



**Adriana Leiras**

**Optimization under Uncertainty for Integrated Tactical and  
Operational Planning of the Oil Supply Chain**

**TESE DE DOUTORADO**

Thesis presented to the Postgraduate Program in Production Engineering of the Departamento de Engenharia Industrial, PUC-Rio as partial fulfillment of the requirements for the degree of Doutor em Engenharia de Produção.

Advisor: Prof. Silvio Hamacher

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*To my family  
and all my past and present teachers*

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*"Que eu não esqueça que a subida mais escarpada  
e mais à mercê dos ventos é sorrir de alegria"*

*Clarice Lispector*

*"A utopia está lá no horizonte. Me aproximo dois passos,  
ela se afasta dois passos. Caminho dez passos e o horizonte  
corre dez passos. Por mais que eu caminhe, jamais alcançarei.  
Para que serve a utopia? Serve para isso: para que eu não deixe de  
caminhar".*

*Eduardo Galeano*

## Abstract

Leiras, Adriana; Hamacher, Silvio (Advisor). **Optimization under uncertainty for integrated tactical and operational planning of the oil supply chain**. Rio de Janeiro, 2011. 117p. Tese de doutorado. Departamento de Engenharia Industrial, Pontifícia Universidade Católica do Rio de Janeiro.

The uncertain nature and high economic incentives of the refining business are driving forces for improvements in the refinery planning process. Decisions made at the oil chain differ mainly in the range of activities (*spatial integration*) and planning horizon (*temporal integration*). This thesis purpose is to address the problem of the oil chain integration under uncertainty at different decision levels. Tactical and operational mathematical programming models are proposed. The tactical model maximizes the expected profit of the supply chain and allocates the production targets to refineries taking logistics constraints into account. The operational model maximizes the expected profit of each refinery determining the amount of material that is processed at each process unit in a given period. Both models are two-stage stochastic linear programs where uncertainty is incorporated in the dominant random parameters at each level (price and demand at the tactical level and oil supply and process capacity unit at the operational level). Spatial integration is discussed at the tactical level (considering supply chain), whereas the temporal integration is discussed in the interaction between the two levels. Two temporal integration approaches are considered: *hierarchical*, where the flow of information is only from the tactical to the operational model, and *iterative*, where there is feedback from the tactical to the operational model. An industrial scale study was conducted to discuss the benefits of integration in a stochastic environment. Results are offered in the context of a study using data from the Brazilian oil industry to demonstrate the effectiveness of the proposed approaches.

## Keywords

Integrated planning, two-stage stochastic optimization, oil supply chain

## Resumo

Leiras, Adriana; Hamacher, Silvio (Orientador). **Otimização sob incerteza para o planejamento operacional e tático integrado da cadeia do petróleo.** Rio de Janeiro, 2011. 117p. Tese de doutorado. Departamento de Engenharia Industrial, Pontifícia Universidade Católica do Rio de Janeiro.

A natureza incerta e os altos incentivos econômicos do negócio de refino são forças motrizes para melhorias nos processos de planejamento das refinarias. Decisões tomadas na cadeia do petróleo diferem principalmente na gama de atividades (*integração espacial*) e no horizonte de planejamento (*integração temporal*). O objetivo desta tese é abordar o problema da integração da cadeia do petróleo sob incerteza em diferentes níveis de decisão. Modelos de programação matemática tático e operacional são propostos. O modelo tático maximiza o lucro esperado da cadeia de suprimentos e aloca metas de produção para as refinarias considerando restrições logísticas. O modelo operacional maximiza o lucro esperado de cada refinaria determinando a quantidade de material processada por unidade de processo em um dado período. Ambos os modelos são lineares estocásticos de dois estágios, onde a incerteza é incorporada nos parâmetros dominantes de cada nível (preço e demanda no nível tático e suprimento de petróleo e capacidade das unidades no nível operacional). A integração espacial é discutida no nível tático (considerando a cadeia de suprimentos), enquanto a integração temporal é discutida na interação entre os dois níveis. Duas abordagens de integração temporal são consideradas: *hierárquica*, onde o fluxo de informações é somente do modelo tático para o operacional, e *iterativa*, onde há retorno do nível operacional para o tático. Um estudo de escala industrial foi conduzido para demonstrar os benefícios da integração em ambiente estocástico. Resultados são oferecidos no contexto de um estudo usando dados da indústria brasileira do petróleo para demonstrar a eficácia das abordagens propostas.

## Palavras-chave

Planejamento integrado, otimização estocástica, cadeia do petróleo



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