Chapter 5

Conclusions, limitations and further research opportunities

Our work aims to contribute to an emerging field of research which deals with the trade-off between economic and environmental performance of supply chains. Supply chains consist of all processes, such as sourcing, production, transport and warehousing, which are necessary to deliver products to the final customer. The main goal of traditional supply chain management is to design the supply chain processes so that the customer requests are fulfilled at low costs. In general, there is a trade-off between efficiency and responsiveness. For instance, it is not possible to minimize inventory costs while simultaneously maximizing product availability. Several drivers influence the efficiency and responsiveness of supply chains and these drivers have to be designed to align the supply chain strategy with the competitive strategy.

In recent years, in addition to traditional economic performance measures, such as cost or profit and customer service, other criteria have become important as well which leads to reconsidering existing supply chain strategies. Especially the impact of supply chains on sustainability is a highly discussed topic at the moment. Sustainability includes the three dimensions, economic, environmental and social sustainability. In particular, the environment has received increasing attention from society, customers and authorities due to global problems, such as the depletion of natural resources, acidification or climate change. Carbon emissions which are produced through the burning of fossil fuels are assumed to be one of the main contributors to climate change. Therefore, international agreements, such as the Kyoto protocol, aim at the reduction of carbon emissions and other greenhouse gases in order to stop global warming. Based on that, environmental regulations have already been and will be implemented which limit the output of carbon emissions. These regulations also have an impact on supply chains and, in particular, their production, sourcing and transportation decisions. In Europe, for heavy, energy-intensive industries the EU emission trading scheme was introduced in 2005 with the aim of limiting and reducing the carbon emissions of certain sectors. Behind energy-intensive industries, transport is the second largest “polluter” in the EU. It is likely that also the transport sector might be confronted with new regulations, such as carbon emission limits, carbon emission taxes or emission trading for transport, on a European or even global scale.
Due to that, in the future, companies have to consider the environment and related regulations in decision-making. Research is needed in order to evaluate the impact of supply chains on the environment and to investigate the impact of regulations on the performance of supply chains. To contribute to this field of research, Chapter 2 deals with the basics of supply chain management and the relations between supply chains and the environment. Then an overview of models which integrate the environmental dimension in decision-making is provided in Chapter 3. It turns out that the environmental dimension can be integrated into decision-making by including environmental costs in the objective function, by (a) adding constraint(s) which reflect the environmental concerns or by relying on multi-objective programming approaches to balance economic and environmental goals.

We want to contribute to this field of research by analysing the economic and environmental sustainability of dual sourcing in contrast to single (offshore) sourcing. We build on the single-period dual sourcing model with an offshore and an onshore source based on the newsvendor framework. With single offshore sourcing the company can order only once before the selling season. In contrast to this, dual sourcing allows the company to order from a cheap, offshore supplier before the selling season and in addition to that from an expensive, onshore supplier which serves as a backup during the season. The economic performance is evaluated with the expected profit and the customer service whereby it is shown that dual sourcing with an offshore and an onshore supplier helps to increase both performance measures. In addition to that, we consider the transport carbon emissions which are produced when ordering from the offshore supplier as environmental criterion. The transport carbon emissions are directly related to the offshore order quantity which means that a lower offshore order quantity automatically leads to lower transport carbon emissions and improved environmental performance. It turns out that simply by switching from a single offshore sourcing strategy to dual sourcing the economic and the environmental performance can be simultaneously improved.

In addition to that we model different environmental regulations which could be valid for the transport sector in the future and analyse their impact on the company’s decision and its economic and environmental performance. In order to be able to model the different regulations, of course, we have to abstract from reality and we relate the environmental regulations to one product unit. So, the reader has to be aware that our results only give indications about how companies might react to the introduction of different regulations concerning transport carbon emissions and are not directly transferable to a real-world setting.

Firstly, we assume that a strict emission limit in the form of emission allowances per product unit is imposed. This restricts the offshore order quan-
tity and the related transport carbon emissions. Of course, a strict emission limit has a negative impact on the company’s economic performance when it restrains the company from ordering the profit-maximizing offshore order quantity. But at the same time the transport carbon emissions can be reduced. Depending on the value of the limit, the cost and price parameters and the demand distribution, the relative improvement on the environmental dimension can outweigh the relative degradation of the economic performance.

Secondly, we assume that a linear emission tax is imposed on transport from the offshore source. The transport emission tax reduces the cost advantage of the offshore supplier and therefore induces the company to order less from the offshore supplier. So, an emission tax also helps to reduce the transport carbon emissions but at the same time severely harms the economic performance of the company; the negative impact is particularly large for companies ordering products with low demand variability.

Thirdly, we assume that an emission trading scheme for transport is implemented. This means that the company receives a certain amount of emission allowances, i.e. emission limit, free of charge which are then used to cover the carbon emissions related to the transport activity from the offshore supplier. Additional emission allowances have to be bought if the transport activity is too high or can be sold if not all emission allowances have been used. We show that with emission trading the offshore order quantity and the related transport emissions can be reduced and at the same time the economic performance measures are nearly not harmed. So, emission trading seems to be compatible from policy and company perspective as it helps to reduce the negative environmental impact of company’s decision while not significantly harming the company’s economic performance.

Our work helps to gain insights into new trade-offs which arise if in addition to economic criteria also environmental ones are considered. It can provide decision support for individual companies on how much to order from a certain supply source. Furthermore, we model different regulation schemes and therefore, our model can also be used to derive implications for policy-making with respect of the design of environmental regulations. But, it has to be noted that our work is only one of the first steps in a new and emerging field of research. Our work also provides a starting point for further research opportunities. It has been shown that the parameters of the regulations, i.e. the emission tax, the emission limit and the prices of the emission allowances, are critical values. So further research is needed into how these parameters can be reasonably set and how they influence each other. For instance, the prices for emission allowances are not set by policy but determined by the market as a function of the emission limit. So the emission prices could be modelled as a decreasing function of the emission limit or with the help of a probability
distribution reflecting the stochasticity of these prices. Furthermore, new developments of emission trading, such as the auctioning of emission allowances, could be considered in further research.