales markets. Hence, both shipment flows have to be regarded separately, due to the model layout. Nevertheless, the systematic of handling is the same, adopted by the fact that the destination is a sales market located in a different nation compared to the production plant, see $m \in MP_f$. Customs value of the demand serving product is its CIF value reduced by the value of antecessors fulfilling an originating status at the destination.

4.3 Extension I: Finame

In a first extension is included the consideration of Finame compliance for serving the Brazilian market. Therefore, a decision variable is introduced, detecting, if all delivered product variations fulfill the Finame request. In case, this is not provided a penalty per every delivered product unit may be considered in the objective function. This penalty reflects the additional costs occurring for the manufacturer to compensate his customers, which cannot apply for the favorable development loan.

Constraint

$$\sum_{i\in I_q}\sum_{f\in F_i} y^{shipM}_{ifmt}\cdot\omega^{Fin}_{if} \geq D_{qmt}-(\psi^{penalty}_{qt}\cdot BigM) \tag{4.14}$$

$$\forall q\in Q, m\in M_B, t\in T$$

The Finame constraint 4.14 screens for all product variations of one type, designated to the Brazilian market, if they comply with Finame value and weight requirements. For every network supply variation of a product the Finame parameter ω^{Fin}_{if} was calculated beforehand.
If the restriction's left hand side, the delivered amount of Finame compliant product type variants to the Brazilian sales market is smaller than the total Brazilian demand, the binary decision variable $\psi^{penalty}_{qt}$ is set to 1. A sufficient big number "BigM" needs to be subtracted to restore the accuracy of the constraint. The binary variable $\psi^{penalty}_{qt}$ recurs in the objective function, where penalty payments are added.

Objective function - extension

$$\sum_{t\in T} R_t\cdot\sum_{q\in Q}\sum_{i\in I_q}\sum_{f\in F_i}\sum_{m\in M_B} y^{shipM}_{ifmt}\cdot\psi^{penalty}_{qt}\cdot C^{penalty}_{t} \tag{4.15}$$

Formula 4.15 is added to the objective function, triggering penalty payments, if not all product type variants serving Brazilian demand are compliant with the Finame requests. In this case penalty payments occur for every sold unit of this type at the Brazilian sales market. The development loan can only be granted, if the product is registered at the BNDES and therefore all its network supply variants have to be compliant with Finame requests.

4.4 Extension II: Capacity planning

The second extension deals with capacity planning decisions. At every plant, capacity levels for production lines are introduced. Different types of products and components are allocated on the same production lines, consuming the same capacity. In the following, the necessary constraints for production line capacity planning are introduced. Constraints, needed for the component and product type to plant allocation are provided in a second step. Finally, the extension to the objective function is presented.

Production line constraints

$$\sum_{i \in I_p} \sum_{m \in M} z_{ifmt} \leq \sum_{l \in L} K_{pfl} \cdot \psi_{pflt}^{activeK} \tag{4.16}$$
$$\forall p \in P, f \in F, t \in T$$

$$\sum_{l \in L} \psi_{pflt}^{activeK} = 1 \tag{4.17}$$
$$\forall p \in P, f \in F, t \in T$$

$$\psi_{p,f,l=0,t=0}^{activeK} = 1 \tag{4.18}$$
$$\forall p \in P, f \in F$$

$$\psi_{pfl't}^{activeK} + \psi_{pflt-1}^{activeK} - 1 \leq \psi_{pfll't}^{swK} \tag{4.19}$$
$$\forall p \in P, f \in F, l\ l' \in L, t \in T$$

To every production plant, production lines are allocated, which can adopt different specifications, so called capacity levels. Product and component variants are clustered by the subsets I_p and allocated to these capacities.

The first capacity constraint 4.16 guarantees that the active level of the production line provides sufficient capacity for the produced quantity. The active capacity level for a production line at a plant is defined through the binary decision variable $\psi_{pflt}^{activeK}$, adopting the value 1 for active or 0 for non-active levels.
Formula 4.17 allows for every product at each site only one active capacity level per period. In period $t = 0$ constraint 4.18 determines the initial capacity level $l = 0$ for all production lines. An imaginary level, where no capacities are available and therefore, no predetermined network configuration is defined. This can be changed to a different initial situation, by adopting the adequate capacity levels.
Switches between capacity levels are detected through formula 4.19. In case, different capacity levels are active in two sequent periods, the formula forces $\psi_{ifll't}^{swK}$ to adopt the value 1 and switching costs are included into the objective function. However, if there is no capacity switch at a plant, $\psi_{ifll't}^{swK}$ might also approve the value of 1 but as this activates switching costs in the objective function the allocated value equals 0.

Product and component type to plant allocation constraints

$$\sum_{i \in I_q} \sum_{m \in M} z_{ifmt} \leq \psi_{qf}^{link} \cdot BigM \qquad (4.20)$$

$$\forall q \in Q, f \in F, t \in T$$

Constraint 4.20 allocates a particular product or component type to a plant and therefore to its associated production line. The allocation is modelled by the binary decision variable ψ_{qf}^{link} adopting the value 1, in case a production of a particular component or product type takes place at the plant. Further, is assured that this decision once taken is proceeded over all periods during the optimization process. Linking a product or component type to a plant is connected with setup costs necessary for the configuration of machines or training the work force.

Objective function - extension

$$\sum_{p \in P} \sum_{f \in F} \sum_{l \in L} C_{pfl}^{invK} \cdot \psi_{pfl0}^{activeK} + \tag{4.21}$$

$$\sum_{q \in Q} \sum_{f \in F} C_{qf}^{setup} \cdot \psi_{qf}^{link} + \tag{4.22}$$

$$\sum_{t \in T} \sum_{f \in F} R_t \cdot \Bigg[\tag{4.23}$$

$$\sum_{p \in P} \sum_{l \in L} C_{pflt}^{fixK} \cdot \psi_{pflt}^{activeK} + \tag{4.24}$$

$$\sum_{p \in P} \sum_{l,l' \in L} C_{pfll'}^{swK} \cdot \psi_{pfll't}^{swK} \Bigg] \tag{4.25}$$

Finally, these are the extensions to the objective function, concerning capacity planning. Formula 4.21 determines the initial investments for the capacity levels necessary in period $t = 0$, while formula 4.22 introduces the setup costs activated through the linking of component and product types to the production plants. These investments have to be realized at the beginning of the process and are therefore not discounted. Formula 4.24 adds periodical fixed costs for active capacity levels of a production line in a plant. In case of capacity switches, characteristic switching costs are included by line 4.25.

5 Numerical Studies

The illustration of the impact of duties, duty drawbacks, LC and Finame requirements on production decisions of a multinational truck manufacturer is the main intention of this chapter. Focus is set on the examination, how global aspects affect the production strategy of a multinational corporation and therefore its production network. A further research question is, if product flexible production networks can be useful when coping with considerable global challenges. The following chapter examines the influence of tariff and non-tariff trade barriers and their legal frameworks at the Mercosul territory on the production network configuration of a truck manufacturer.

In different studies the advantages of the developed mathematical optimization model are highlighted. In the first study, interactions of duties, LC requirements and duty drawbacks are examined, in a single-product, single-period environment.

In contrast, the second study enlarges the problem statement by reviewing an extended time framework and introducing capacity planning decisions. Through parameter variations knowledge on the interactions of the incorporated aspects is concluded. In a third study the impact of the particular Brazilian non-tariff trade barrier, Finame, on the production network design is examined.

5.1 Test design

The numerical studies are based on the planning problems of an international truck manufacturer producing one type of truck. Figure 5.1 gives an overview on the underlying network and its sales markets. Trucks can be produced in three different plants, Argentina (AR), Brazil (BR) and the European Union (EU). Two of them are located on Mercosul territory. Sales markets taken into account

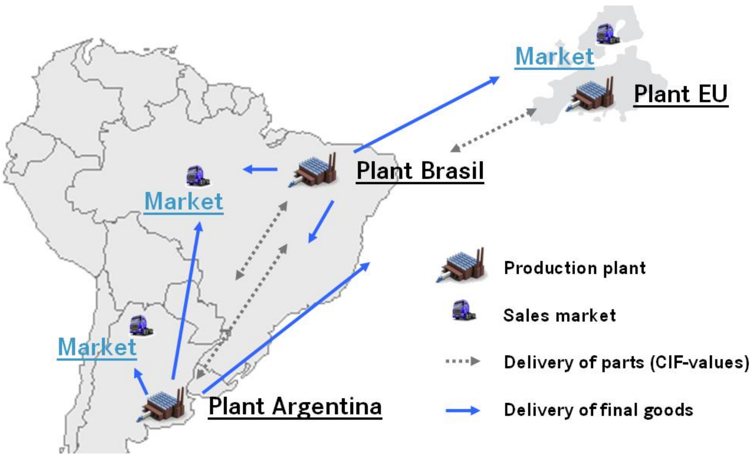


Figure 5.1: Network structure

are AR, BR and the EU.

Throughout all case studies a three-staged bill of material for the truck, compare figure 5.2 is regarded. Components from the first, the second and the final stage are produced inside the global production network of the truck manufacturer. Production plants are fully flexible and therefore capable to fabricate all components, given by the BOM as well as assembling the truck. The BOM considers the most valuable parts of a truck: cab, engine and chassis, whilst the built up of the chassis is part of the truck assembly process. The BOM further divides the engine into shortblock and remaining engine parts.

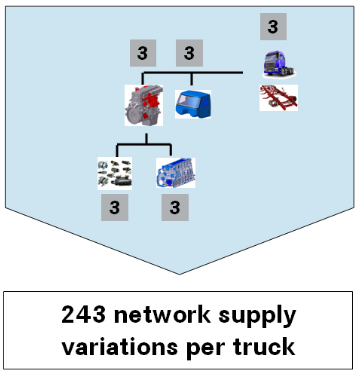


Figure 5.2: Network supply variations per truck

The set-up under fully flexible production plants and the three-staged BOM re-

sults in 243 network supply variations for the truck. This is composed through multiplying all producing and assembly opportunities with each other.
Every network supply variant shows a different VNM and thereby, a different LC and Finame proportion. Mercosul LC and Finame quota for the three-staged BOM are calculated accordingly to the formulas presented under section 3.3.1. Components without any antecessors produced in a Mercosul plant possess a LC of 100%.

Component or product	Nation	Material costs	Working hours	Labor costs	Total costs [$ US]	weight [kg]
enging parts	BR	6,860	5	90	6,950	200
shortblock	BR	9,800	6	108	9,908	1,000
cab	BR	6,370	50	900	7,270	1,500
engine	BR	490	10	180	670	50
truck	BR	17,150	85	1,530	18,680	2,500
					43,478	5,250
enging parts	AR	7,000	5	70	7,070	200
shortblock	AR	10,000	6	84	10,084	1,000
cab	AR	500	50	140	640	1,500
engine	AR	6,500	10	700	7,200	50
truck	AR	17,500	85	1,190	18,690	2,500
					43,684	5,250
enging parts	EU	5,740	5	300	6,040	200
shortblock	EU	8,200	6	360	8,560	1,000
cab	EU	5,330	50	3,000	8,330	1,500
engine	EU	410	10	600	1,010	50
truck	EU	14,350	85	5,100	19,450	2,500
					43,390	5,250

Table 5.1: Summary production costs

Table 5.1 introduces the material costs, working hours per component or product and weights of a truck. These data represent realistic but altered values, provided by the truck manufacturer. All costs are converted into a common currency, *$ US*. Weight information illustrated in the last column of the table provide generalized average values on all parts. These values are necessary for Finame non-originating weight calculation.
Material costs for at truck at the Brazilian plant are reduced by 2 % compared to the Argentinean plant, due to more favorable logistic conditions and a stronger Brazilian Real opposite the Argentinean Peso. Material costs for at truck at the EU plant are cut down by 18% compared to the Argentinean plant. Production materials can be sourced cheaper through the opportunity of utilizing low-cost suppliers from Eastern Europe.
Working hours reflect the need for industrial labor to fabricate the specific product or component. Due to the same production technologies at all plants, working hours necessary for manufacturing a product or component do not differ between the sites.

country	costs per working hour [$US]
BR	18.00
AR	14.00
EU	60.00

Table 5.2: Industrial labor costs

Table 5.2 introduces the costs for one hour of industrial labor at the production plants. At the EU site labor costs are significantly higher with 60 *$ US* compared to 18 *$ US* in Brazil and 14 *$ US* in Argentina (Kaufmann, Panhans, Poovan and Sobotka 2005). Total costs are obtained through adding up material and labor costs.
Following, transportation costs are presented. They depend on realistic but altered container freight rates provided by the truck manufacturer and the quantity included into one container, compare table 5.3.

container rates			
from	AR	BR	EU
to AR	500	1,000	3,000
to BR	1,000	500	2,000
to EU	4,000	3,000	500

parts per 40 foot container	
engine	25
transmission	40
cab	4
engine parts	120
shortblock	30

Table 5.3: Composition transportation costs

Trucks are shipped via the so called roll-on roll-off traffic, therefore no containers are necessary. Nevertheless, for all trucks the same costs as provided for container rates apply. Between the production lines of one particular plant, it is assumed that no logistic costs have to be paid.

	components	truck
EU	10%	15%
Mercosul	14%	35%

Table 5.4: Duty rates

To conclude the data framework of the test design, duty rates for cross border deliveries are presented under table 5.4. WTO average import tariff values are applied, reflecting the mean of all effective tariffs from one specific country opposite all other third party countries. For the EU sales market an import duty of 10% on components and 15% on trucks is assumed. Mercosul duty rates differentiate between an average rate on components of 14% and a duty rate of 35%

on trucks (WTO 2011). All duties are paid on CIF values. The market price for trucks at the sales markets is assumed to be 50,000 *\$ US*, for truck engines a price of 25,000 *\$ US* is supposed.

5.2 Study 1: Interactions of Mercosul LC, duties and duty drawbacks

The main intention of the first study is to examine the interactions of duties, duty drawbacks and Mercosul LC constraints on production decisions of a multinational truck manufacturer for a single period. Relevant questions are:

- How reacts the production network when taking different global aspects into consideration while optimizing the network configuration?
- Are products and components delivered to Mercosul territory fulfilling Mercosul LC?
- Is it advisable to take detailed legal frameworks into account and update them, if necessary?
- How is the composition of total costs?

In order to examine these questions a single product environment with sufficient high capacities for the production lines at the fully flexible production plants is chosen. Variable costs are presumed as presented before.

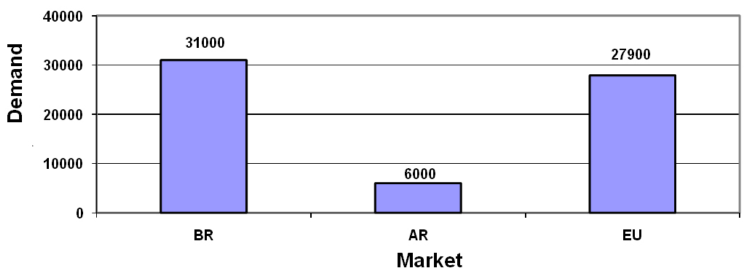


Figure 5.3: Single period demand

Figure 5.3 illustrates the truck demand for one exemplary period in the markets Brazil, Argentina and EU. In order to analyze the interactions of duties, duty drawbacks and Mercosul LC, the study is separated into four different approaches. First, the base case disregards duties, duty drawbacks and LC requirements. It optimizes the classical planning situation, where no external factors are accounted for. In a next step duties and Mercosul LC requirements are included (extension I). Thereon, additionally duty drawbacks are respected (extension II). Finally, the Mercosul legal framework as intended in the future, without intra-Mercosul duty drawbacks is examined (extension III).

5.2.1 Base case: classical planning situation

Under this approach the classical planning situation is analyzed. No external factors are taken into account, when optimizing the problem. This results in the production program displayed in figure 5.4. The diagram shows for every plant its specific advised production amounts and chosen product to plant allocation at the production lines. Colorized diagram bars for the produced quantities at the production lines imply information on intended sales markets. This is especially useful in terms of understanding inward and outward processing schemes proposed through the optimization solution. The routing inside the production network can hereby, be retraced.

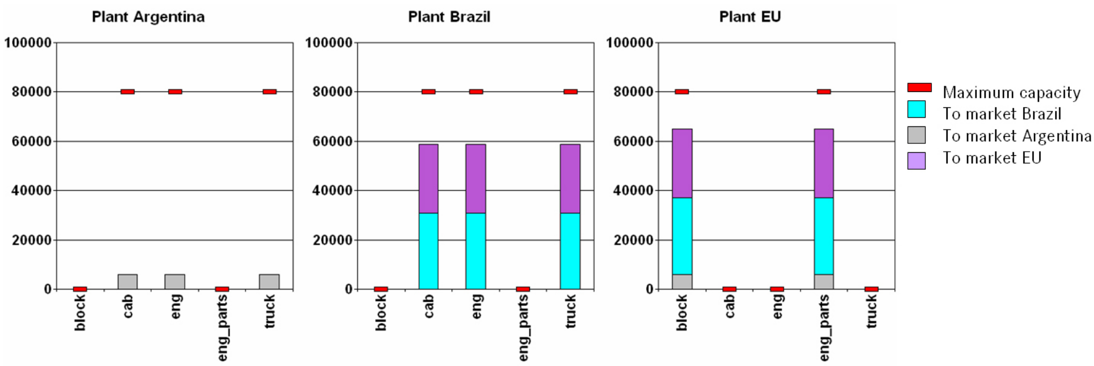


Figure 5.4: Network configuration for the base case

Due to disregarding LC requirements, duties and duty drawbacks the EU production plant is fully utilized for the lower cost components, shortblock and engine parts, serving the full demand. Labor intensive processes as the cab and truck production take place on Mercosul territory due to lower labor costs. The truck for the EU sales market is assembled jointly with the Brazilian cab and engine in Brazil. At the Argentinean plant, cab, engine and truck production lines are open, serving its home market based on otherwise higher transportation costs.
The overall cost optimal truck network supply variations are produced in Brazil and Argentina. It is intuitive that the shortblock and the engine parts are due

to their cost advantage produced at the EU plant.

Production	Logistics	Duties	DD	Total Costs
2,675	94	255	-57	2,967

Table 5.5: Costs base case

A detailed overview on costs for the complete production program is given in table 5.5. All costs are displayed in million *$ US*. Under production costs are summarized all costs occurring through the production of components and trucks. Logistic costs account for all deliveries from plant to plant and plant to sales markets.
The production proportion requests the biggest proportion of total costs, while logistic costs have only an inferior position. The provided duty payments and drawback claims are calculated ex-post relating to the chosen production program after the optimization process and deliver therefore a benchmark for the following extensions.

5.2.2 Extension I: Mercosul LC and duties

At this first extension, duty payments under Mercosul LC requirements are further included when optimizing the manufacturer's production network. Duties have to be paid for cross border deliveries, respectively EU and Mercosul territory. If, the LC requirement of 60% for Mercosul border crossings is fulfilled, no duties are charged.

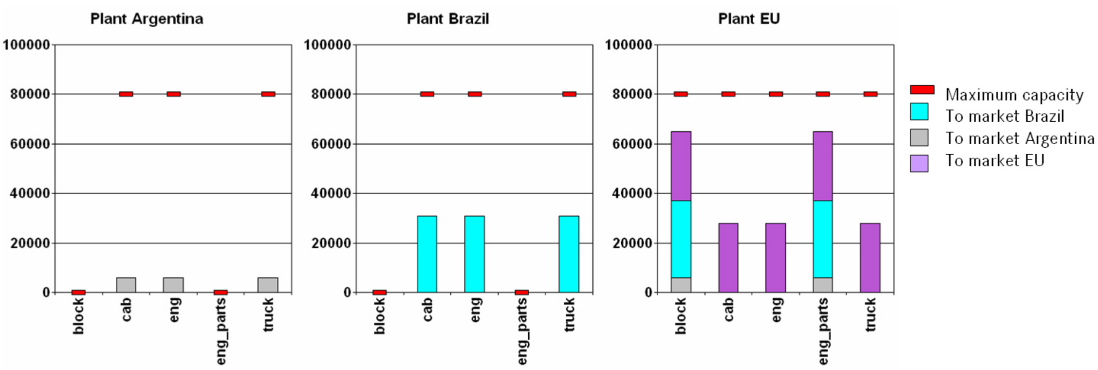


Figure 5.5: Network configuration for extension I

Consequently, the production program is liable to changes, compare figure 5.5.

The most obvious alteration is that it is no longer favorable to serve the EU sales market with network supply variations assembled in Brazil as under the base case. The EU plant produces the complete truck itself, due to otherwise high duty payments. Nevertheless, it is still beneficial using the EU shortblock as well as EU engine parts in engines designated for the Brazilian and Argentinean sales markets, due to their cost advantage.
For serving the Argentinean and Brazilian sales markets with trucks, no duties apply, since both are still served from their own plants. It is notable that each plant produces just one specific network supply variation. This can be explained through the sufficient high capacities available at the plants. Out of the 243 variations the most beneficial for the specific production program at each site is chosen. This results in three variations picked, dependent on external factors and cost structures given under this case.

Production	Logistics	Duties	DD	Total Costs
2,735	50	76	-	2,861

Table 5.6: Costs extension I

The cost structure for the optimized production program when considering Mercosul LC and duty payments is provided in table 5.6. Due to duty considerations it is no longer profitable to produce always the cost minimal components, based on production and transportation costs. Therefore, production costs increase compared to the base case. Duties occur for the exportation of EU shortblocks and EU engine parts to the Mercosul territory. The significant decrease in duty payments, through its consideration while optimizing, results in lower overall costs, compared to the base case. Duty drawbacks cannot be claimed under this production network configuration.

5.2.3 Extension II: Mercosul LC, duties and duty drawbacks

This approach considers, beneath duties and LC requirements, additionally duty drawback possibilities for the EU and Mercosul territory. Inward and outward processing opportunities ascend into the focus of interest. Figure 5.6 illustrates the optimal production program for extension II. Additionally, icons are introduced providing information, if goods crossing Mercosul borders are compliant with Mercosul LC or not.

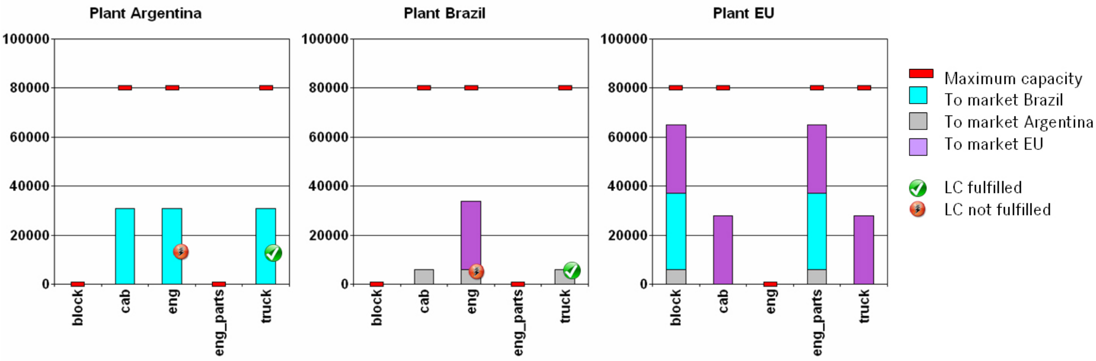


Figure 5.6: Network configuration for extension II

At the EU production plant almost the same pattern as under extension I can be seen, with one exception. The allowance of duty drawbacks leads to an outward processing of EU shortblocks and EU engine parts for the EU sales market in Brazil. This is caused due to lower assembling costs in Brazil and the opportunity to claim drawbacks on paid Mercosul import duties.
The second observation is the more interesting one and not intuitive at the first sight. The Brazilian production plant delivers one specific, LC compliant network supply variant of the truck to the Argentinean market and vice versa. Indeed, this is done to enable duty drawback claims on the EU shortblock and EU engine parts used for the truck engines assembled in Brazil and Argentina and incorporated in the truck variants on-site. Since, duty drawbacks only can be demanded for components imported for further exportation, the optimization program has to make sure that a second border crossing takes place for the EU engine parts and the EU shortblocks, to claim paid Mercosul import duties. This is provided by serving the Brazilian market with trucks, incorporating the EU components from Argentina and vice versa. Both truck variations fulfill the Mercosul LC request, therefore, no duties apply for these deliveries.

Production	Logistics	Duties	DD	Total Costs
2,723	75	136	-133	2,801

Table 5.7: Costs extension II

Table 5.7 provides the cost structure for extension II. Production costs decrease slightly, compared to extension I through the consideration of inward and outward processing schemes. Duties are almost fully compensated by drawbacks. Although, this results in higher logistic costs, overall costs decrease furthermore, compared to the base case and extension I.

5.2.4 Extension III: future legal framework

This approach considers duties, Mercosul LC and duty drawback schemes as they are intended to in the future of the Mercosul territory. Intra-Mercosul duty drawbacks should be abolished by CMC/DEC 20/09 until December 31st 2016. The consequence of this modification in the Mercosul legal framework is the objective of this extension.

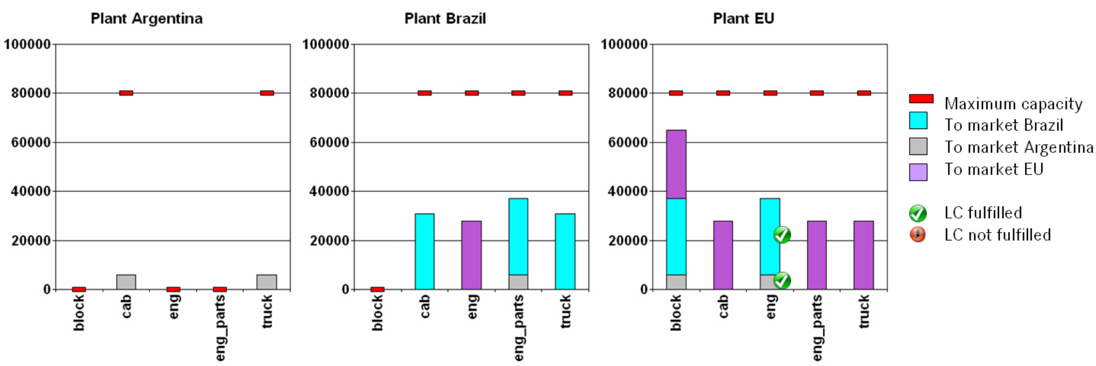


Figure 5.7: Network configuration for extension III

Figure 5.7 provides the optimal production program. The EU sales market is served with trucks the same way as under extension II, incorporating the inward processed engine from Brazil. A change in contrast to intra-Mercosul duty drawback allowance can be seen, in terms of how the Brazilian and Argentinean sales markets are satisfied. As duty drawbacks can be claimed no longer for intra-Mercosul deliveries the production program as chosen under extension II is modified. The Brazilian and Argentinean plant attend under extension III their home markets with local truck variants. However, the incorporated engines for the Brazilian and Argentinean truck variants under intra-Mercosul duty drawback prohibition, are assembled at the EU plant. Therefore, the Brazilian engine parts and the EU shortblock are used. For the Brazilian engine parts duty drawbacks can be claimed on the paid EU import duties. Since, the engine is compliant to Mercosul LC, no duties apply for the import to Mercosul, while the cheaper EU shortblock can be utilized.

Production	Logistics	Duties	DD	Total Costs
2,772	56	85	-83	2,830

Table 5.8: Costs extension III

Table 5.8 provides an overview on the cost structure under the assumptions of the future Mercosul framework. Production costs rise, while at the same time costs for logistics and duty payments are reduced compared to extension II. Total costs under the prohibition of intra-Mercosul duty drawbacks increase compared to the case of intra-Mercosul duty drawback allowance.

5.2.5 Summary study 1

In this first study the production programs for three sites serving one product to three sales markets are analyzed for a single-period. Thereto, four approaches are analyzed.

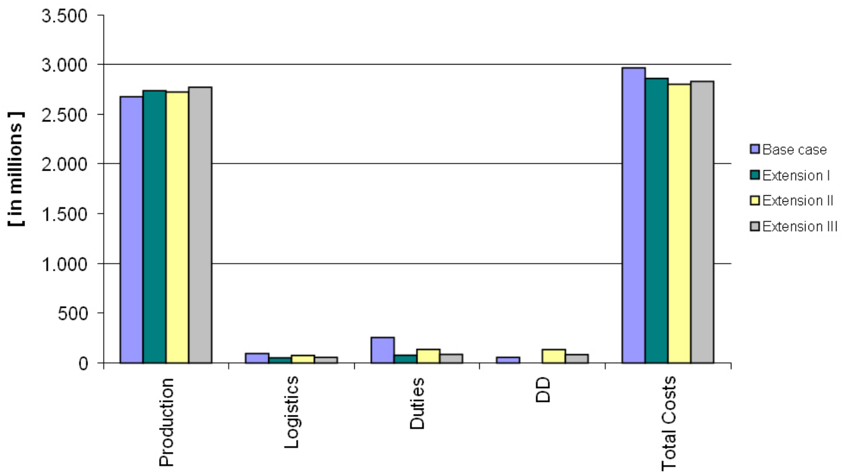


Figure 5.8: Cost overview study 1

Figure 5.8 contrasts the cost structures of the different optimization approaches

with each other. Even though, in the base case production costs represent the minimum, the additional ex-post calculation of duties and duty drawbacks results in the highest total costs. Through introducing step by step extensions to the optimization, total costs decrease with exception of extension III. Under this approach no intra-Mercosul duty drawbacks can be claimed and a less beneficial production program, compared to the case of intra-Mercosul drawback allowance, needs to be realized.
It can be observed that the production network configuration differ significantly depending on the considered global aspects while optimizing. A joint consideration of duties, duty drawbacks and LC restriction is therefore advisable. Furthermore, under this study this extension derives in the lowest total costs. As long as intra-Mercosul duty drawbacks still are applicable they should be integrated into production planning.

	Production	Logistics	Duties	DD	Total Costs	% change
Base case	2,675	94	255	-57	2,967	
Extension I	2,735	50	76	-	2,861	-3.6%
Extension II	2,723	75	136	-133	2,801	-5.6%
Extension III	2,772	56	85	-83	2,830	-4.6%

Table 5.9: Cost summary study 1

Table 5.9 illustrates the percental changes in total costs, with regard to the different approaches. Under extension II the highest cost reduction with 5.6 % compared to the base case can be achieved. Extension III still ends up in cost savings compared to the base case by 4.6%. Thus, it is beneficial to integrate duty drawback schemes into the production planning process.
It can be noticed that the joint consideration of the global aspects Mercosul LC, duties and duty drawbacks results in a more flexible production network configuration, compared to the base case or extension I. Under the base case and extension I a closer to the market production can be observed. This changes, if the opportunity to claim duty drawbacks is taken into account. Product flexible plants are configured in a way to minimize obstacles to free trade and therefore total costs.
Furthermore, can be stated that a detailed implementation of legal frameworks and updating changes in these framework is advisable. This can be verified by the different production network configuration for extension II and extension III, where the two different legal frameworks for Mercosul duty drawbacks are exam-

ined resulting in different production network configurations.
Even though, 243 network supply variations are available for producing the truck in all four approaches, the chosen variants are limited to a maximum of three different truck variations per extension. Yet, not in every approach are chosen the same variations. In total 5 out of the 243 possibilities are applied. This can be explained by the sufficient high capacities, which enable the optimization program to choose at every time the most valuable variants considering all external influences and cost.
Finally, it can be concluded that a joint consideration of all global aspects is advisable as production network configurations adopt to these aspects in order to minimize total costs, adjusting to this more realistic implemented environment.

5.3 Study 2: Capacity planning

The first study revealed that Mercosul LC, duties and duty drawbacks should be considered jointly. This second study is based on these findings and extends the first study with regard to capacity planning. This is done to address the global production planning problems in a more realistic context. Capacities are no longer sufficient high but different capacity levels at the production plants can be chosen. Thus, product flexibility is still assured. Under these changed general conditions the second study starts by contrasting the two different duty drawback legal frameworks. The recommended joint consideration of Mercosul LC, duties and duty drawbacks is extended by capacity planning decisions. Relevant questions investigated are:

- How interact the different legal frameworks with capacity planning decisions?
- Which capacities are chosen at the plants for the production lines?
- Where are components and products produced over the time horizon?
- Is there a trade-off between network flexibility and further investments into capacity?
- How is the capacity utilization of opened production lines?

The second part of the study deals with parameter variation. The production network configuration is examined on how cost structures and duty rates influence capacity planning decisions.

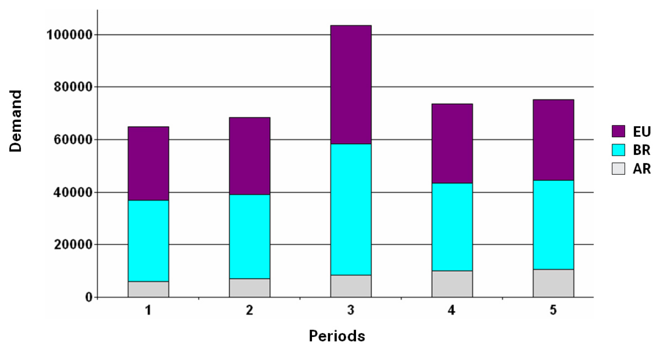


Figure 5.9: Truck demands per period

In order to execute the second study the time horizon is enlarged to five periods.

Investments and fixed costs for different capacities of the production lines are introduced. Due to, high investments for capacities, high capacity adjustment costs and associated fixed costs, this topic is crucial, when designing optimal production networks. In the following, the enlarged data framework underlying the second study is presented. Figure 5.9 introduces the truck demands for the five periods at the three sales markets Brazil, Argentina and EU. The demands are based on "global insight" forecast data for the years 2011 - 2015 (Global-insight 2011). For the first three periods, an increase in demand at all markets can be seen. In period four demand features a dent, due to weaker economic developments.

	Plant Argentina			
Capacity	0	40,000	80,000	120,000
Capacity level	1	2	3	4
Investments				
Engine parts	0	36,000,000	72,000,000	108,000,000
Shortblock	0	36,000,000	72,000,000	108,000,000
Engine Assembly	0	42,000,000	84,000,000	126,000,000
Cab	0	36,000,000	72,000,000	108,000,000
Truck Assembly	0	63,000,000	126,000,000	189,000,000
	0	213,000,000	426,000,000	639,000,000

Table 5.10: Production line capacities at the Argentinean plant

At each plant the same four different capacity levels are available for each production line. Table 5.10 provides detailed information on volumes and investments for the capacity levels at the Argentinean plant. Investments at the Brazilian plant are thereto reduced by 20%. At the EU plant associated investments account for twice the sum of the Argentinean plant. At all production lines capacity level 1 reflects an imaginary volume of 0 and therefore a non-utilization. Hence, the optimization model can decide, if a certain production line is opened or not. Capacity levels for a production line may vary over time.
A switch in capacity levels is occupied with capacity adjustment costs. Table 5.11 provides exemplary adjustment costs for cab and truck production at the Argentinean plant. Adjustment costs for upgrading the capacity level at all plants are derived through the difference of the investments between two levels. A disinvestment, regardless to the amount of levels, causes always 20,000,000 *$ US*. Costs for a capacity downsize need to be dispensed for employees and the dismounting of manufacturing equipment.

Cab	Plant Argentina			
To level	1	2	3	4
from level 1	0	36,000,000	72,000,000	108,000,000
from level 2	20,000,000	0	36,000,000	72,000,000
from level 3	20,000,000	20,000,000	0	36,000,000
from level 4	20,000,000	20,000,000	20000000	0

Truck	Plant Argentina			
To level	1	2	3	4
from level 1	0	63,000,000	126,000,000	189,000,000
from level 2	20,000,000	0	63,000,000	126,000,000
from level 3	20,000,000	20,000,000	0	63,000,000
from level 4	20,000,000	20,000,000	20,000,000	0

Table 5.11: Capacity adjustment costs

Periodical fixed costs for the capacity volume of a production line are set to 100 *$ US* per capacity unit of the active level at all plants. The net present value of total costs is minimized over all five periods, using a discount rate of 10%.

5.3.1 Capacity planning under different legal frameworks for Mercosul

The first study has shown that it is beneficial to include LC, duties and duty drawbacks when designing a production network. The extension on capacity planning is based on this approach. The objective of this subsection is to contrast the two legal frameworks of duty drawbacks for the Mercosul territory in terms of capacity planning decisions. In the following, the production network for intra-Mercosul duty drawback allowance, illustrated under figure 5.10 and intra-Mercosul duty drawback prohibition, figure 5.11 are examined in detail.

Intra-Mercosul duty drawback allowance

At the EU plant the production lines for shortblocks and engine parts are activated on capacity level 3. The lines produce for the EU, the Brazilian and Argentinean sales market. Engines and trucks designated for the Brazilian sales market are assembled at the Argentinean plant. This is done to obtain duty drawbacks on the EU components used for the truck engines at the Argentinean plant. Hence, drawback claims on the EU engine components outweigh the more

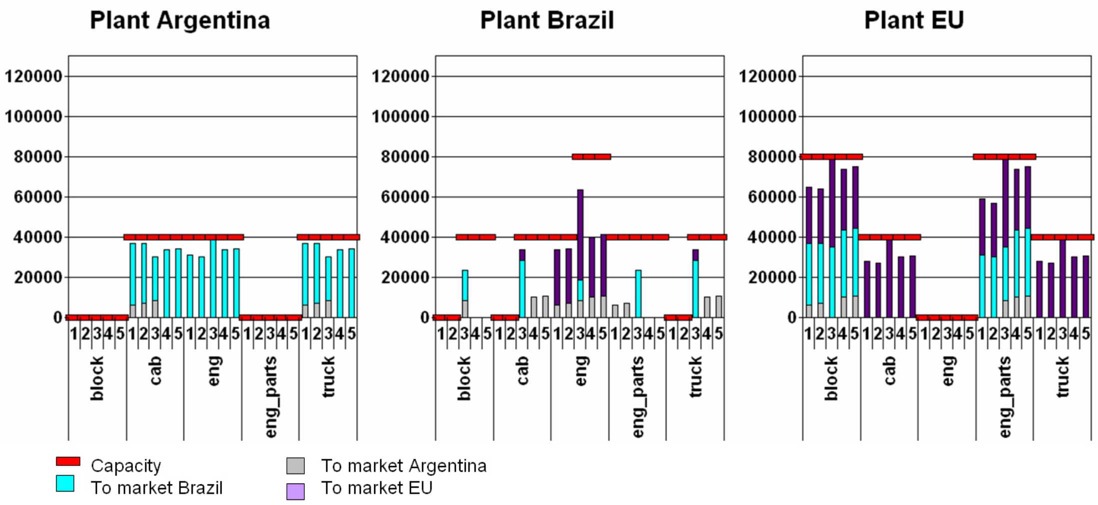


Figure 5.10: Production network with intra-Mercosul duty drawbacks

expensive investments for the EU site compared to the Mercosul plants.
The engine designated for the EU sales market is processed at the Brazilian plant using the EU shortblock and the EU engine parts. Duty drawbacks are claimed for these EU components. Therefore, the capacity level at the Brazilian engine production line rises with demand from level 2 to 3.
It can be concluded that the same effects as under study 1 can be observed. Capacities inside the production network are chosen in a way to enable duty drawback claims, when using the most favorable components from the EU plant. This results in particular low utilization of active capacities for production lines, at the Brazilian plant.
Nevertheless, a trade-off between investments or disclaiming duty drawbacks can be observed. In period three, when demand peaks, at the EU plant shortblock and engine parts production are not further extended to level 4. Instead, the Brazilian plant produces the exceeding amount of shortblocks and engine parts. This is done because additional investments at the EU plant outweigh possible duty drawback claims and the cost advantage of the EU shortblock and engine parts.

Intra-Mercosul duty drawback prohibition

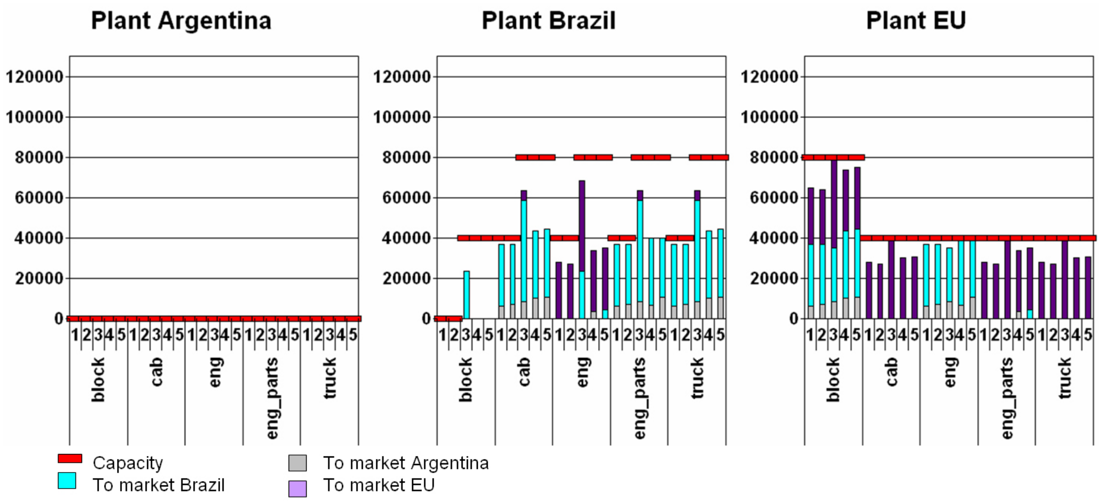


Figure 5.11: Production network without intra-Mercosul duty drawbacks

Figure 5.11 illustrates the production network under intra-Mercosul duty drawback prohibition. No duty drawbacks can be claimed, when crossing borders inside the Mercosul territory. The change in the legal framework has a high impact on the capacity planning decisions.

The Argentinean plant with its higher investments, in contrast to the Brazilian plant is not used at all. Cross border deliveries of trucks between Brazil and Argentina to obtain duty drawbacks are no more possible. The Argentinean and Brazilian sales markets are served by the Brazilian plant with Mercosul LC compliant truck variants. Capacity levels for the Brazilian production lines rise with the demanded amounts from level 2 to 3.

The truck engines designated for the Mercosul markets are assembled at the EU plant. It is incorporated the EU shortblock, due to its cost advantage and the Brazilian engine parts. The engines fulfill Mercosul LC and can therefore be delivered without paying Mercosul import duty. This explains the chosen capacity level 3 at the EU plant for shortblocks.

In summary, can be observed that the prohibition of intra-Mercosul duty drawbacks concludes in a less flexible production network and a closer to the market production in Brazil. Fewer production lines are opened, while their capacities are used to a higher extend. Further, can be observed a trade-off for investing into additional capacities and cost savings through duty drawbacks. As long as possible drawbacks outweigh investments into capacities these are realized.

	Production	Logistics	Duties	DD	Duties paid	Investment	Fixed costs	Total costs
Intra-Mercosul duty drawbacks	13,278	347	627	-598	28	807	220	14,680
No intra-Mercosul duty drawbacks	13,479	291	423	-380	43	781	212	14,806

Table 5.12: Cost structure comparison

Table 5.12 contrasts the cost structures of both approaches. As explained the two production network configurations differ. In terms of total costs the difference is not as crucial. The less flexible production network, under intra-Mercosul duty drawback prohibition results in lower investments and fixed costs. At the same time higher production costs have to be accepted. The loss of intra-Mercosul duty drawback claims concludes that it is no longer beneficial to produce by all means the cheapest network supply variations of the truck. Import duties into the Mercosul territory cannot be retrieved; consuming possible cost advantages of the EU components.

5.3.2 Parameter variation

The consequent parameter variation is based on the intra-Mercosul duty drawback allowance approach. It reflects the actual legal framework and is applicable at least until end of 2016 (Mercosul/CMC 2009b). This approach is further referred to as base case when conducting the parameter variation. The goal of the parameter variation is to examine, how cost parameters and different duty rates affect:

- capacity planning decisions,
- production network flexibility and
- capacity utilization at the production lines.

The subsection is three folded. First, the impact of varying duty rates is regarded. The second variation deals with different investment sums. Finally, the impact of altering fixed costs on capacity decisions is examined.

5.3.2.1 Parameter variation: duty rates

This parameter variation accommodates the dynamic environment of duty regulations. In today's cross linked economy the number of PTAs, currently 283 (WTO 2010a), permanently increases and therefore related duty rates are under steady change. Duty rates are not static over time, as they respond to economical developments. This subsection examines the effects of altering duty rates on capacity planning decisions of a truck manufacturer acting on Mercosul territory. In the following, duty rates for the EU and Mercosul territory are varied separately. First, the impact of decreasing EU import duty rates is covered, followed by an inquiry on altering Mercosul import duties.

Decrease of EU import duties

Under the base case an import duty rate of 10% for components and 15% for trucks to the EU market is assumed. During the parameter variation, it is no longer differentiated between components and products as a common duty rate is provided.

	Duty rates
Base case	10% / 15%
Alterations	10%
	5%
	3%
	0%

Table 5.13: EU import duty rate alterations

Table 5.13 shows the different conducted alterations on EU import duty rates starting with a common import duty of 10%. In the following, the changes in terms of capacity planning decisions compared to the base case are explained. Through analyzing the modifications, correlations between duties and capacity planning are concluded.

The first cutback to 10% EU import duties has no effect on the production network compared to the base case. A further decrease to 5% implies the first modifications for capacity planning opposite the base case. Capacities for producing cabs designated for the EU sales market are shifted from the EU plant to the Brazilian plant. The cost advantage due to lower labor costs of the Brazilian cab are no longer compensated through high EU import duties. A further diminishment to a EU import duty rate of 3% causes a relocation of capacities for the trucks designated for the EU sales market. The production is shifted from the EU to the Brazilian plant, compared to the base case. This is caused by the same reasons as for the cab. The related production network configuration is given by figure 5.12.

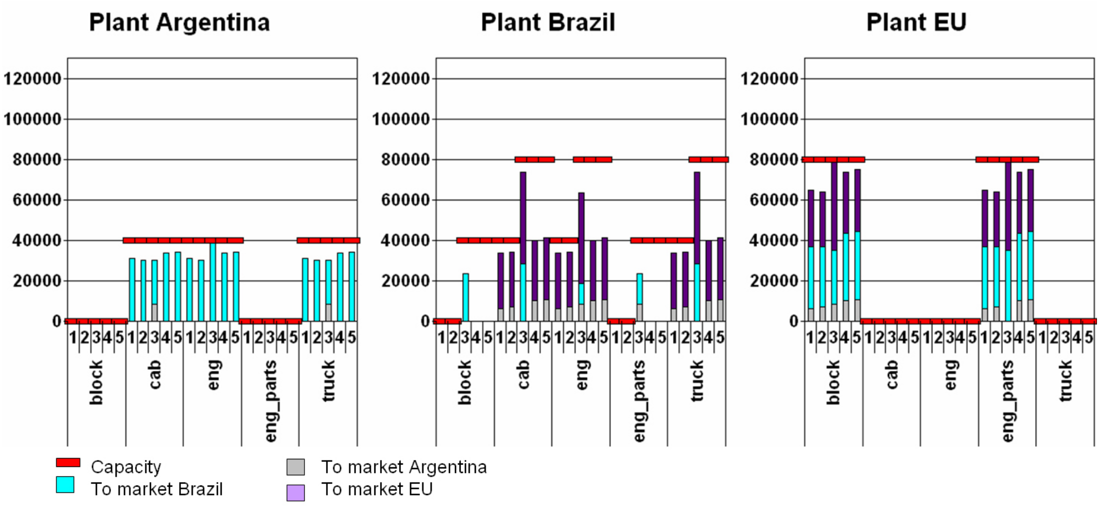


Figure 5.12: Production network for 3% and 0% EU import duty rates

The EU truck production line is not active. Instead, capacities at the Brazilian truck production line are enlarged serving additionally the EU market, opposite the base case. A reduction of EU import tariffs to 0% results in the same capacity decisions as under the EU import duty rate of 3%.

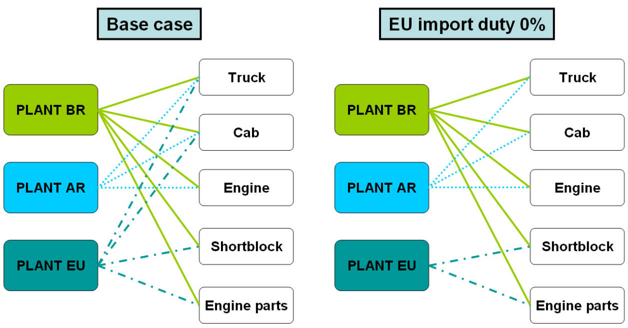


Figure 5.13: Network configuration for decreasing EU import duties

Figure 5.13 contrasts the production network configuration under the base case to the network configuration under 3% or 0% EU import duties. Links between the plants and components or products imply the activation of the particular production line. It can be noticed that under lower EU import duty rates the production network is less flexible. The distorting effect of duties on the manufacturer's production network declines and production is relocated to the components, which offer cost advantages.

	Production	Logistics	Duties	DD	Duties paid	Investments	Fixed costs	Total costs
Base case	13,278	347	627	-598	29	807	219	14,680
EU import duty 10%	13,278	347	621	-598	23	807	219	14,674
EU import duty 5%	13,130	450	672	-609	63	767	219	14,629
EU import duty 3%	13,031	531	725	-609	116	683	212	14,573
EU import duty 0%	13,031	531	609	-609	0	683	212	14,457

Table 5.14: Decreasing EU import duty rates

Table 5.14 provides an overview on the cost structures for decreasing EU import duty rates. The less flexible production network configuration results in lower investments and therefore lower fixed costs. Fewer production lines have to be opened in order to balance the effects of duties through duty drawback claims on the production network. Increasing logistic costs are caused by serving the EU sales market through the Brazilian plant, opposite the EU on-site production under the base case. Nevertheless, total costs decline for decreasing EU import duty rates.

Decrease of Mercosul import duties

The second alteration deals with Mercosul import duties. Under the base case a duty rate of 14% on components and 35% for trucks was assumed. However, for the parameter variation purpose again a common Mercosul import duty rate is assumed and altered.

	Duty rates
Base case	14% / 35%
Alterations	10%
	5%
	3%
	0%

Figure 5.14: Mercosul import duty rate alteration

Table 5.14 introduces the different conducted alterations on Mercosul import duty rates. For the first two alterations there are no modifications concerning capacity planning decisions, compared to the base case. Beginning with a Mercosul import duty rate of 3% cab, engine and the truck capacities are almost completely shifted from the Argentinean production lines to the Brazilian plant, compared to the base case. However, for a Mercosul import duty rate of 0% all capacities located under the base case in Argentina are now built-up at the Brazilian production lines, compare figure 5.15.

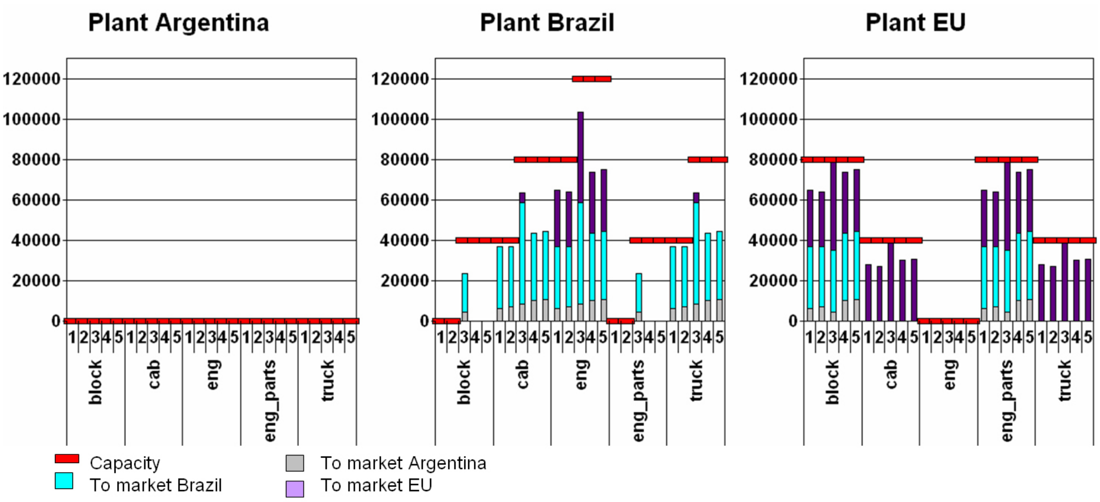


Figure 5.15: Production network for 0% Mercosul import duty rate

This shift from Argentina to Brazil results from the decreasing import duty load of components produced at the EU plant, imported into the Mercosul territory. Hence, the amount of possible duty drawback claims diminishes as well. Capacities at the Argentinean plant served the production network under the base case as basis for drawback claims. The advantage of this set-up reduces with the duty load. A trade-off between investing in Argentinean capacity and claiming duty drawbacks can be observed. Capacities at the Argentinean production lines are installed as long as duty drawback claims outweigh associated investments.

Figure 5.16 contrasts the production network of the base case to the network configuration under 0% Mercosul duties. Due to decreasing Mercosul import duties and therefore duty drawbacks, the production network becomes less flexible.

High import tariffs result in production networks seeking for legal leeways to dilute these obstacles to free trade. Duty drawbacks offer therefore an opportunity.

To enable duty drawback claims, adjustments inside the production network have to be made, resulting in a higher flexibility.

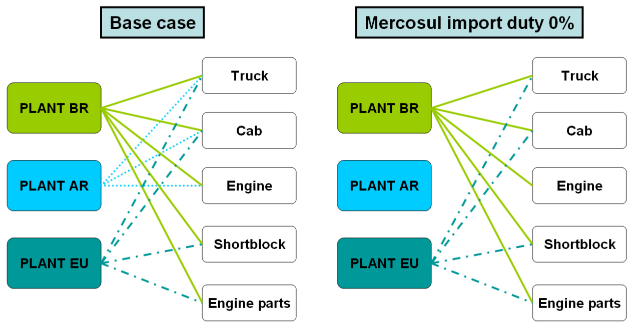


Figure 5.16: Network configuration for decreasing Mercosul import duties

Table 5.15 provides an overview on the cost structures reflecting the transitions described. Investments and fixed costs decrease with lowering Mercosul import duties. The same can be observed for duty payments and duty drawback claims.

	Production	Logistics	Duties	DD	Duties paid	Investments	Fixed costs	Total costs
Base case	13,278	347	627	-598	29	807	219	14,680
Mercosul import duty 10%	13,266	347	463	-417	46	802	212	14,673
Mercosul import duty 5%	13,266	347	376	-333	43	802	212	14,670
Mercosul import duty 3%	13,278	290	202	-108	94	781	212	14,655
Mercosul import duty 0%	13,279	278	28	0	28	773	212	14,570

Table 5.15: Decreasing Mercosul import duty rates

Increase of Mercosul import duties on components

In a last step increasing duty rates on components for the Mercosul territory are regarded. The base case introduced a duty rate of 14% on components and a import duty rate of 35% for trucks. Tariffs on components are altered towards the level of the already very high import duties levied for trucks.

	Duty rates
Base case	14% / 35%
Alterations	18%
	22%
	26%
	35%

Table 5.16: Mercosul increasing import duty rates

Table 5.16 presents the duty rate alteration steps. Under the base case, the production network configuration has the opportunity to fully retrieve paid Mercosul import duties. This is achieved through building up capacities for serving trucks to the Brazilian market at the Argentinean site and vice versa. Paid Mercosul import duties on incorporated EU components can fully be claimed. Therefore, capacity planning is for all alterations the same as presented under the base case. It can be concluded that production networks, capable to retrieve import duties are robust against high protective tariffs. In case legal frameworks allow local manufacturers duty drawbacks, this scope can be used through a proper configuration of the production network to compensate the distortion of high protective tariffs.

5.3.2.2 Parameter variation: Investments

Capacity decisions depend on: local variable production costs, LC requirements, duties and amongst others required investment sums. The objective of this subsection is to examine the impact of investments. The analysis on altering investments is two folded. First the impact of increasing investments is regarded, followed by an examination of decreasing investments sums.

Increasing investment sums
Investments are step by step increased, compared to the base case. Table 5.17 illustrates the alteration steps.

	Investments
Base case	set-up 2. study
Alterations	+10%
	+20%
	+50%
	+100%
	+200%
	+400%
	+700%

Table 5.17: Increasing investment alterations

An increase of 10% for investments derives in a switch of capacities compared to the base case for cab and truck production from the Argentinean to the Brazilian plant. Investments at the Argentinean site no longer outweigh possible duty drawback claims on EU components incorporated into trucks designated for the

Mercosul sales markets.

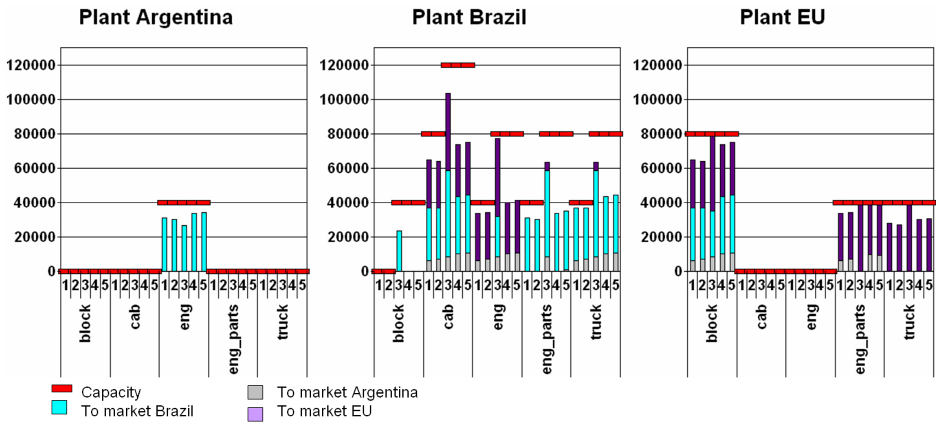


Figure 5.17: Network configuration for alterations +50%, +100% and +200%

Altering investments by +50%, +100% and +200% leads to the same capacity planning decisions for the production network. Figure 5.17 illustrates this network configuration. Compared to the base case, in addition to the shifts observed for +10% on investments, the EU cab production line capacities for the EU sales market are relocated to Brazil. This is caused through the higher investment needs for the EU cab production line, opposite the Brazilian line. Additional investments at the EU plant exceed transport costs and duty payments for producing the cab in Brazil and delivering it to the EU plant.

It can be stated that fewer production lines are activated with increasing investment sums. This results in a less flexible production network. Flexibility inside production networks is used to balance external impacts as for example Mercosul LC requirements or duty payments. However, maintaining flexibility is allocated to investments. As investment sums rise the cost advantage generated through network flexibility declines, resulting in fewer activated production lines. Figure 5.18 displays this development. Increasing investment sums result in a cutback of opening production lines at the plants. This is reflected by the reduction of product or component to plant allocations.

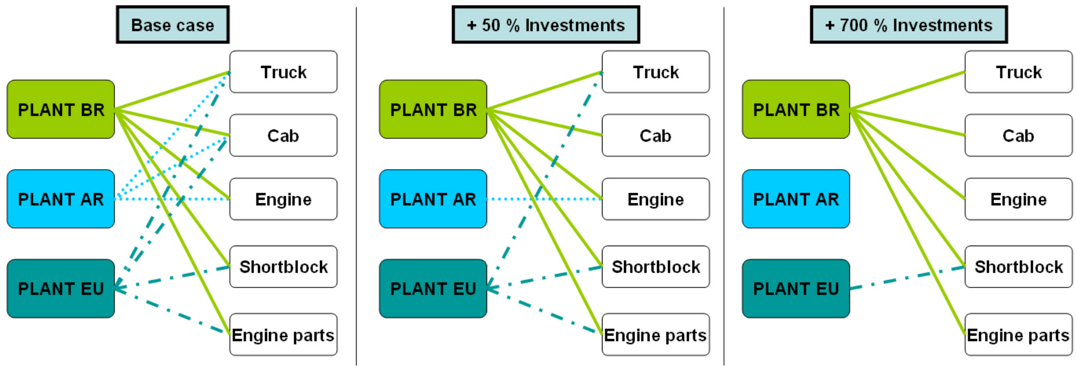


Figure 5.18: Different production network configurations under increasing investments

Table 5.18 introduces the resulting cost structures for the investment alteration. Besides the increasing investment sums, caused by the alterations, can be seen that production costs and paid duties ascend. The production network looses incrementally its ability to outbalance external trade obstacles. Therefore, higher production costs and duty loads are accepted to avoid further investments into additional capacities. A trade-off between production network flexibility and investing into capacities can be observed.

	Production	Logistics	Duties	DD	Duties paid	Investments	Fixed costs	Total costs
Base case	13,278	347	627	-598	29	807	219	14,680
Investments +10%	13,403	296	521	-490	31	813	212	14,755
Investments +20%	13,403	296	521	-490	31	887	212	14,829
Investments +50%	13,266	393	624	-490	134	1,044	212	15,049
Investments +100%	13,266	393	624	-490	134	1,392	212	15,397
Investments +200%	13,266	393	624	-490	134	2,087	212	16,092
Investments +400%	13,434	374	482	-319	163	3,221	212	17,404
Investments +700%	13,486	452	929	-187	742	4,379	212	19,271

Table 5.18: Cost structures for increasing investments

Decreasing investment needs
In a second step the impact of decreasing investment sums is examined. Table 5.19 illustrates the alterations conducted.

	Investments
Base case	set-up 2. study
Alterations	-10%
	-20%
	-50%
	-70%

Table 5.19: Decreasing investment alterations

Under the base case the production network configuration is already very flexible. Capacities are activated to enable duty drawback claims on EU components incorporated into trucks for the Mercosul territory. Thus, the observed reaction for decreasing investments on capacity planning decisions can be explained. Decreasing investments by -50% leads to the first small shift compared to the base case. The Brazilian truck production line is activated in addition for the first two periods, producing trucks for the Argentinean sales market. Since, the truck demand at the Argentinean market is not very high investments into capacities outweigh possible duty drawback claims under the base case.
Active capacity levels between the base case and the "- 70% decrease" alteration differ beneath the described shift in truck production for the production lines EU shortblock and Brazilian shortblock. Compared to the base case, capacities from the Brazilian line are shifted to the EU shortblock production line. The complete shortblock demand is produced at the EU plant utilizing capacity level 4. Due to the decreasing investment sums it is beneficial to further invest into capacity level 4 at the EU shortblock production and satisfy the complete demand.
Table 5.20 provides an overview on the cost structures for decreasing investments. Production costs and duties paid are almost on a stagnant level caused by the nearly identical production networks. Since, the production network configuration of the base case is already capable to anticipate the distorting external effects, decreasing investments have only a marginal impact on capacity planning decisions.

	Production	Logistics	Duties	DD	Duties paid	Investments	Fixed costs	Total costs
Base case	13,278	347	627	-598	29	807	219	14,680
Investments -10%	13,278	347	627	-598	29	726	219	14,599
Investments -20%	13,278	347	627	-598	29	646	219	14,519
Investments -50%	13,266	356	637	-609	28	406	219	14,275
Investments -70%	13,239	364	661	-633	28	284	219	14,134

Table 5.20: Cost structures for decreasing investments

5.3.2.3 Parameter variation: fixed costs

Under the base case fixed costs are set to 100 *$ US* per active capacity unit. Again the analysis is two folded. First, the impact of increasing fixed costs is examined, followed by decreasing fixed costs.

Increasing fixed costs

Table 5.21 provides the alteration steps for increasing fixed costs.

	Investments
Base case	100
Alterations	110
	125
	150
	200
	400

Table 5.21: Increasing fixed costs alteration

The first alteration of fixed costs up to 110 *$US* shows a small impact on capacity planning. Capacities for the Argentinean engine parts located under the base case in Brazil are shifted to the EU plant. This is caused through increasing fixed costs and the otherwise low capacity utilization at the Brazilian production line. The remaining capacities inside the production network are equivalent to the base case.

A further increase of fixed costs to 125 *$ US* results in the capacity planning displayed under figure 5.19. It is the same network configuration as the outcomes for all further alterations suggest. Capacities for EU engine parts designated for the Brazilian market are shifted for the first two periods from the EU plant to the Brazilian plant, compared to the base case. Possible duty drawbacks on the EU engine parts exceed no longer the additional investments and attached fixed costs

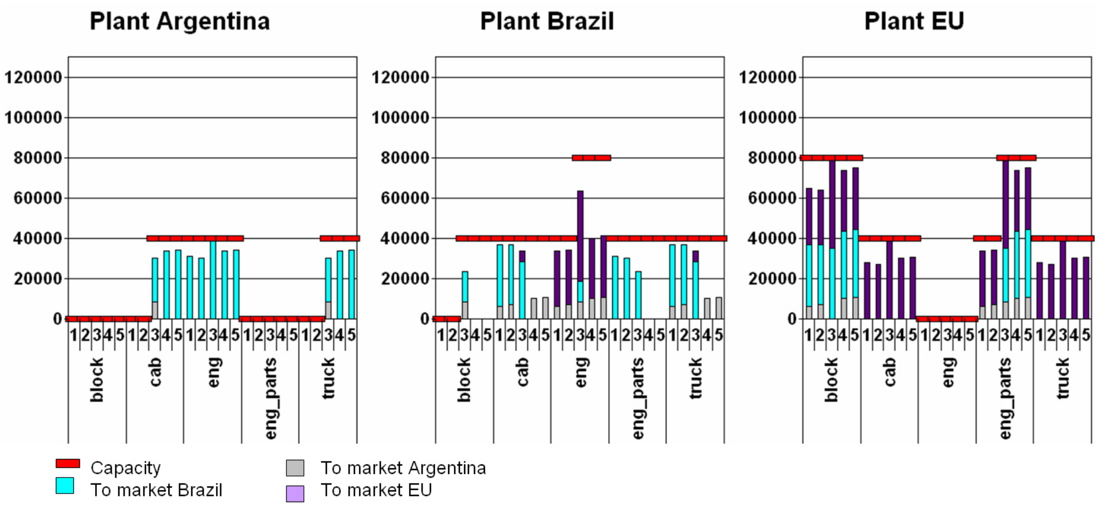


Figure 5.19: Network configuration for fixed costs: 125 - 400 *$ US* per unit

at the EU engine part production line. Caused by this change in the production network the relocation of capacities from the Argentinean truck production line to the Brazilian line can be explained, opposite the base case. The decrease of possible duty drawbacks on EU components makes a cross border delivery of trucks from Argentina to Brazil, in order to obtain drawbacks on paid Mercosul import duties, no longer beneficial.

Table 5.22 provides the associated cost structures for the alterations. The shift in production from the EU to the Brazilian plant opposite the base case generates higher production and logistic costs. However, import duties decrease, since less EU components are utilized. It can be concluded that increasing fixed costs induce a higher utilization of activated capacities.

	Production	Logistics	Duties	DD	Duties paid	Investments	Fixed costs	Total costs
Base case	13,278	347	627	-598	29	807	219	14,680
Fix costs 110	13,272	347	632	-591	41	805	237	14,702
Fix costs 125	13,324	325	588	-559	29	792	265	14,735
Fix costs 150	13,324	325	588	-559	29	792	318	14,788
Fix costs 200	13,324	325	588	-559	29	792	424	14,894
Fix costs 400	13,324	325	588	-559	29	792	779	15,249

Table 5.22: Cost structures for increasing fixed costs

Decreasing fixed costs

For this analysis fixed costs are altered as given by table 5.23

	Investments
Base case	100
Alterations	90
	75
	50
	10

Table 5.23: Decreasing fixed costs alteration

The effects of decreasing fixed costs can be summarized briefly. For all alterations the same production network configuration, as under the base case is chosen. This can be explained by the decreasing significance of fixed costs compared to total costs. The percentage fluctuates between 1.5% for fixed costs under the base case and 0.2% for the alteration step to 10*$ US* per active capacity unit. It can be concluded that the production network configuration chosen under the base case is robust towards decreasing fixed costs.

5.4 Study 3: Consideration of Finame requirements

The third study deals with the impact of the Brazilian non-tariff trade barrier Finame on the production network of the truck manufacturer. In order to sell his trucks on the Brazilian market the manufacturer has two possibilities. First, serving the Brazilian market with solely Finame-compliant variations. Or second, satisfying demands with non-compliant variations and therefore compensating his clients. The compensation is necessary, to adjust the disadvantage for clients not enabled to apply for the favorable development loan Finame. This payment is introduced as a penalty payment during the optimization process and accounts for 3,000 *$ US* per truck, reflecting the financial disadvantage caused through the difference of the credit base rates. Thus, the optimization model can decide, if all network supply variations of the truck fulfill Finame requirements, or if associated penalties are taken into account. Relevant questions under this study are:

- How influences the rigid non-tariff trade barrier Finame the production network configuration?
- Are Finame compliant network supply variants delivered to the Brazilian market?
- In case Finame compliant variants are produced, which components are incorporated?
- How changes the composition of total costs?

In order to examine these questions this study is organized as follows: In a first examination the single-period set-up (compare study 1) is regarded, to obtain unbiased information. Subsequently, the influence of Finame requirements on the enlarged set-up for capacity planning is analyzed (compare study 2).

Single period set-up

The first study revealed that production network optimization should consider Mercosul LC, duties and duty drawbacks. The now introduced Finame extension is therefore based on Mercosul LC, duties and duty drawback consideration (extension II, study 1) and enlarges it by the Finame requirements in value and weight.

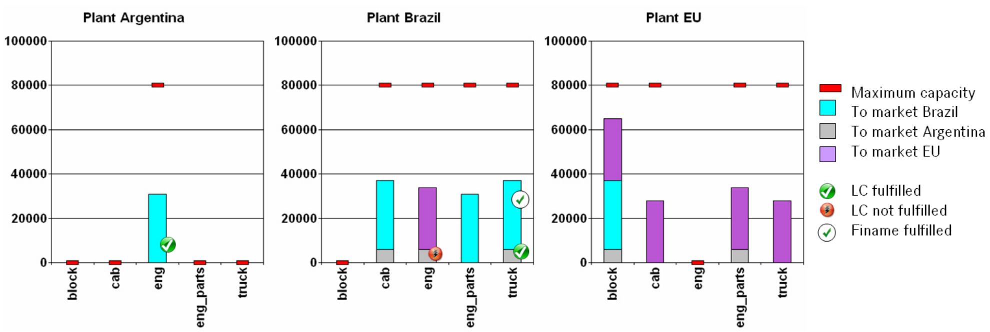


Figure 5.20: Network configuration for Finame extension

Figure 5.20 provides the suggested production program. In the following, the changes due to the introduction of Finame requirements, compared to extension II of the first study are explained. First can be noted, the EU market is served in the same way as under extension II, including the outward processed truck engine from Brazil for the EU sales market. The Argentinean sales market is still

attended by the Brazilian production site. Truck variants compliant to Mercosul LC are used in order to claim duty drawbacks on incorporated EU shortblocks and EU engine parts.
Indeed, a shift of production from Argentina to Brazil for the Brazilian sales market can be seen, opposite the case of non consideration of Finame restrictions. Due to the introduction of the Finame requirements and associated penalty payments, it is no longer beneficial to serve the Brazilian truck demand from Argentina and claim duty drawbacks on incorporated EU components. The Brazilian production plant handles domestic demand through producing one specific Finame compliant truck, incorporating a engine from Argentina. Thereto, the EU shortblock and Brazilian engine parts are used to assemble a Mercosul LC compliant truck engine.
Along with that come two advantages: first duty drawbacks for the EU shortblock incorporated into the Argentinean engine can be claimed, due to its inward processing in Argentina. And second, the shortblock's weight is converted from non-originating to originating weight, through the Mecosul LC compliance of the engine. The issuing of a Mercosul LC certificate for a good concludes that the whole item and therefore all its antecessor components account as originating. This is especially interesting in terms of Finame weight fulfillment. It enables the manufacturer through proper production decisions capitalizing scopes of the Mercosul legal framework. The remaining components are produced in Brazil and assembled on-site to conclude Finame compliant trucks.

	Production	Logistics	Duties	DD	Penalty	Total Costs	% change
extension Finame	2,754	60	109	-107	0	2,816	-1.7%
adjusted extension II	2,723	75	136	-133	62	2,863	

Table 5.24: Costs Finame extension

Table 5.24 lists the associated costs for the production program as well as the adjusted cost structure for extension II (Mercosul LC, duties and duty drawbacks) presented under the first study. When determining the benefit of incorporating Finame requirements a proper comparison can only be made, if possible penalty payments are considered. Therefore, penalty payments for the suggested production program under extension II are estimated and added ex-post to adjust the cost structure.
For the Finame extension can be seen that production costs rise due to intro-

ducing the most restrictive obstacle of free trade in Brazil. However, penalty payments diminish to 0. It is more convenient to avoid penalty payments and accept therefore higher production costs. Overall costs are at their lowest, when considering in addition the Finame requirement.

Finame consideration under capacity planning

The single period set-up has shown that it is beneficial to include Finame requirements, when attending the Brazilian market. The chosen production network is adjusted to avoid penalty payments.

This set-up is now extended with regard to capacity planning. Therefore, the base case of study 2 (Mercosul LC, duties, intra-Mercosul duty drawback allowance) is enlarged by the introduction of Finame requirements.

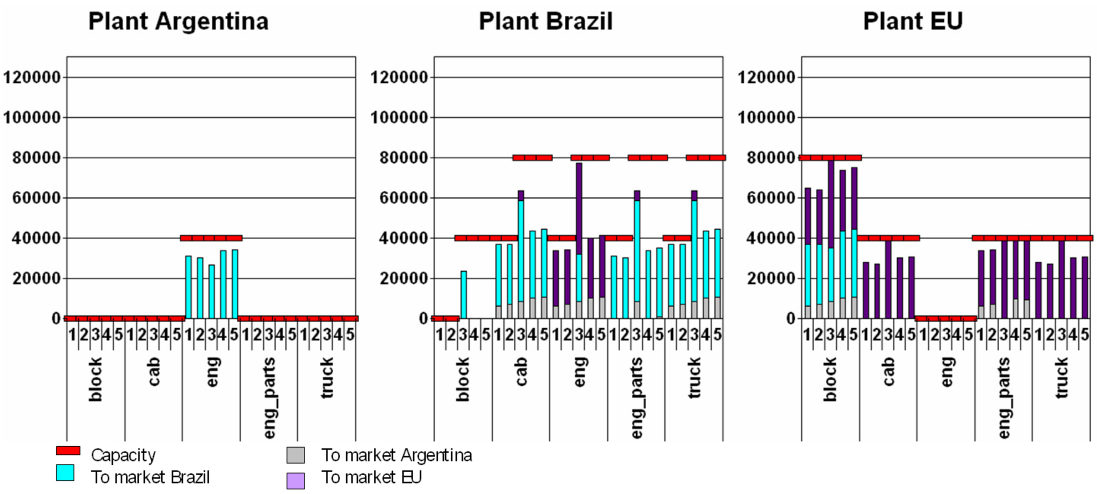


Figure 5.21: Production program under Finame consideration

Figure 5.21 displays the production network for the provided set-up. Capacities for the Brazilian cab and truck production are relocated from Argentina to the Brazilian plant opposite the base case. This is caused to avoid possible penalty payments by serving Brazilian demand with Finame compliant trucks. Capacities at the Argentinean engine production line are activated at level 2, producing a Mercosul LC compliant truck engine for the Brazilian market. The engine features the EU shortblock and Brazilian engine parts. Therefore, on the EU shortblock duty drawbacks can be claimed and its weight accounts at the end as originating in terms of Finame requirements. It can be summarized that the effects observed under the single period set-up recur for capacity planning. Capacities are built up in a manner to avoid penalty payments and produce Finame compliant trucks for the Brazilian sales market.

	Production	Logistics	Duties	DD	Duties paid	Penalty	Investment	Fixed costs	Total costs	
Finame consideration	13,403	296	521	-490	31	0	739	212	14,712	-3%
Adjusted base case	13,278	347	627	-598	28	536	807	220	15,245	

Table 5.25: Cost structure under Finame consideration

Table 5.25 provides an overview on the related costs. It compares the adjusted base case from the second study, where additional penalty payments were added ex-post, to the case of capacity planning under Finame requirements. Even though production costs rise through the shift to the Brazilian plant, cost savings of 3% on total costs can be achieved through the avoidance of penalty payments by reconfiguring the production network.

Concluding can be summarized that a truck manufacturer attending the Brazilian market in a great deal should incorporate this special non-tariff trade barrier into his production network design process. Cost savings can be realized and capacity planning decisions alter in order to fulfill Finame requirements. Capacities are under Finame consideration built up closer to the market. An effect intended by non-tariff trade barriers.

5.5 Performance analysis

Under this subsection the performance of the developed mixed integer program (MIP) is presented. The runtime analysis was executed on an Intel Core i5 processor with 3 GB random access memory (RAM) available. The used optimizer software was Xpress Mosel Version 3.2.0.
Mercosul LC and Finame calculations are based on network supply variations. Their number is concluded by multiplying all possible producing and assembling opportunities for one product inside the production network. Network supply variations define the dimension of the proposed optimization model. Therefore, the quantity of network supply variations is gradually enlarged to gain insight on

computational times.

Set-up	Network supply variations	Truck types	Description	Computing times for the base case	Rows	Columns
1	243	Truck type I	data framework study 2	394 sec	18,545	27,165
2	486	Truck type I Truck type II	additional truck type	1,358 sec	21,660	29,456
3	1,458	Truck type I Truck type II	additional component	2,470 sec	83,424	118,778

Table 5.26: Computational times

Table 5.26 provides the results of the conducted analysis. The first set-up refers to the data framework of the second study. Computational times are provided for the base case. Thereupon, for the second set-up an additional truck type is added. This results in 486 network supply variations. Finally, under the third set-up an additional component is incorporated into the bill of materials, concluding in 1,458 variations.

As the production opportunities inside the network increase, network supply variants rise as well. It can be observed that computational times are dependent on the amount of network supply variations, which have to be considered. The increasing number of network supply variations results in a significant rise of rows and columns at the associated matrices. It can be concluded that the variants on the one hand define the dimension of the problem and on the other hand limit therefore the size of the solvable problem.

6 Conclusions

6.1 Summary

In the face of increasing globalization, a multinational corporation has to meet numerous challenges when designing its production network. This thesis focuses on duties, duty drawbacks and non-tariff trade barriers and their impact on capacity planning decisions and production network design. However, international legal frameworks are endless and often differ in addition for specific industries. A general treatment of these obstacles to trade is therefore not advisable. The focus on this work is especially the legal framework of the Mercosul automotive industry. It develops an optimization model for production networks with regard to this sector.

The implemented model extends the existing literature, as it is able to evaluate the LC on a product specific level, required by the Mercosul legal framework and the Finame calculation method. Further, a detailed consideration of inward and outward processing reliefs is implemented in order to generate valid results for an optimal production network configuration.

Based on this model the numerical studies showed that a joint consideration of Mercosul LC, duties and duty drawbacks is advisable when designing the production network. Network configurations differ significantly depending on the global aspects incorporated. However, through a joint consideration of all aspects the highest cost savings could be achieved during the first study. Production networks are equipped with flexibility to reduce the impact of distorting influences on free trade, through utilizing legal scopes of the underlying framework. Study 2 revealed that there is a trade-off between network flexibility and necessary investments into capacities and therefore flexibility. As long as duty drawback claims outweigh additional investments, the flexible production network is maintained. Further, the parameter variation revealed that duty drawback possibilities offer

an opportunity to bypass high import tariffs. Through a suitable production network configuration the set-up is robust against high import tariff rates.
It could be shown that an accurate implementation of legal frameworks is essential when designing production networks. The two different legal approaches for intra-Mercosul duty drawbacks result in different production network configurations and highlight therefore that an exact implementation of global aspects is important.
Study 3 deals with the Brazilian development loan Finame. It concludes that for a manufacturer acting on the Brazilian market, it is favorable to incorporate this specific non-tariff trade barrier into his production network design. Major adjustments for the production network are recommended, to comply with this specific non-tariff trade barrier, opposite the case of non-considering. Hence, the manufacturer's importance with regard to the Brazilian market has to be considered very carefully.

6.2 Outlook

Future research should focus on the improvement of the developed mathematical model. The quantity of possible network supply variations defines the dimension of the optimization problem. However, out of the available set only a small fraction is applied at the end. Since, the amount of network supply variations restricts the size of the solvable problem, it should be focused on developing methods to limit their amount up-front optimizing.
Another direction of future research is to extend the territorial focus. Due to the increasing number of PTAs and their cross-linked cooperation, opportunities arise with regard to production network design. Incorporating further legal frameworks into the optimization process are in the future important topics for multinational corporations. It enables them to cope with the increasing complexity of their surrounding and adjust associated production networks efficiently.

References

ALADI (2010). *ACE 14, PA 39: Acordo sobre a Politica Automotiva comum entra a Republica Argentina e a Republica Federativa do Brasil.* Asociación Lationamericana de Integración.

Arntzen, B. C., G. G. Brown, T. P. Harrison and L. L. Trafton (1995). Global Supply Chain Management at Digital Equipment Corporation. *Interfaces 25*(1), S. 69 – 93.

Basedof, J. and S. Jürgen (2000). *Rechtsquellen des Mercosur, Spanischer Text und deutsche Übersetzung der wichtigsten Verträge und Rechtsakte Teilband I.* Nomos Verlagsgesellschaft, Baden Baden.

Bernstorff, C. (2010). *Incoterms 2010 der Internationalen Handelskammer (ICC).* Bundesanzeiger Verlag, Köln.

Bhagwati, J. (1993). Regionalism and multilateralism: an overview. In: J. de Melo and A. Panagariya (Hrsg.), *New Dimensions in Regional Integration*, S. 23 – 51. Press Syndicate of the University of Cambridge, Cambridge.

Bhutta, K. S., F. Huq, G. Frazier and Z. Mohamed (2003). An integrated location, production, distribution and investment model for a multinational corporation. *International Journal of Production Economics 86*(3), S. 201 – 216.

Bihlmaier, R., A. Koberstein and R. Obst (2009). Modeling and optimizing of strategic and tactical production planning in the automotive industry under uncertainty. *OR Spectrum 31*, S. 311–336.

BNDES (03.01.2010). *Instrucoes para Credenciamento de Fabricantes.* Banco nacional do desenvolvimento.

BNDES (28.07.2006). *Circular No. 195.* Banco nacional do desenvolvimento.

Bouzas, R. (2007). The "New Regionalism" and the Negotiation of a Free Trade Area of the Americas. *International Negotiation 12*(3), S. 333 – 345.

Cadot, O., J. de Melo and M. Olarreaga (2003). The protectionist bias of duty drawbacks: evidence from Mercosur. *Journal of International Economics 59*(1), S. 161 – 182.

Chakravarty, A. K. (2005). Global plant capacity and product allocation with pricing decisions. *European Journal of Operational Research 165*(1), S. 157 – 181.

Chao, C.-C., E. S. YU and W. YU (2006). China's import duty drawback and VAT rebate policies: A general equilibrium analysis. *China Economic Review 17*(4), S. 432 – 448.

Coyle, J., C. Langley, E. Bardi, B. Gibson and R. Novack (2008). *Supply chain management: a logistics perspective*. South-Western College publishing, Boston.

Dyckhoff, H. (2006). *Produktionstheorie*. Spinger Verlag, Heidelberg.

Funders, F. (2007). *Die Wirtschaftsverfassung des Mercosur*. Duncker und Humblot, Berlin.

GATT (1947). General Agreement on Tariffs and Trade (GATT 1947).

Global-insight (2011). South American Automotive Industry Forecast Report. *IHS global insight January 2011.*

Grainger, A. (2000). Customs and International Supply-Chains Issues. *Logistics and Transport Focus 2*(9), S. 40 – 43.

Guerrieri, P. and D. Dimon (2006). The Trade Regionalism of the United States and the European Union: Cooperative or Competitive Strategies?. *International Trade Journal 20*(2), S. 85 – 93.

Guo, Y., Y. Li, A. Lim and B. Rodrigues (2008). A Multi-Exchange Heuristic to Production Line Design under Free Trade Agreement. *http://www.cs.cornell.edu/~guoys/publications/auai.pdf(18.01.2011)*.

Hübner, R. (2007). *Strategic Supply Chain Management in Process Industries*. Springer Verlag, Heidelberg.

IDB-INTAL (1996). *Mercosur Report No. 1.* Institute for the Integration of Latin America and the Caribbean.

IDB-INTAL (1997). *Mercosur Report No. 3.* Institute for the Integration of Latin America and the Caribbean.

IDB-INTAL (2006). *Mercosur Report No. 10.* Institute for the Integration of Latin America and the Caribbean.

IDB-INTAL (2009). *Mercosur Report No. 13.* Institute for the Integration of Latin America and the Caribbean.

Jacob, F. and G. Strube (2008). Why go global? The Multinational Imperative. In: E. Abele, T. Meyer, U. Näher, G. Strube, and R. Sykes (Hrsg.), *Global Production - a Handbook for Strategy and Implementation*, S. 2 – 31. Springer Verlag, Heidelberg.

Kaufmann, L., D. Panhans, B. Poovan and B. Sobotka (2005). *China Champions. Wie deutsche Unternehmen den Standort China für ihre globale Strategie nutzen.* Gabler Verlag, Wiesbaden.

Kohler (2008). *Global Supply Chain Design - Konzeption und Implementierung eines mulitkulturelllen Optimierungsmodells für die Gestaltung globaler Wertschöpfungsaktivitäten.* CfSM.

Krueger, A. O. (1997). Free trade agreements versus customs unions. *Journal of Development Economics 54*(1), S. 169.

Li, Y., A. Lim and B. Rodrigues (2007). Global sourcing using local content tariff rules. *IIE Transactions 39*(5), S. 425 – 437.

Mah, J. S. (2007). The effect of duty drawback on export promotion: The case of Korea. *Journal of Asian Economics 18*(6), S. 967 – 973.

Malcher, I. (2004). *Der Mercosur in der Weltökonomie.* Nomos Verlagsgesellschaft, Baden-Baden.

Meixell, M. J. and V. B. Gargeya (2005). Global supply chain design: A literature review and critique. *Transportation Research: Part E 41*(6), S. 531 – 550.

Melo, M., S. Nickel and F. S. da Gama (2009). Facility location and supply chain management - A review. *European Journal of Operational Research 196*(2), S. 401 – 412.

Mercosul (1991). *Tratado de Asuncion.*

Mercosul (2010). *Codigo aduaneiro do Mercosul.*

Mercosul/CMC (1994a). *DCE 22/94: Tarifa externa comum.*

Mercosul/CMC (1994b). *DEC 05/94: Regime de Adequacao.*

Mercosul/CMC (1994c). *DEC 10/94: Harmonizacao para a aplicacao e utilizacao de incentivos as exportacoes pelos paises integrantes do Mercosul.*

Mercosul/CMC (1994d). *DEC 24/94: Regime de Adequacao.*

Mercosul/CMC (1994e). *DEC 29/94: Adequacaou ao regime automoriz co-*

mum.

Mercosul/CMC (2000a). *DEC 31/00: Relancamento do Mercosul incentivos aos investimentos a producao e a exportacao, incluindo zonas francas, admissao temporaria e outros regimes especiais.*

Mercosul/CMC (2000b). *DEC 69/00: Revisao da tarifa externa comum.*

Mercosul/CMC (2000c). *DEC 70/00: Politica automotiva do Mercosul.*

Mercosul/CMC (2003). *DEC 32/03: Regimes especiais de importacao.*

Mercosul/CMC (2004). *DEC 54/04: Eliminacao da dupla cobranca da TEC e distribucao da renda aduaneira.*

Mercosul/CMC (2005). *DEC 33/05: Regimes especiais de importacao.*

Mercosul/CMC (2006). *DEC 02/06: Regimes especiais de importacao.*

Mercosul/CMC (2008). *DEC 57/08: Regimes especiais de importacao.*

Mercosul/CMC (2009a). *DEC 01/09: Regime de origem Mercosul.*

Mercosul/CMC (2009b). *DEC 20/09: Regimes especiais de importacao.*

Mercosul/CMC (2009c). *DEC 28/09: Tarifa externa comum.*

Mercosul/CMC (2010a). *DEC 10/10: Eliminacao da dupla Cobranca da TEC e distribucao da renda aduaneira.*

Mercosul/CMC (2010b). *DEC 27/10: Codigo aduaneiro do Mercosul.*

Mesa, V. A. (2009). *Der Zollkodex des Mercosur.* Rechtswissenschaftliche Fakultät der Westfälischen Wilhelms-Universität zu Münster.

Meyer, T. and F. Jacob (2008). Network Design: Optimizing the Global Production Footprint. In: E. Abele, T. Meyer, U. Näher, G. Strube, and R. Sykes (Hrsg.), *Global Production - a Handbook for Strategy and Implementation*, S. 140 – 190. Springer Verlag, Heidelberg.

Munson, C. L. and M. J. Rosenblatt (1997). The impcat of local content rules on global sourcing decisions. *Production and Operations Management 6*, S. 277–290.

Oh, H.-C. and I. A. Karimi (2006). Global multiproduct productionDistribution planning with duty drawbacks. *AIChE Journal 52*, S. 595–610.

Panagariya, A. (1992). Input tariffs, duty drawbacks, and tariff reforms. *Journal of International Economics 32*(1-2), S. 131 – 147.

Petersen, J. (2004). *Local Content Auflagen: Betriebswirtschaftliche Relevanz und Handhabung am Beispiel des internationalen Großanlagenbaus.* Deutscher Universitäts Verlag, Wiesbaden.

Richard, S. (2010). Regional trade Agreements in the World Trade Order. In: J. P. T. Christoph Herrmann (Hrsg.), *European Yearbook of International Economic Law 2010*, S. 227 –245. Springer Verlag, Heidelberg.

Rocha de Mello Martins, R. (2001). *Verfassungskonformität des Mercosur in Brasilien.* Nomos Verlagsgesellschaft, Baden-Baden.

Schirm, S. (1999). *Globale Märkte, nationale Politik und regionale Kooperation.* Nomos Verlagsgesellschaft, Baden Baden.

SECEX (24.05.2010). *SECEX Nº 10*. Secretaria de Comercio Exterior.

Stephan, H. A., S. Bossert and S. Minner (2008). Strategic network design under local content requirements. *working paper*.

Stolle, M., U. Näher, J. Frank, N. Reinecke, J. Hexter and M. Dervisopoulos (2008). Sourcing: Extending the Footprint Reconfiguration to Suppliers. In: E. Abele, T. Meyer, U. Näher, G. Strube, and R. Sykes (Hrsg.), *Global Production - a Handbook for Strategy and Implementation*, S. 324 –348. Springer Verlag, Heidelberg.

Vermulst, E. (1994). Rules of Origin as commercial Policy Instruments. In: J. Bourgeois and P. Waer (Hrsg.), *Rules of Origin in International Trade*, S. 433 – 485. The University of Michigan Press, Michigan.

Vidal, C. J. and M. Goetschalckx (1997). Strategic production-distribution models: A critical review with emphasis on global supply chain models. *European Journal of Operational Research 98*(1), S. 1 – 19.

Villegas, F. and J. Ouenniche (2008). A general unconstrained model for transfer pricing in multinational supply chains. *European Journal of Operational Research 187*(3), S. 829 – 856.

Wehner, U. (1999). *Der Mercosur.* Nomos Verlagsgesellschaft, Baden-Baden.

Wilhelm, W., D. Liang, B. Rao, D. Warrier, X. Zhu and S. Bulusu (2005). Design of international assembly systems and their supply chains under NAFTA. *Transportation Research Part E: Logistics and Transportation Review 41*(6), S. 467 – 493.

WTO (10.02.2011). Tariff analysis. *http://tariffanalysis.wto.org/welcome.aspx?ReturnUrl=%2fDefault.aspx%3fui%3d1&ui=1*.

WTO (12.12.2010a). List of all RTAs in force. *http://rtais.wto.org/UI/PublicAllRTAList.aspx*.

WTO (25.01.2010b). North-South agreements. *http://rtais.wto.org/*

UI/PublicSearchByMemberResult.aspx?enc=bUbyxPA3Wob5pG8+pdmN/y73hFinG4awT3OiAUf7WfZsosGwmiY3CNtGLuMNSfTDXEckP7+3wkjH5ekItviEN2iFvPAwSnOWtdpUlmlMWJ0=.

Abstract

International acting corporations have to meet various challenges in the globalized world. Besides the advantages, companies face increasing complexity with regard to their environment. Tariff and non-tariff trade barriers have considerable impact on their supply chains. Nevertheless, legal frameworks are sophisticated and differ often in addition for specific industries.
In this thesis the focus is set on the Mercosul automotive industry. Mercosul LC, duties, duty drawbacks and a specific Brazilian non-tariff trade barrier are considered on a product specific level when designing production networks. To analyze the impact of the global aspects a mathematical model is provided. Numerical studies reveal insight on interactions of global aspects on the production network of an international acting truck manufacturer.
It can be shown that the production network configuration differ significant dependent on the attended global aspects. A joint consideration of Mercosul LC, duties and duty drawbacks is therefore advisable when designing production networks. Production networks are equipped with flexibility to reduce the impact of distorting influences on free trade, through utilizing legal scopes of the underlying framework.

Keywords: production planning, Mercosul, local content, duties, duty drawbacks, mixed-integer programming

Zusammenfassung

International agierende Unternehmen sind mit einer Vielzahl an Herausforderungen im globalen Wettbewerb konfrontiert. Neben den sich ergebenden Vorteilen steigt jedoch auch die Komplexität ihres wirtschaftlichen Umfelds. Tarifäre und nicht-tarifäre Handelshemmnisse beeinflussen die Planung von Produktionsnetzwerken. Entsprechende rechtliche Rahmenbedingungen sind jedoch sehr zahlreich und unterscheiden sich oft zusätzlich im Bezug auf Industriezweige.
Diese Arbeit spezialisiert sich aus diesem Grund auf die Regelungen der Automobilindustrie im Wirtschaftsraum Mercosul. Es wird ein Modell zur Produktionsnetzwerkplanung entwickelt, dass neben produktspezifischen local content Entscheidungen, Zöllen und Zollrückzahlungen auch eine spezielle nicht-tarifäre Regelung für Brasilien berücksichtigt. Um die Wechselwirkungen dieser globalen Aspekte, auf das Netzwerk zu untersuchen werden in einem letzten Teil der Arbeit numerische Studien durchgeführt.
Es kann gezeigt werden, dass die Konfiguration der Produktionsnetzwerke sich in Abhängigkeit von den mitberücksichtigten globalen Faktoren erheblich unterscheidet. Aus diesem Grund ist es sinnvoll bei der Produktionsplanung Mercosul LC, Zölle und Zollrückzahlungen miteinzubeziehen. Aufgrund produktionsflexibler Netzwerke können so rechtliche Spielräume ausgenutzt werden um die Behinderungen des freien Warenverkehres zu minimieren.

Stichwörter: Produktionsplanung, Mercosul, local content, Zölle, Zollrückzahlungen, gemischt-ganzzahlige Programmierung

Curriculum Vitae

zur Person

Name:	Georg Maier
Geburtsdatum:	13.04.1984
Geburtsort:	Eggenfelden
Nationalität:	Deutsch

Ausbildung

Seit 10/08	Universität Wien
	Studium: Magisterstudium Betriebswirtschaft
	Schwerpunkt: Supply Chain Management und Controlling
10/04 - 05/08	Technische Universität München
	Studium: Bachelorstudium Betriebswirtschaft
	Schwerpunkt: Entrepreneurial Finance

Praxiserfahrung

10/10	Daimler AG
	Diplomand, Daimler Trucks Netzwerkplanung