LUND UNIVERSITY
School of Economics and Management

Master programme in Economic Growth, Innovation and Spatial Dynamics

THE NETHERLANDS AND FOREIGN TRADE EMBODIED ENERGY: A DECOMPOSITION ANALYSIS OF STRUCTURAL AND TECHNOLOGICAL EFFECTS

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ABSTRACT:

This thesis examines whether there exists any causal relationship between foreign trade and declining energy intensity in the Netherlands. In other words, does the Netherlands outsource its energy intense industries to less developed countries rather than solve them internally? No significant causal relationships is found between international trade and declining energy intensity, since the Netherlands has long been a net exporter of embodied energy and continues to be so until 2005. In addition, the ratios of net exported energy to total consumption are increasing, which means that international trade counteracted with the decline of energy intensity. These results suggest that internal forces, like efficiency and technological improvements, changed consumption patterns and transformation of the energy system, have been crucial for the decline in energy intensity in the Netherland, while foreign trade has played a negative role.

Keywords: Energy, Foreign trade, Environmental kuznets curve, Dematerialization, Energy intensity

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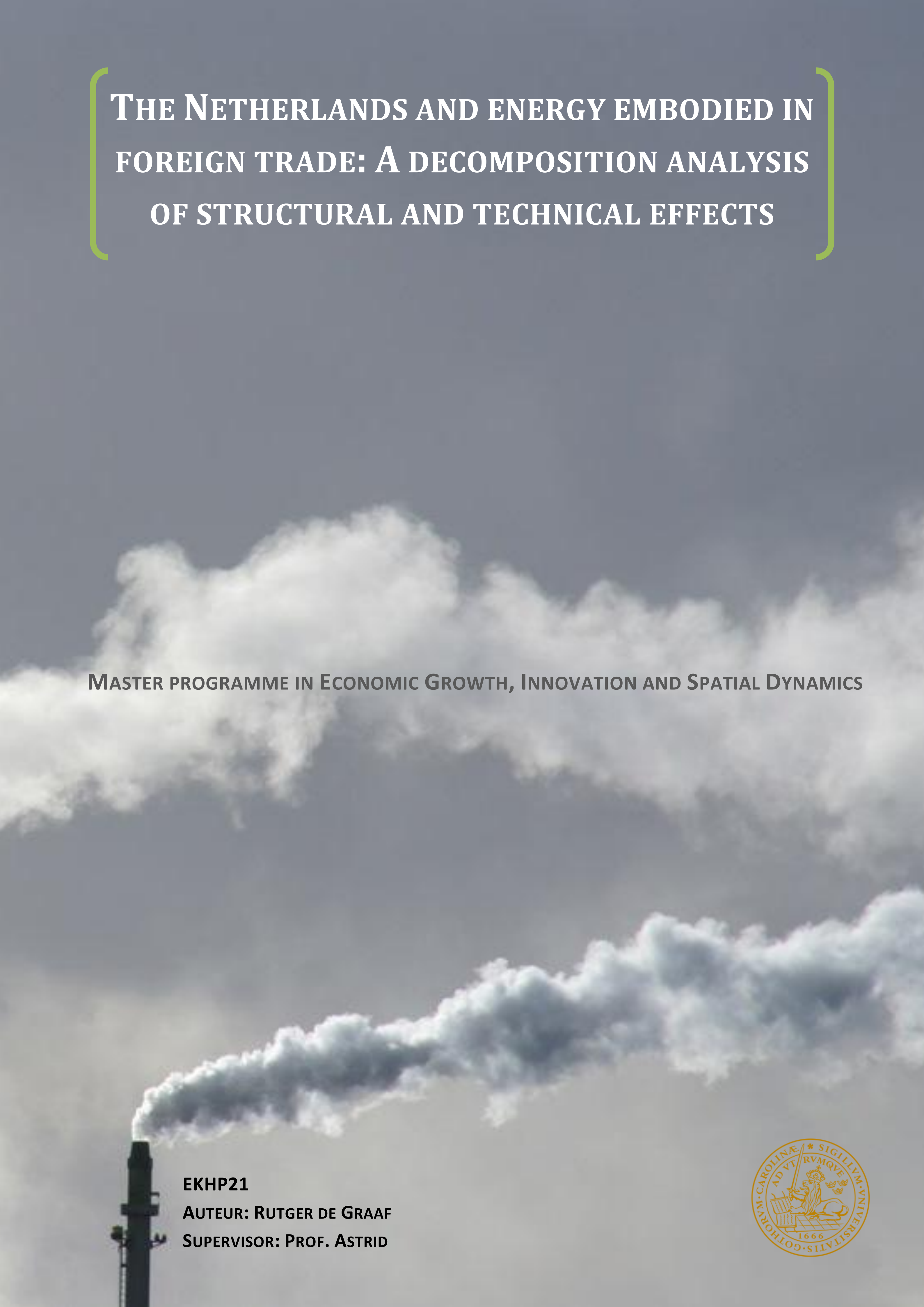
The Netherlands and energy embodied in foreign trade: A decomposition analysis of structural and technical effects



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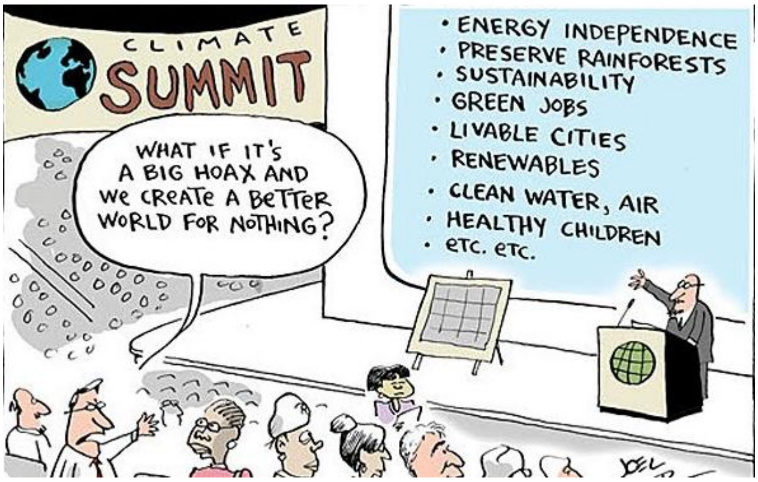
PREFACE:

The thesis is the final work of my first year as Master student at the Department of Lund University School of Economics and Management at the faculty of Economic History. It serves as documentation of my skills and knowledge gained during the program.

The interest for this subject came from following a master course on Innovation, Energy and Sustainability. After reading a particular article, 'Baumol's disease and dematerialization of the economy' by Professor Astrid Kander, associated with the Department of Lund University School of Economics and Management, Faculty of Economic History, I decided to look for a subject related to this article.

I would like to express my sincere appreciation and gratitude to my supervisor Professor Astrid Kander. Without her advice, ideas and support this thesis would by no means have become a reality.

Finally, I wish to express my greatest thanks to the members of my project group that gave me insight and knowledge and who were of continuous support during the process.



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1. INTRODUCTION:

Economic growth since the mid-1970s represents a new degree of global trade integration (Krugman, 1995). Opposed to this globalization process stands the fear for adverse trade effects on environmental quality. International trade has been a prominent characteristic of the world economy over current decades, with today's global trade volumes being over fifteen times greater than those of 1950 and its contribution towards the gross domestic product (GDP) on a global scale having tripled (Havik & Kieran, 2006). While some scholars argue that the contribution of world trade as a share of world output is not that significant since it did not recover to its 1913 level until the mid-1970s (Krugman, 1995), this analogy does not account for the fact that world trade in goods as a share of world industrial production is currently at unmatched levels. In addition, while trends at the aggregated level have been relatively stable, world trade has witnessed a considerable compositional shift. Consequential specific categories of commodities diverged sharply. On the commodities side, manufacturing products have significantly increased their share to at present account over sixty percent of the total world export (compared to fifty percent in 1985) (Havik & Kieran, 2006). This raises the concern that the Dutch decline in energy intensity could be driven by their position in international trade - outsourcing their high energy consuming and polluting industries to the developing world - rather than driven by internal factors.

Is this environmental fear grounded? Eiras and Schaeffer (2001), for example, argued that countries with an open economy - on average - score thirty percent higher on environmental sustainability than countries that are moderately open economies, and almost double as high as countries with closed economies. Does this then indicate that increasing international trade is good for the global environment? Not directly: causality could still run in the other direction (Frankel & Rose, 2005). The observed correlation by Eiras and Schaeffer (2001) could be resulting from strengthened environmental regulation - see here Dasgupta et al. (1995), who showed that the per capita income of a country and its level of environmental regulations are strongly correlated - or due to the composition effect (structural changes in the shares of agriculture, manufacturing and services industries in GDP) in combination with the technical effect - given the fact that any sector can produce using cleaner or dirtier techniques – will result in different environmental consequences (Frankel & Rose, 2005). Nevertheless, Kander (2005) indicated that there is reason to be cautiously optimistic concerning the greening of growth based on structural change within the economy. She indicated first of all that the changing impact on material demands of the economy over time, measured by the indicator energy/GDP, based on the composition shift from an industrial economy towards a service economy could merely be an illusion concerning the real production structure. Secondly, there is another long run structural reason, namely the large technical shift, described as the third industrial revolution (microelectronic revolution). The third industrial revolution would indicate a composition effect *within* the manufacturing industry, from heavy towards light manufacturing industry. Kander's (2005) study found that the real share of the Swedish service sector in terms of production did not grow in the long run when sectors were measured in constant prices. This implies that in the period after 1970 structural change within specific (manufacturing) sectors outweighs structural change between sectors.

This thesis will contribute to the discussion about the environmental consequences of trade by focusing on one country, the Netherlands, in a historical perspective. The Dutch energy consumption witnessed a vast increase from 1800 until the mid 1970s. Even though the Netherlands does not show any long term time trend for energy intensity according to Gales et al. (2007) due to their early transition to modern energy systems and carriers, there is evidence of a weak linear decline since the 1980 onwards that contributes in neutralizing the upward trend in energy consumption (see appendix figure A). The methods of this thesis will be based on previous research done by Kander and Lindmark (2006). The main aim is to address the trade direction of the Netherlands concerning energy. The central question is formulated as followes: "*Would the Dutch energy intensity have gone down without the possibility of international trade?"* This is an interesting question for three reasons. First of all, the data is quite unique compared to that of previous research. As argued by Kander and Lindmark (2006), most studies addressing the causal relation between trade and energy consumption are based on econometric techniques. These techniques enable scholars to cover several countries and allow them to present broad conclusions. However, this does not allow them to directly address the adverse environmental effects of trade. Instead they use related indicators such as import/production and export/production for manufacturing industries or trade openness as a ratio of the summation of imports and exports toward GNP (Kander and Lindmark, 2006). The methods used for this thesis are suitable to directly address the adverse environmental effect of trade. The second reason for why this question is interesting is that although the theme is the subject of a fast growing study area, the results are not settled. Without any doubt, the effect of international trade on the environment is theoretically ambiguous (Frankel and Rose, 2005). The third reason lies in the fact that a similar research has been done for Sweden, which makes it possible to compare two developed (West-European) countries concerning their embodied energy import/export due to foreign trade.

In this thesis, section one introduces the problem. Section two outlines previous research and provides a theoretical discussion, which connects the service transition with the decoupling discussion and international trade with energy intensity and environmental degradation. This part finishes with the thesis hypotheses. Section three presents and discusses the data and the choice for the ISIC classification. Section four describes the analytical methods used for our research. The Logarithmic Mean Divisia Index (LMDI) is used to analyze to what extent within or between sectoral changes in the manufacturing industry influence the production structure of the aggregated Dutch economy. For analyzing the trade direction of the Netherlands concerning energy detailed trade and production statistics are used to subtract sectoral: sale (€), energy (PJ), energy/sales ratio (MJ/€), net export (€) and net export (PJ) values. In calculating these ratios only direct energy consumption of the final production is taken into account, and, as stated by Kander and Lindmark (2006), not the energy demand of the entire production chain. In analogy with Kander and Lindmark (2006), the analytical methods will only be applied to analyze the trade of manufacturing products between the Netherlands and the rest of the world (divided into OECS countries and non-OECD countries). Section five accounts for the research outcomes, and is divided into two parts: one for the results on the decomposition analysis and one on the relation between international trade and energy. Section six will summarize and reflect on the main findings and place them in the ongoing scientific discussion.

2. PREVIOUS RESEARCH AND THEORETICAL FOUNDATIONS

The shift in trade patterns and the ongoing assimilation of national economies into a global trading system is being driven by a wide range of factors. This includes declining transport and communication cost, increasing productivity growth, liberalization of markets, increasing income levels and an increasing international division of labor combined with the establishment of more global production systems. All of these are considered driving forces behind prosperous international trade and the increase in total world production (Markussen, 1995). A traditional recognizable trade pattern is that between the developed and developing world. Due to the hypothetical comparative advantages on production cost by means of laxer environmental, energy and safety regulation and cheap excess to raw materials, developing countries would be tempted to create an economic system based on export led growth of early stage industrial manufacturing goods (Cole, 2003). This yet does not necessarily lead to a trade surplus in term of energy consumption for developing countries. The traded volume may be significant larger, but the energy input of imports minus the exports can still compensate for the deficit in volume. Nonetheless, the nature of the comparative advantages observed by developing countries warranted scholars, they expressed their concern about the possible detrimental effects of the North-South trade relation on the environment, energy consumption and on working conditions in developing countries (Kander and Lindmark, 2006).

In short, there is yet no clear indication to what extent international trade is responsible for the decrease of energy intensity in developed countries. What is known is that a combination of composition and technical effect needs to out weight the scale effect if internal forces are debit to the downward slope of domestic energy consumption. Copeland and Taylor (2003) and Grossman and Krueger (1993) decompose the internal impact into technique, scale and composition effects (Frankel and Rose, 2005). The scale effect may trigger the energy consumption and environmental degradation as increasing trade volumes (in particular exports) raise the size of the economy. More output requires more input, which can result in a higher pressure on natural resources and energy use. In short growing trade reveals a scale effect that could stimulate increasing energy consumption and environmental degradation. Technical effects refer to changes in the production method that can go along with further trade liberalization. Technical spillovers from the North to the South could be beneficial for energy consumption, the environment as for labor conditions (Dosi et al, 1990; Fagerberg, 1994). The composition effect indicates that the industrial structure of a country will change depending on their increasingly specialization in those activities in which they possess a comparative advantage (Cole and Elliott, 2003). The energy consumption consequence of the composition effect depends as a result upon the causes of a country's comparative advantage. When this is related to relatively cheap access to raw energy input, energy-intensive production could increase in one country while it decreases in another country due to international trade. However, Cole and Elliott (2003) indicate that energy-intensive production may not follow the North South trajectory concerning environmental degradation. They argue that the comparative advantage based on the country's endowment of labor, pollution/energy and capital, could activate opposing comparative forces. For one thing the effects of environmental regulation imply that a country with weaker regulations will have a comparative advantage in producing pollution intensive products. Combining this with the strong correlation between per capita income of a country and its level of environmental regulations (Dasgupta et al. 1995), this would lead to a situation in which developing countries would take on pollution industries – described as the pollution haven hypothesis - while the developed world would witness a transition towards less energy intensive and polluting economic activities such as the service sector (Dinda, 2004). In theory this transition towards a service economy would indicate a decline in energy intensity, based on the fact that the service sector creates more economic value per used energy unit than the manufacturing industry.

Academic results for this pollution haven effect are twofold. For instance, Jaffe et al. (1995) and Janicke et al. (1997) do not verify the assumption that strict environmental regulations influence international trade in environmentally harmful products. The opposite, however, is argued by Mani and Wheeler (1998) who showed results for the existence of temporary pollution havens. Also Birdsall and Wheeler (1993) indicated that the increase in pollution intensity for developing countries was significantly higher in times when developed countries strengthened their environmental regulations. Cole and Elliott (2005) reversed the causality of the pollution haven hypothesis by introducing the capital versus labor effect. Consequently in the occurrence of international trade, developed countries would specialize in capital intensive production – that scores higher on energy intensity – while the developing world would specialize in labor intensive production; showing an opposing effect than that of environmental regulation. This is based on the high correlation between capital intensity and energy intensity (Kander, 2002; Cole & Elliott, 2005). The argumentation of Cole and Elliott (2005) is supported by Dean (1991), who concluded that although environmental costs in absolute terms are huge, the proportion of the total firm costs is around two percent. In addition, Xepadeas and De Zeeuw (1999) argue that the environmental costs of production are not even significantly related to environmental regulation, due to the fact that they barely ever surpass four percent of the total production cost. Nevertheless, according to Copeland and Taylor (2003) and Jaffe et al. (1995) support for the pollution haven effects is found, although such effects do not appear to be extensive, indicating that it only plays a marginal role compared to other variables, of which the labor-capital effect is one for explaining North South trade flows.

Despite the indicated marginal role of environmental regulation for the production location, suspicion needs to be raised concerning the relation between international trade and the downward slope of the EKC (Environmental Kuznets Curve) (Kander & Lindmark, 2006). Instead of the elimination of environmental problems internally, a geographical shift - in the form of a rat-race to the bottom - will lead to undesirable consequences both for developing countries as for the global environment. Environmental problems such as the greenhouse effect truly represent global environmental consequences (Kander & Lindmark, 2006). As Stern (1998) indicated, if structural change is debit to a general shift of manufacturing activities from developed towards developing countries, this may at least partly contribute in the EKC inverted U shaped relation. This undermines the explanatory power of the EKC as 'cure' for environmental problems (Cole, 2003).

The difficulty that remains is to what extend the turning point towards environmental improvement is influenced by international trade – outsourcing of pollution industries – and/or to what extend it is based on internal courses (Stern et al., 1996). The inclusion of international trade in the above equation created a need to control for the possible causal relation between international trade and pollution (Kander & Lindmark, 2006). It is of importance to indentify to what extend these (environmental regulation) effects are debit to the trajectory followed by developed countries compared to internal forces. Previous research, which associated international trade to the EKC, did this under the assumption that international trade is indissoluble related to economic growth and would ultimately lead to lower environmental stress. (Kander & Lindmark, 2006). By doing so, the causal relation between trade and the EKC is not examined at all. However, those who did address the causal relation between trade and the EKC stumbled on contradicting results. For instance, Lucas et al (1992) who analyzed the toxic intensity due to manufacturing output over 80 counties showed that a high degree of trade disturbing policies (environmental regulation) swells pollution in rapidly developing countries. Antweiler (1996) showed that highly developed countries export more embodied pollution products than they import. Suri and Chapman (1998), in their turn, try to capture structural changes (form heavy industry towards light industries in developed countries) by introducing a ratio for manufactured exports compared to domestic manufacturing production; a similar method is applied for imports. In both cases they represent independent variables for energy use (Cole, 2003). This provided evidence for the fact that the export ratio tended to show a positive relationship with energy use while the import ratio showed a negative relationship (Cole, 2003). The overall results however provided little evidence that trade had a damaging effect on the environment. This would not confirm the existence of an international (environmental) race to the bottom driven by international trade or the pollution haven hypothesis

Structural environmental degradation based on economic growth shows clear contradiction with the EKC. The EKC suggests that there exists an inverted U-shape relation between income per capita and environmental degradation, to that extend that after a peak economic growth reduces the environmental impact of economic activity (Dinda, 2004). Panayotou (1993) explained this through the following reasoning; when economic development accelerates – due to intensification of agriculture and the take-off of industrialization – resource depletion will overtake resource generation until a tipping point, were economic development reaches such a level that structural change – move towards information intensive industries and services in combination with environmental awareness, strengthened environmental regulations and technical improvement – will result in a gradual decline of environmental degradation. In short, over time demand side effect will be debit for the inverted U-shape patron (Kriström, 2000). The composition effect – transition from manufacturing towards a service economy - described by Panayotou (1993) explicitly indicates this as one of the main forces for the declining environmental impact of economic growth. Although that this idea is quite intuitive - industrialized countries use more energy than de-industrialized countries - under constant demand it would irrevocably lead to a situation in which developing countries are producing energy intensive exports for the developed world (Henriques & Kander, 2010). Nonetheless, Kander (2002, 2005) argues that the greening of the internal industry could be based on false beliefs regarding the possible transition towards a service economy. Without dispute employment and the overall share of GDP – for developed countries - in the service sector increased dramatically during the last decades. However, as indicated by Kander (2005) this does not relate to what matters for energy consumption - the real production structure measured as the sector shares in constant prices - in the case of Sweden[1]. In short, we need to be cautious in expecting too impressive results of a service transition in actual production terms. It is not grounded to assume that with a transition towards a service industry the manufacturing industry got relocated. As indicated by the Baumol cost disease, higher productivity growth in the manufacturing industry compared to the service industry could compensate for the expected decline in energy consumption and pollution (Kander, 2005). Instead of outsourcing energy intensive production, technical and organizational development within energy intense industries in developed countries could be debit of the inverted U-shape patron. Declining energy intensity is then not offset by structural change between sectors but by structural change within sectors. See here Henriques and Kander (2010), who conclude that the service transition was less impressive in real terms than is normally assumed. The service sectors' share in terms of real production is significantly smaller than the increase of share in GDP in current prices and employment compared to the manufacturing industry. The decomposition analysis based on a five sector economy (Service, industry, agriculture, transport, personal consumption) indicated that structural shifts did not at all - in the case of Italy, Spain and Sweden – or only modestly contribute to the decline in energy intensity for developed countries, including the Netherlands. The technical effects outweighed the between sectoral structural shifts significantly, and especially in the manufacturing and personal consumption sectors. This points out that even when we keep in mind that Panayotou's (1993) reasoning - based on an economic model that assumes a neutral effect for trade on environmental degradation (Stern et al., 1996) - the composition effect indicating a transition between sectors – representing growing import of energy intensive manufacturing products - could only have a marginal role in the absolute decline of energy use and the decrease of pollution output, while the technical changes and within manufacturing structural change could have

[1] See here the previous mentioned reasoning of Cole and Elliott (2005) concerning the reversed causality based on the capital versus labor difference.

a strong effect on the decline of energy intensity. However, as the results presented by Henriques and Kander (2010) indicate a unified industrial manufacturing sector, in where both low- and high-energy intensity sub-sectors are present, it is not possible to distinguish structural within sectoral- from technical change. The high aggregated level could mask structural changes within the industry, which could cover the possible increasing share of light sub-sectors based on the transition towards the microelectronics industry. Technical changes within the different sub-sectors - due to the microelectronic revolution - could result in increasing efficiency control that reduces the energy flow and waste by use of computerized production processes (Kander, 2005). Nonetheless sub-sectoral changes in the manufacturing industry could also result from the between sub-sectoral structural change towards lighter industries.

The above mentioned theoretical discussions give reason to be cautious with designating trade as key factor for the decline in energy use and the output of pollution in developed countries. As a result, the following hypothesis is proposed:

1) *The Dutch decline in energy intensity is driven by internal factors instead of their position in international trade*

This hypothesis is based on theoretical arguments mentioned above in combination with previous research results for Sweden, which confirmed the hypothesis in an empirical test (Kander & Lindmark, 2006). However, Sweden may be unique due to its natural resources endowment and nuclear energy policy. Therefore, there is reason to control whether a relatively comparable country according to their position in the western world shows similar results.

3. DATA

When studying economic phenomena it is not always possible to take all elements into account simultaneously. This creates the need to group certain elements based on matching characteristics. Thus, economic processes that need to be described with use of statistics need to be organized by a certain systematic classification (United Nations Statistical Commission, 2002).

3.1 Classification

The classification is the system used for communication, describing statistical processes used to analyze the economic phenomena. The classification needs to create as homogeneous groups as possible in order to stay as close as possible to reality. The ISIC classification used for this research groups productive economic activities as homogeneous as possible. It provides groups of activity categories that are utilized from the collection of statistics according to their activity. It presents the set of activity categories in such a manner that entities are classified according to the economic activity they fulfill. However, the overall homogeneity and available data are in constant conflict, due to the fact that the more homogeneous the economic activity the less data will be available. In order to overcome this problem broad category need to be used, making it possible to compare groups on a more aggregated sub-sectoral level.

The international ISIC database is in general less detailed than the Dutch national accounts. Due to differences in historical circumstances, the level of industrial development and organization of economic activities the Netherlands classify their data different according to their prominent economic activities. However, in order to compare the results in a later stage on an international level, it is of importance to use a classification that is easily transformable from the general national account. The ISIC classification is being employed by the United Nations, OECD, IAE and other international organizations in order to compare data from a wide range of national statistical information under a unified classification according to economic activity. By using the ISIC classification for this research the national classification is not surpassed, but integrated into a framework that enables us to do international comparison of national statistics. If the Dutch national classification would have differed to a large extent from the international classification it should have been necessary to regroup certain figures obtained by the National statistical agency in order to still compare the specific economic activities.

The main challenge that arises when using set classification in economic historical research is that the classifications are subject to periodic reviews concerning their structure, definitions of the categories and original principles (United Nations Statistical Commission, 2002). These classifications are constrained to changes in the organization of economic activities, by means of economic transitions new economic activities emergence based on new technologies and new divisions of labor. Still, the general structure of the classification did not change dramatically, but a greater level of detail is introduced during the period 1980-2005, especially related to the fields of service activities and information production.

3.2 Datasets

For calculation both the decomposition as the trade direction several primary quantitative datasets on energy quantities and economic values will be used. Because the required data for both analyses differ to a large extend they will be discussed separately. The data used for the decomposition analysis could be divided into two main segments: Economic structure (measured in value added in constant prices) and final users of energy (measured by energy consumption per economic sector). For calculating the economic structure the EU KLEMS[2] database will be used, this database subtracted most of its data for the Netherlands from the Dutch Central Bureau for Statistics database STATLINE. Both databases record data by individual sectors. In order to focus on a possible transition within the manufacturing industry, it is required to align the individual sectors between the different databases. When using the STATLINE database a SBI classification (based on the ISIC classifications) is used as hieratical categorization for economic activities. This one needs to be aligned with the EU KLEMS database which uses an ISIC rev 3 classification. In doing so the following points are of importance. First, the updating of the SBI coding to capture changes in economic activities has been relatively slow in special for new industrial sectors such as high technology information industries compared to the ISIC rev 3 classification. Yet when the SBI coding is updated it is not always clear whether an entirely new industrial sector has emerged or an old one is divided into two or more different sectors. It is therefore of the utmost importance to position every sector on an individual basis and on an as detailed level as possible. For the decomposition the individual sectors are based on the ISIC rev 3 classification and divided into: Mining and quarrying; food, beverage and tobacco; textile; wood; paper and printing; chemical industry; primary metals; non-metallic mineral products; machinery and equipment and transport equipment (See appendix table A). These main industrial sectors consist of smaller sub-sectors, on the moment these individual sub-sectors are joint they need to produce one single value for total real value added. However, straightforwardly adding up the sum of all individual sub-sectors at constant prices from the lowest to the highest aggregated level could lead to a serious substitution bias in case the structure of the economy has changed between 1980 and 2005. In order to make sure this does not occur, the Törnqvist aggregation procedure is used (GGDC, 2006). The dataset already contains the Value added in current prices measured at producer prices. And it is also converted to constant 1980 Euros by the 1999 official fixed euro conversion rate. The main challenge for locating the final users of energy (measured by energy consumption per economic sector) is to combine the EU KLMES with the IEA database. However as both databases are based on the ISIC classification this process is relatively straightforward. This in turn does not mean

[2] An overview of the construction of the EU KLEMS database is provided by: O'MAHONY M and TIMMER M (2009), "Output, Input and Productivity Measures at the Industry Level: the EU KLEMS Database", *Economic Journal*, 119(538), pp. F374-F403

that that there were no problems as described above with the positioning of individual sector to the corresponding collective sector, due to the two benchmark periods.

The data necessary to calculate the Dutch trade direction for manufacturing production regarding energy is provided by the OECD STAN[3], EU KLEMS and IEA databases. The sales value in current prices (EU KLEMS), energy consumption per sectors (IEA) and the export and import of manufacturing goods (OECD STAN) is distracted from these databases. Due to the fact that all these databases are based on the ISIC classification it is relatively easy to group the different variable. Again the largest difficulty lies in the classification of the sectors over time. Furthermore, only direct energy consumption of the final production is taken into account and not the energy demand of the entire production chain. This resolves the problem of indicating the individual contribution per sector of energy consumption when the production-chain is spread out over different economic/manufacturing sectors. The sales value in current prices and the import and export values can be without any modification subtracted from the OECD STAN and EU KLEMS databases.

4. METHODS

In order to study whether the possible causal relationship between increasing international trade and the decline in the Dutch energy intensity since the 1980s onwards is based on a spurious association – where the confounding factor behind the decline in energy intensity are based on internal forces - it is necessary to decompose – in terms of energy - the Dutch aggregated manufacturing industry (see figure 1). This is done to control for the possible composition effect within the manufacturing industry towards lighter industrial production based on the microelectronics revolution. The appropriate decomposition method needs to separate within-sectoral changes from between-sectoral changes. It then distinguishes structural factors (change in sectors shares while energy intensities stay constant) and intensity factors (changes in the sector energy intensities while the structure of the economy stays the same).

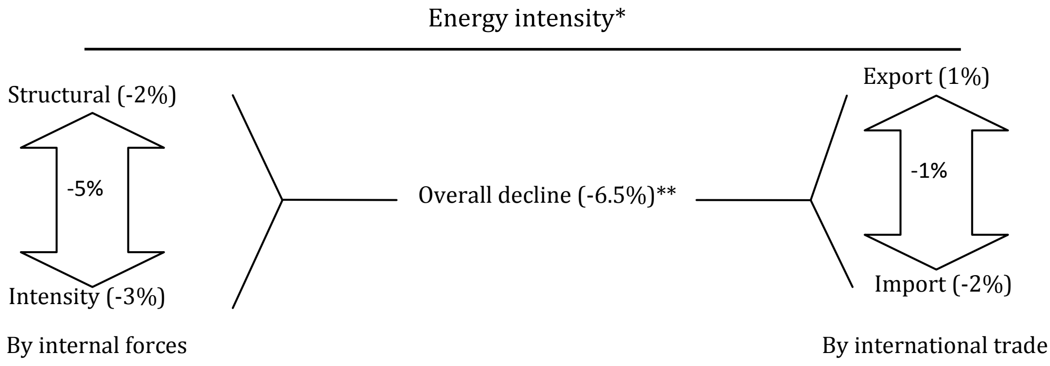


Figure 1. The spurious association for energy intensity. Source: Own research

**Suppose that if the energy intensity declined by 2% due to foreign imports, while exports increased energy intensity by 1%. How strongly does this support the statement that imports (international trade) are driving down energy intensity? The relation could be spurious if there is a confounding factor that is stronger. For instance, when energy intensity is declining due to internal forces. Suppose that structural changes in the manufacturing industry lead to only a small change of imported product with a low energy intensity. Than internal conditions – such as technical/intensity changes – may to a larger extend explain the decline in energy intensity. They then contribute both to the decrease of energy intense exports as to the internal decrease of energy use for production. By so internal factors instead of the Dutch position in international trade could drive the Dutch energy intensity down.*

[3] An overview of the construction of the OECD STAN database is provided on: http://www.oecd.org/dataoecd/52/54/47447210.pdf

***The values used in this example are not based on reality.*

All general index decomposition analyses are able to study the impacts of structural change and sectoral energy intensity change on the development in energy use in the aggregated economy. The exploration of which specific index decomposition analysis is suitable for our research starts by defining the function that relates the aggregated to be decomposed into pre defined factors of significance (Ang & Zhang, 2000). In this case the aggregated Dutch manufacturing industries total energy intensity change need to be decomposed into intensity and structural effects. After defining what needs to be decomposed, a variety of decomposition methods could be formulated to address the impact of structural and intensity changes.

The most commonly used decomposition methods among scholars can broadly be divided into two groups: methods based on the Laspeyres index and methods based on the Divisia index. The main difference between these methods is that the Laspeyres index calculates the proportional change in various characteristic of a group items over time, by weights based on values in a base year, where the Divisia index calculates this by the sum of the weights of components shares in total value, - in the form of a line integral - resembles a weighted sum of logarithmic growth rates (Ang, 2005). In sum the Laspeyres index methods are based on the concept of percentage change while the concept of Divisia index methods is based on logarithmic change. Due to the fact that the methods based on the Divisia index allow a complete decomposition without any residual and are invariant to the choice of base year, these methods would be more appropriate for decomposing the Dutch manufacturing industry between the 1980 and 2005. This based on the fact that the decomposed period is coupled to an event instead of to a specific timeframe. Another advantage of the Divisia index methods over the Laspeyres methods is that they create a symmetric and additive indicator for relative change compared to regular percentages which values are asymmetric and non-additive (Ang & Zhang, 2000).

The two main decomposition methods based on the Divisia index are the Logarithmic Mean Divisia Index (LMDI) and the Arithmetic Mean Divisia Index (AMDI). Both way methods can perform either a multiplicatively or an additively decomposition. In case of a multiplicative decomposition the ratio change of the aggregated is decomposed where in the additive case the difference in change is decomposed. Regardless of the method, in order to decompose the total energy intensity ratio change into structural and intensity consumption effects both the multiplicative and additively can be used simultaneously. In order to select the most suitable decomposition method four issues need to be considered, namely: the theoretical foundation, adaptability (not all methods suit to the available data), ease of use (in how far a method can be effortlessly applied to the subject, without modifications) and ease of understanding and interpretation results (Ang, 2005). The theoretical foundation of the index decomposition methods is largely based on that of index numbers. The choice between the two mentioned methods largely depends on their result on the factor reversal index number test. The outcome of this test is also important for the interpretation of the results, when they leave no unexplained residual term the results will be substantially easier to understand. Ang and Lui (2001) tested both methods for different data sets and found that in case you're decomposing the aggregated economy on a non-chain basis using two decomposition years (in this study 1980 and 2007) covering a wide time span, the AMDI methods fails the factor reversal test; by showing a large residual value. Furthermore the adaptability of the AMDI methods is limited by the fact that it cannot contain a zero value in the data set. Nonetheless, the AMDI methods are easier of use due to their basic mathematical formulation. However, in sum the LMDI based method would be the most appropriate to use for this decomposition, due to its theoretical foundation, easiness of interpretation and adaptability prevail over those of the AMDI method.

The elements in the LMDI decomposition method are as follows[4]:

E	Final energy consumption (=∑Ei+∑Ek)
Ei	Energy consumption in economic/manufacturing sector i
Ek	Energy consumption in non-economic sector k
Y	Total value added (constant prices)
Yi	Gross value added of sector i (constant prices)
I	Final energy intensity (= E/Y)
Ii	Energy intensity of sector i (= Ei/Yi)
Si	Share of sector i in total value added (=Yi/Y)
Dtot	Total energy intensity change
Dstr	Change of I due to structural effect (between-sector changes)
Dint	Change of I due to technical effect (within-sector changes)
Dpcons	Change of I due to personal consumption effect (non-economic sector changes)

Dtot=IT/I0 where T is the year of comparison (2007) and 0 is the starting year (1980).

The decomposition (Dtot) of the total energy intensity change is done into structural (Dstr), intensity (Dint) (Henriques and Kander 2010): Dtot = Dstr Dint

Ang (2005) provided the following mathematical formulas to compute Dstr and Dint:

$$D_{str} = \exp\left[\sum_i w_i^{'} \ln\left(\frac{S_i^T}{S_i^O}\right)\right] \qquad D_{int} = \exp\left[\sum_i w_i^{'} \ln\left(\frac{I_i^T}{I_i^O}\right)\right]$$

The weights of the different sectors i and k are compute on a similar basis, the logarithmic mean of the energy consumption of the individual sectors is divided by the total value added in the numerator and then divided by the logarithmic mean of the total energy intensity (Ang, 2005; Henrigues & Kander, 2010), in order that:

$$W_i(k)^{'} = \frac{L\left(E_i(k)^T, E_i(k)^0\right)}{L\left(I^T, I^0\right)} \quad ?$$

In where the logarithmic mean weight function of the two positive number is formulated as followed (Ang, 2005; Henriques & Kander, 2010):

$$L(x,y) = \frac{x - y}{\ln\left(\frac{x}{y}\right)} \quad ?$$

The second step, after controlling for the composition effect - which could indicate a possible structural change towards a lighter manufacturing industry - the Dutch trade direction regarding energy, requires to be calculated. In order to do so, detailed trade and production statistics are used to subtract sectoral: sale (€), energy (PJ),

[4] This decomposition scheme is provided by Kander (2011), based on HENRIQUES S. and KANDER A. (2010) The modest environmental relief resulting from the transition to a service economy. Ecological Economics 70, 271-282

energy/sales ratio (MJ/€), net export (€) and net export (PJ) values. Methods used (including the one that will be applied in this research) to analyze energy in commodity trade in general contain three sources of imperfection. First,the level of aggregation is relatively high so the actual structures may get huddled together during different periods (Kander & Lindmark, 2006). When using benchmarks that cover a wide time span, the division of the aggregated may change due to the introduction of new and the exit of old sectors or to changes made by statistical agencies in the way they divide sectors. Second, energy studies tend to assume that the manufacturing of certain commodity in a foreign country entail the same amount of energy as manufacturing them within your own borders; technical and organizational differences between countries are not taken into consideration what could lead to skewed results.[5] Finally, these studies commonly include only the energy use of the last production sector, and by so ignore the energy embodied inputs of intermediate production inputs (Kander & Lindmark, 2006). Nonetheless this last imprecision can be corrected by using input output methods that are able to include these intermediate inputs. However, the use of an input output method for this research would not be achievable due the high data demand and the relatively short time frame to collect and process the data.

The general method used to process the data could be divided into three steps. First, the energy figures will be divided by the sales value in current prices per individual sector. This creates a value that is a special kind of energy intensity. The second step uses these special energy intensity figures to calculate the energy content for the net export of goods by each individual sector. In order to do so the export minus the import in sales value for each sector is calculated and multiplied by the special energy intensity value of each sector. This method does not allocate imports to a specific sector based on where the imports are used for but considers the Dutch economy as the receiving unit. The third step relates the industrial energy consumption to the previous results, what makes it possible to search for relative changes that take place during the researched period. It is then possible to see whether foreign trade had any effect on industrial energy intensity and in combination with the results of the decomposition analysis if the national energy intensity was influenced by foreign trade or not.

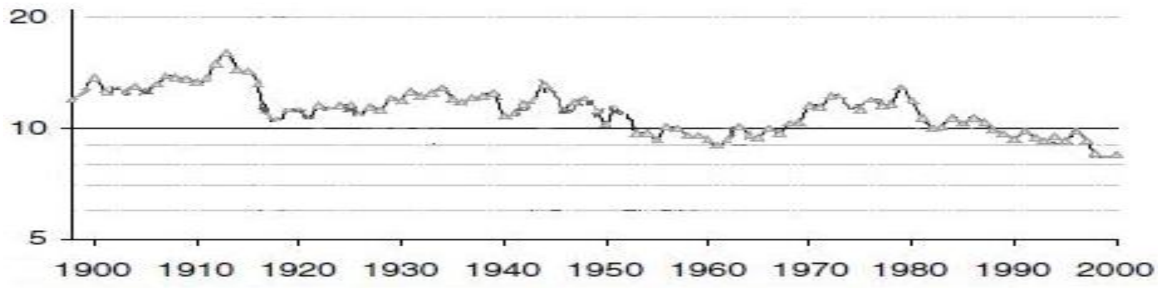
5. RESULTS

5.1. Overview of energy consumption in the Netherlands:

The Dutch energy consumption witnessed a vast increase from 1800 until the end of the 1930s. After a strong decline during the Second World War the Netherlands reconstruction resulted into high growth rates during the period 1950-75. Only since the mid 1970s the Dutch energy consumption leveled out. According to Gales et al. (2007) the increase in per capita GDP is the most important variable in explaining the growth patron of energy consumption in the Netherlands. Even though the Netherlands does not show any long term time trend for energy intensity – according to Gales et al. (2007), this due to their early transition to modern energy systems and carriers – the weak linear decline since the 1980 onwards contributes in neutralizing the upward trend in energy consumption, as shown in figure 2 (see also appendix figure A). The continuous weak linear decline in energy intensity for the Netherlands started around a decade after the supposed take-off of the service transition. (Schön, 2000). In order to exclude the service transition as main incentive for the decline in energy intensity since the 1980s, we first have to show that the real production structure did not shift for a large proportion to the direction of the service sector. As indicated by Henriques and Kander (2010) the share of the Dutch service sector in terms of GDP in constant prices did not show any substantial increase (see table 1).

[5] This could however be considered an analytical advantage. It means the pure trade effect is calculated, if technologies were assumed to be different in the calculations it would be necessary in a second step to decompose the estimated trade effects into technology effects and flow effects.

Figure 2. Long term energy intensity in the Netherland,s 1900-2000(mj/int. ppp 1990$).



Source: Gales et al. 2007

Table 1

Service sector share (of GDP in current and constant prices, in employment) 1950, 1971, 1990, 2005

	1950	1971	1990	2005
Employment	50%	60%	72%	79%
Current prices	n.a	58%	66%	74%
Constant prices	72%	65%	68%	73%

Source: Henriques and Kander (2010)

Moreover, when looking at the sector share for total output in constant prices the service industry only witnessed an incremental increase in size whereas the manufacturing industry did not showed a substantial decrease (see table 2). These results indicate that a service transition in terms of real production could be considered a price illusion based on the Baumol's price disease[6].

Table 2

Sector sector share in the Netherlands (of total output in constant and current prices, in percent)

	1971	1980	1990	2005
Manufacturing industry in current prices	36,1%	32,1%	30,8%	24,8%
Manufacturing industry in constant prices	30,0%	29,9%	28,7%	25,7%
Service sector in current prices	54,5%	56,7%	60,0%	67,9%
Service sector in constant prices	65,7%	62,0%	62,9%	67,4%

Source: Own calculations based on EU KLEMS 2009

After the preliminary analyze of structural change, it is time to look at whether structural change or technical change is driving the energy intensity of the aggregated Dutch economy down. In order to analyze this, the Dutch economy needs to be decomposed. For various time frames decomposition analyses on the decline in energy intensity are done for the Netherlands. Farla and Blok (2000) decompose the change in the energy intensity for the period 1980 till 1990 into structural changes and changes in specific energy consumption. Their results indicate that intra-sectoral shifts played a minor role, but that inter-sectoral shifts to a large extend caused by the disproportional growth of the heavy industry led to a six percent increase of the national energy intensity. However, this intense growth was compensated by quality improvements in combination with technical and organizational changes. The quality

[6] Baumol's (1967) cost disease is a phenomenon described by William J. Baumol and William G. Bowen. It describes a rise of salaries in jobs (service) that have experienced no increase of labour productivity in response to rising salaries in other jobs (manufacturing) which did show such labour productivity growth. This does not follow the theory in classical economics that wages are always closely tied to labour productivity changes.

improvements on an aggregate level of all individual sectors resulted in a 6.3 percent decline (ratio of production and value added) of energy intensity. Technical and organizational changes within the individual sectors resulted in an energy intensity decreased of 12.6 percent. The largest sectoral contribution came from the heavy industry which accounted for 7.9 percent of the total decrease in energy intensity. Neelis et al. (2007) who studied the energy efficiency developments in the Dutch energy intensive manufacturing industry for the period 1995–2003 concluded that since the mid 1990s significant energy efficiency improvements were visible for the Dutch manufacturing industry. These improvements varied from sector to sector (heavy industry as frontrunner), year to year and also between the type of energy used (Neelis et al. 2007). Both, Farla and Blok (2000) as Nellis et al. (2007) results are in line with Kander (2002) finding for Sweden. Kander's (2002) study demonstrated that structural changes at the sectoral level played only a marginal role, while changes within individual industrial sectors where the major driving force behind the decline in energy intensity in Sweden. According to Schipper and Grubb (2000) the Dutch – as well as the Swedisch – output structure is far more weighted towards energy intensive industries such as; metal, chemicals and the paper and pulp industry compared to other OECD countries. These heavy industrial branches make up a large extend of the export. Schipper and Grubb (2000) conclude that this development is driven either by low-cost fuels (or electricity) or low-cost raw materials or a combination of both (Schipper and Grubb, 2000).

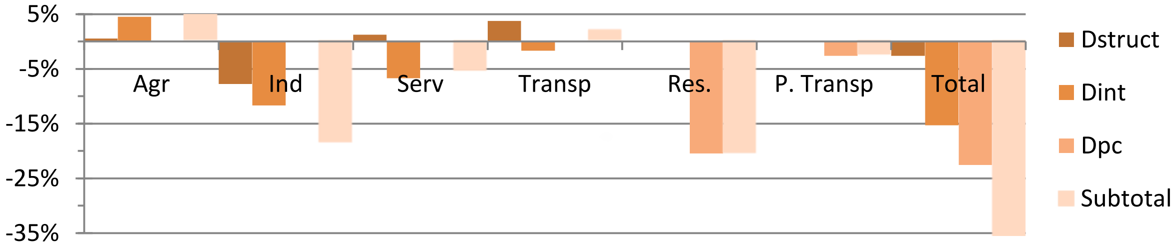


Figure 3. Decomposition analysis of the Netherland 1971-2003. Source: Henriques and Kander, 2010

Henriques and Kander (2010) decomposition analysis based on a five sector economy (Service, industry, agriculture, transport and residential[7]) for the period 1971-2003 indicated that structural shifts within the Dutch economy only counted for a modest contribution to the decline in energy intensity, see figure 3 and appendix table B. The overall decline in energy intensity was 36%. In the case of the Netherlands the impact of technical effects on the overall energy intensity reduction accounted for approximately 23 percent, outweighing the between sectoral structural shifts significant. In general, the manufacturing industry and residential energy consumption weighted heaviest in the declining of energy intensity for the Netherlands since 1971. Nevertheless the residential energy use – seen as declining personal energy consumption – could be both subject to changes in other sectors as to international trade, where the manufacturing industry is to a large extend driven by technical change within the sector[8]. However the results of Henriques and Kander (2010) deals with a unified industrial manufacturing sector, in where both low- and high-energy intensity sub-sectors are present, this making it impossible to distinguish structural within sectoral- from technical change. The high aggregated level mask structural change within the industry, which could cover the possible increasing share of light sub-sectors based on the transition towards the microelectronics industry.

[7] Service (serv), industry (ind), agriculture (agr), transport (transp) and residential (res)

[8] As a result of the third industrial revolution based on microelectronics household energy consumption could in theory decline based on the following reasoning. Industrial products in the past, like the hairdryer and refrigerator demanded substantial quantities of energy when used, compared to recently introduced IT-products, such as the mp3 player, tablet pc etc. which can manage with little energy. This not only indicates that these products need less energy in production in relation to their economic value but also not tend to increase household energy consumption by that quantity compared to the previous consumer products (Kander, 2005).

In sum the results indicate that when dematerialization occurs over the course of economic growth and development this is due to enhanced resource productivity in the manufacturing and other secondary industries instead of structural change, in the form of a transition towards the service sector. For so far it is clear that for the Dutch aggregated economy, structural change - from in particular the manufacturing industry - to the service industry did not occur in terms of energy consumption; the real production structure. It has to be acknowledged that based on these findings it is not grounded to assume a composition effect towards the service industry will lead to a relocation of the manufacturing industry outside the Netherlands. This indicates that what drives energy intensity down is mainly what takes place within or between sub-sectors in the manufacturing sector. However the within -sectoral changes could still contribute to the relocation of sub sectors abroad , in particular heavy industries within the manufacturing industry.

In order to control for a possible composition effect within the manufacturing industry towards lighter industrial production based on the microelectronics revolution or trade we need to look at the results of the decomposition analysis for the Dutch manufacturing sector on a detailed sub sectoral level for the period 1980-2005.

5.2. The Dutch manufacturing industry decomposed

The decomposition analysis of the Dutch manufacturing industry shows that structural changes between 1980 and 2003 contributed to the increase of energy intensity, while technical change tended to decrease energy intensity. Figure 4 shows the relative effects from structural changes, i.e. changes in sector shares, and changes within sectors for energy intensity. The ten main manufacturing sectors differ significantly with respect to energy use. Manufacturing sectors such as the chemical- and primary metal industry are considered heavy industries that consume relatively much energy, while manufacturing sectors as mining, paper and publishing and wood industries demand relatively less energy. As the contribution of the 'heavy industry' is relatively large, efficiency/technical improvements in this sub sector is of crucial importance for e overall development of energy intensity in the Netherlands. It is clear from figure 4 and appendix table C. that between 1980 and 2003 when chemical and

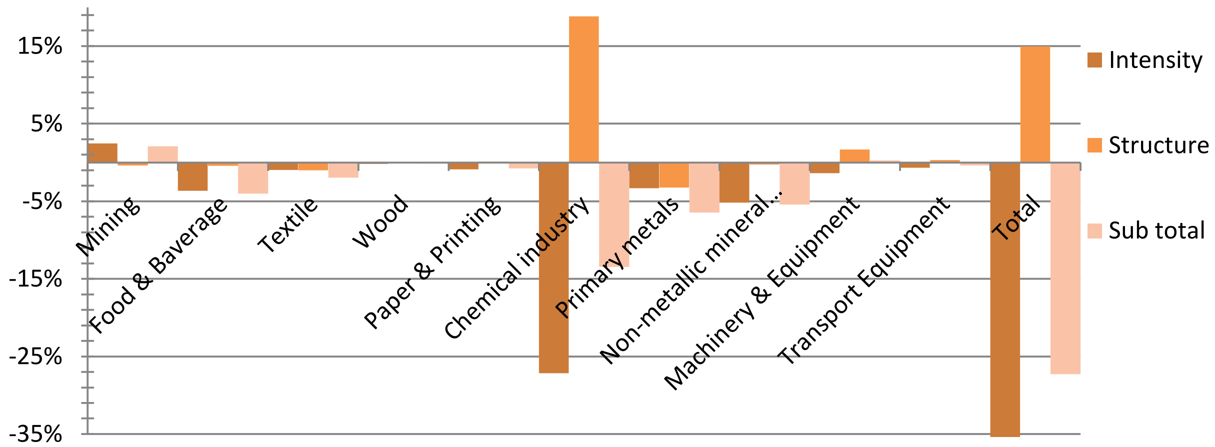


Figure 4. Decomposition analysis of the Dutch manufacturing industry 1980-2003. Source: Own calculations

machinery and equipment industry expanded relative to the other sectors, structural changes (inter-sectoral shifts) increase the Dutch energy intensity. The results show a move to the more heavy industries. Nevertheless in the studied period changes within the sectors (technical changes) were of substantial magnitude to outweigh this increase and push the net effect during the studied period to a 25 percent decline of energy intensity. The results do not underpin the possible composition effect within the manufacturing industry towards lighter industrial production based on the microelectronics revolution, but another declining effect is still possible.

These results indicate that there is a positive environmental impact due to technical change in the Dutch manufacturing industry, as where structural changes between sectors had a negative impact on the environment. Still, this does not rule out structural change within the economy to cause a positive environmental impact. Structural change within the Dutch manufacturing industry may not be visible as a move to permanently lighter industries (between sector structural change), but the transition towards the information society based on micro-electronics could explain the technical changes within the different sub-sectors. The main impact from microelectronics on within-sectoral change is that it enables a more efficient control of material and energy flows, this by use of process computers which reduce the output of waste. Less waste in turn means less energy consumption, ceteris paribus. As visible in figure 4, it is the heavy industrial branches that profit most from this. Some evidence for this can be given in anecdotal form for the chemical industry. Here process improvement made it possible to process by-products on a more efficient way what reduced the need for material and energy. In addition processes also became more automatically integrated, using more direct production lines. By means of this material intensity declined, but also the need for human capital increased. In sum, within-sectoral changes could be driven by the emergence of the microprocessor that enabled fine tuning of material and energy flows, reducing waste and reducing energy demands in relation to specific energy services. These technical improvements/changes could be considered similar to within-structural change of different sub-sectors. In this manner the production structure within the manufacturing industry did not change dramatically, it however slightly moved to the heavy industry. Yet the emergence of microelectronics – third industrial revolution – is recognizable in the Dutch manufacturing industry. To sum, there is no evidence in the case of the Dutch manufacturing industry for the possible composition effect within the manufacturing industry towards lighter industrial production based on the microelectronics revolution. The decomposition analysis does not support the concern that the heavy Dutch manufacturing industry is being outsourced/re-located to the developed world. It rather shows that internal factors are reducing the Dutch energy intensity.

Declining energy intensity in the Dutch manufacturing industry may still be a composition effect related to international trade. Consumption effects could still result in increasing embedded energy imports. Now it is necessarily to exam whether the Netherlands in the 20th century, and even more so after 1980, profited from her position in the developed world in the sense that she imported more energy embodied in goods than she exported? When this is the case, the Dutch energy intensity in production would be lower than her energy intensity in consumption. Changes in the net export of energy may thus be part of an explanation for changes in the Dutch manufacturing industry energy intensity. This could prove the existence of a confounding factor indication the spurious association between international trade and internal forces that drive down the Dutch energy intensity within the manufacturing sector.

5.3. The Dutch energy consumption and foreign trade

This results are based on the total Dutch industrial energy consumption, we here explore whether there were any relative changes taking place between 1980 and 2005, in other words the results indicate if foreign trade had any effect on the Dutch industrial energy intensity and thus on the total national Dutch energy intensity. The results for 1980, 1995 and 2005 are presented in appendix table D. In all three years the Netherlands had a substantial net export of energy in manufacturing goods, which indicate that the Dutch industrial energy consumption was increased by its foreign trade. The two dominant branches in energy exports are chemical and food. The rest of the branches have a small negative impact on the overall energy consumption, the Netherlands is for all of them a net importer of embodied energy. Regarding the Dutch energy intensity, the crucial measure is the net export's share of total industrial energy consumption. This share stayed stable during the first interval period. In 1980 the share was 56.8/488.1, i.e. 11.5% and in 1995 the share remained almost similar 61.7/531.1, i.e. 11.6%. Indicating that foreign trade between 1980 and 1987 did not change its influence during this period on the actual energy intensity changes that took place. The results point to that the effect of foreign trade on the energy intensity decline between 1980 and 1995 did not exist. Nonetheless the net export's share of total industrial energy consumption in 2005 accounted for 104.1/585.6, i.e. 17.8%. This demonstrates that foreign trade between 1995 and 2005 counteracted the actual decline of energy intensity in the Dutch manufacturing industry. In practice this would lead to a situation where not participate in international trade would have resulted in an even steeper decrease of energy intensity for the Dutch manufacturing industry. In sum the Dutch energy intensity would have gone down without the possibility of international trade.

The concern that the Dutch decline in energy intensity could be driven by their position in international trade - outsourcing their high energy consuming and polluting industries to the developing world - instead of by internal factors is taken away by the above presented results. However, the results only reflect on international trade as one homogeneous group. There is no distinction made between groups of countries, all countries that conduct trade with the Netherlands are added together. A traditional recognizable trade patron between the developed and developing world is then not direct visible. In order to get an indication of the energy embodied goods traded between the Netherlands and developing countries international trade is divided into two groups of countries; OECD and non-OECD[9]. The results intended for foreign trade with OECD countries and the effect on the Dutch industrial energy intensity and thus on the total national Dutch energy intensity are presented in appendix table E. In both 1995 as 2005 the Netherlands had a significant net export of energy in manufacturing goods to OECD countries. The Dutch industrial energy consumption increased by trading with these countries. The dominant branches in energy exports are chemical, machinery and equipment and food. The rest of the branches have a small impact on the overall energy consumption. The net export's share of total industrial energy consumption increased from 67.8PJ/488.1PJ, i.e. 13.9% in 1995, to 194.5PJ/585.6PJ, i.e. 33.2% in 2005. This resulting in a situation where trade between the Netherlands and OECD countries strongly counteracted the actual decline in energy intensity that took place. Most notable here is that the energy embodied products exported by the Netherlands where all produced by the heavy industry. However, when analyzing the trade relation with non-OECD countries a different trade patron comes forward. The results for foreign trade with non-OECD countries and the effect on the Dutch industrial energy intensity are presented in appendix table F. The Dutch industrial energy consumption decreased by trading with these countries. The dominant branches in energy imports are mining and machinery and equipment. The rest of the branches have little impact on the overall energy consumption. The net imported share of total industrial energy consumption increased from 7.3PJ/488.1PJ, i.e. 1.5% in 1995, to 95PJ/585.6PJ, i.e. 16.2% in 2005. This resulted in a situation where trade between the Netherlands and non-OECD countries increased the decline in energy intensity. Most noteworthy here is the increase of machinery and equipment imports that are part of the heavy industry.

6. Conclusion

From the results could be concluded that the Netherlands was a substantial net exporter of energy in terms of goods when all the relevant trade partners are included between 1980 and 2005. Without the Dutch participation in international trade, the Dutch energy industrial energy consumption would have been even lower than it actually was during this period. To support this finding and to make a judgment for the probable impact of trade on changes in energy consumption or changes in the energy intensity one cannot simply look at the negative or positive values in the energy balance, but rather need to look at changes in this balance. When examining the ratio of net exported

[9] For information on the member states and the requirement to join see http://www.oecd.org/pages/0,3417,en_36734052_36761800_1_1_1_1_1,00.html

energy compared to total energy consumption, one needs to realize that an increase in this ration during a substantial period of time implies that foreign trade during this period added to the increase of energy consumption and by so perhaps also to the increase in energy intensity. As the ratio of net exported energy to total energy was stable between 1980 and 1995, this indicated that foreign trade could not explain the stabilization of energy consumption during this period. Yet, between 1980 and 2005 international trade counteracted with the actual decline in energy intensity that was witnessed during this period. In short, without international trade the decline in energy intensity would have been even more significant than it already was. These findings are substantiated by results of Fara and Blok (2000) who argued that intra-sectoral shifts played only a minor role, but that inter-sectoral shifts caused by the disproportional growth of the heavy industry pushed down the Dutch energy intensity. Technical changes within the individual sub sectors caused the energy intensity to decrease. Schipper and Grubb (2000) pointed out that the output structure of the Dutch manufacturing industry is weighted towards energy intensive industries such as; chemicals and metal industry compared to other OECD countries. This is also visible when international trade flows for OECD and non-OECD countries got separated. The output structure of the Dutch manufacturing industry is indeed weighted towards heavy industries. However, the Netherlands is a net importer of embodied energy from non-OECD (developing countries). This designates that the Netherlands may be an exception among OECD countries due to the fact that the output structure is weighted towards energy intensive industries. The traditional recognizable trade patron described by Cole (2003) between the developed (OECD) and developing (non-OECD) world based on comparative advantages in laxer environmental regulation, energy cost, labor cost, safety regulation and cheap excess to raw materials could be substantiated by the trade results indicating an export based economic growth based on the export of early stage industrial manufacturing goods. In addition to this the results underline the capital versus labor effect for the Netherlands. Consequently in the occurrence of international trade, developed countries would specialize in capital intensive production - that score higher on energy intensity – while the developing world would specialize in labor intensive production.

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APPENDIX

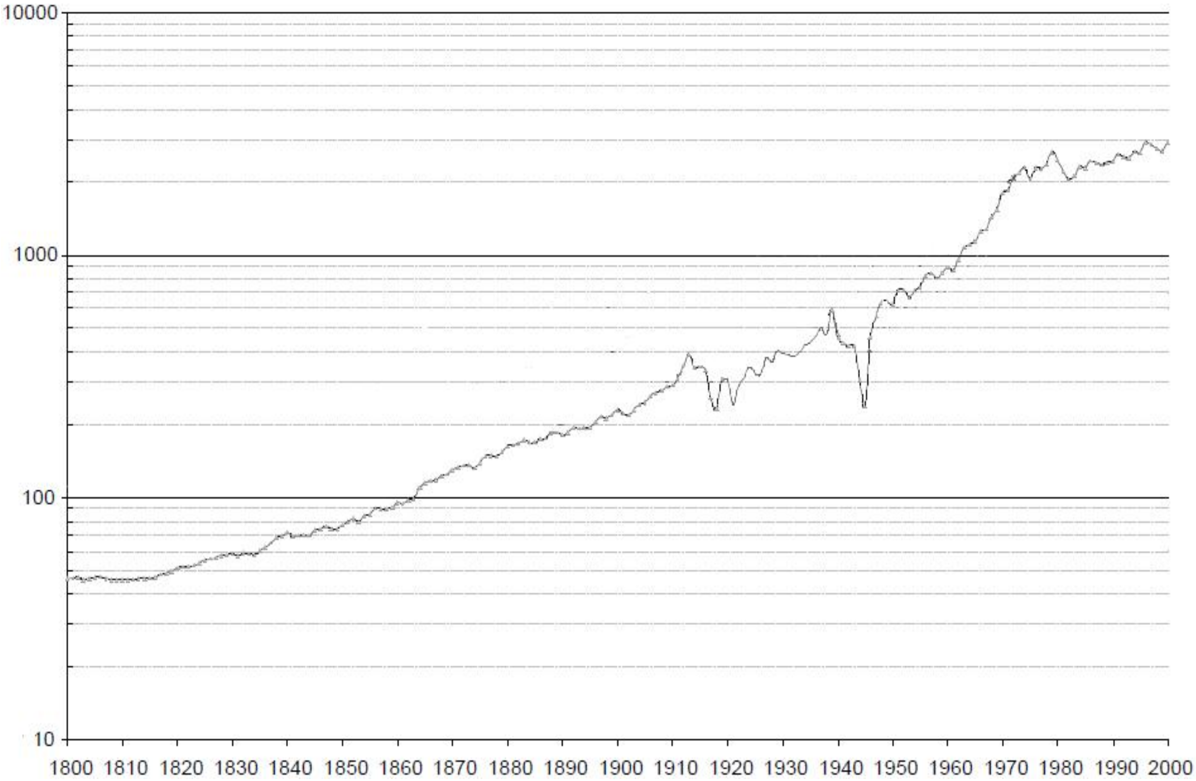

FIGURE A. Long term primary energy intensity in the Netherlands 1800-2000. Source: Gales et al. 2007

Table A. ISIC Classification coding system

Category	Code	Description
Mining	**C10T14**	**MINING AND QUARRYING**
	C10T12	Mining and quarrying of energy producing materials
	C10	Mining of coal and lignite, extraction of peat
	C11	Extraction of crude petroleum and natural gas and related services
	C12	Mining of uranium and thorium ores
	C13T14	Mining and quarrying except energy producing materials
	C13	Mining of metal ores
	C14	Other mining and quarrying
	C15-T37	MANUFACTURING
Food	**C15-T16**	**Food products, beverages and tobacco**
	C15	Food products and beverages
	C16	Tobacco products
Textile	**C17T19**	**Textiles, textile products, leather and footwear**
	C17T18	Textiles and textile products
	C17	Textiles
	C18	Wearing apparel, dressing and dyeing of fur
	C19	Leather, leather products and footwear
Wood products	**C20**	**Wood and products of wood and cork**
Pulp, paper	**C21T22**	**Pulp, paper, paper products, printing and publishing**
	C21	Pulp, paper and paper products
	C22	Printing and publishing
Chemical	**C23T25**	**Chemical, rubber, plastics and fuel products**
	C23	Coke, refined petroleum products and nuclear fuel
	C24	Chemicals and chemical products
	C24X	Chemicals excluding pharmaceuticals
	C2423	Pharmaceuticals
	C25	Rubber and plastics products
non-metallic mineral products	**C26**	**Other non-metallic mineral products**
Metal	**C27T28**	**Basic metals and fabricated metal products**
	C27	Basic metals
	C271T31	Iron and steel
	C272T32	Non-ferrous metals
	C28	Fabricated metal products, except machinery and equipment
Machinery and equipment	**C29T33**	**Machinery and equipment**
	C29	Machinery and equipment, n.e.c.
	C30T33	Electrical and optical equipment
	C30	Office, accounting and computing machinery
	C31	Electrical machinery and apparatus, n.e.c.
	C32	Radio, television and communication equipment
	C33	Medical, precision and optical instruments
Transport equipment	**C34T35**	**Transport equipment**
	C34T35	Motor vehicles, trailers and semi-trailers
	C35	Other transport equipment
	C351	Building and repairing of ships and boats
	C353	Aircraft and spacecraft
	C352A9	Railroad equipment and transport equipment n.e.c.

Table B							
Divisia decomposition for the Netherlands 1971-2003 (Multiplicative version)							
	Agriculture	Industry	Service	Transport	Residential	P. Transport	Total
Dstruct	1.005	0.923	1.012	1.038			0.974
Dint	1.045	0.883	0.933	0.983			0.847
Dpc					0.795	0.974	0.775
Subtotal	1.051	0.815	0.945	1.020	0.795	0.974	0.639

Source: Henriques and Kander (2010)

Table C											
Divisia decomposition for the Dutch manufacturing industry 1980-2005											
	Mining	Food	Textile	Wood	Paper & Printing	Chemical industry	Primary metals	Non-metallic mineral	Machinery & Equipment	Transport Equipment	Total
Intensity	0.996	0.996	0.990	1.000	1.001	1.188	0.968	0.997	1.017	1.003	1.150
Structure	1.025	0.964	0.990	0.998	0.991	0.728	0.967	0.948	0.986	0.993	0.633
Sub total	1.021	0.960	0.980	0.998	0.992	0.865	0.935	0.946	1.003	0.996	0.727

Source: Own calculations.

Table D

Dutch net export of energy (PJ) 1980, 1995, 2005

Type ISIC*	Sales value/Gross output in million €, at current basic prices			Energy (PJ), Including internal fuels, el (s)			Energy/Sales value (MJ/€)			Net export (in current million €)			Net export (PJ)		
	1980	1995	2005	1980	1995	2005	1980	1995	2005	1980	1995	2005	1980	1995	2005
Mining	9,707	9,715	17,372	0.5	2.0	15.0	0.0001	0.0002	0.0009	-2,986	-3,927	-15,388	-0.3	-0.8	-13.3
Food	26,642	40,130	47,852	77.3	91.4	92.3	0.0029	0.0023	0.0019	4,380	10,987	14,440	12.7	25.0	27.8
Textile	3,526	4,174	3,755	12.1	8.9	5.2	0.0034	0.0021	0.0014	-2,445	-1,892	-1,599	-8.4	-4.0	-2.2
Wood products	1,126	1,949	265	2.8	2.8	3.3	0.0025	0.0015	0.0125	-1,015	-1,005	-1,249	-2.5	-1.5	-15.7
Pulp, paper	8,201	15,107	13,348	31.8	38.0	41.0	0.0039	0.0025	0.0031	-509	-194	952	-2.0	-0.5	2.9
Chemical	27,084	38,440	76,154	221.5	230.2	246.2	0.0082	0.0060	0.0032	9,143	9,260	24,214	74.8	55.5	78.3
Metal	10,178	4,621	22,921	77.4	74.4	74.9	0.0076	0.0161	0.0033	-549	-507	-466	-4.2	-8.2	-1.5
Non metallic mineral	2,785	15,940	5,834	44.4	33.8	30.8	0.0159	0.0021	0.0053	-506	-717	147	-8.1	-1.5	0.8
Machinery and Equipment	4,935	25,585	18,052	15.5	44.0	71.9	0.0031	0.0017	0.0040	-1,183	-202	7,010	-3.7	-0.3	27.9
Transport Equipment	5,303	10,078	13,456	4.9	5.6	5.0	0.0009	0.0006	0.0004	-1,610	-3,477	-2,722	-1.5	-1.9	-1.0
Total	99,487	165,739	219,009	488.1	531.1	585.6	0.0486	0.0351	0.0359	2,720	8,325	25,338	56.8	61.7	104.1

Source: own calculations

*From the ISIC classification the following categories are extracted: Food (food beverages and tobacco), Textile (Textiles, textile, leather and footwear), Wood products (Wood and of wood and cork), Pulp, paper (Pulp, paper, printing and publishing), Chemical (Chemical, rubber, plastics and fuels), Metal (Basic metal and fabricated metal), Non metallic mineral (stone ect.), Machinery and Equipment, Transport Equipment.

Table E
Dutch net export to OECD of energy (PJ) 1995, 2005

Type ISIC*	Sales value/Gross output in million €, at current basic prices		Energy (PJ), Including internal fuels, el (s)		Energy/Sales value (MJ/€)		Net export (in current million €)		Net export (PJ)	
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Mining	9,707	17,372	0.5	15.0	0.0000	0.0009	120	634	0.0	0.5
Food	26,642	47,852	77.3	92.3	0.0029	0.0019	9,682	14,347	28.1	27.7
Textile	3,526	3,755	12.1	5.2	0.0034	0.0014	-87	1,613	-0.3	2.2
Wood products	1,126	265	2.8	3.3	0.0025	0.0125	-589	-627	-1.5	-7.9
Pulp, paper	8,201	13,348	31.8	41.0	0.0039	0.0031	-766	460	-3.0	1.4
Chemical	27,084	76,154	221.5	246.2	0.0082	0.0032	7,538	22,337	61.6	72.2
Metal	10,178	22,921	77.4	74.9	0.0076	0.0033	-460	-310	-3.5	-1.0
Non metallic mineral	2,785	5,834	44.4	30.8	0.0159	0.0053	-251	1,558	-4.0	8.2
Machinery and Equipment	4,935	18,052	15.5	71.9	0.0031	0.0040	-1,787	23,281	-5.6	92.7
Transport Equipment	5,303	13,456	4.9	5.0	0.0009	0.0004	-4,423	-4,307	-4.1	-1.6
Total	99,487	219,009	488.1	585.6	0.0486	0.0359	8,977	58,986	67.8	194.5

Source: own calculations

*From the ISIC classification the following categories are extracted: Food (food beverages and tobacco), Textile (Textiles, textile, leather and footwear), Wood products (Wood and of wood and cork), Pulp, paper (Pulp, paper, printing and publishing), Chemical (Chemical, rubber, plastics and fuels), Metal (Basic metal and fabricated metal), Non metallic mineral (stone ect.), Machinery and Equipment, Transport Equipment.

Table F
Dutch net export to non-OECD of energy (PJ)

Type ISIC*	Sales value/Gross output in million €, at current basic prices		Energy (PJ), Including internal fuels, el (s)		Energy/Sales value (MJ/€)		Net export (in current million €)		Net export (PJ)	
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
Mining	9,707	17,372	0.5	15.0	0.0000	0.0009	-4,104	-16,025	-0.2	-13.8
Food	26,642	47,852	77.3	92.3	0.0029	0.0019	837	25	2.4	0.0
Textile	3,526	3,755	12.1	5.2	0.0034	0.0014	-1,802	-3,218	-6.2	-4.5
Wood products	1,126	265	2.8	3.3	0.0025	0.0125	-400	-623	-1.0	-7.8
Pulp, paper	8,201	13,348	31.8	41.0	0.0039	0.0031	132	492	0.5	1.5
Chemical	27,084	76,154	221.5	246.2	0.0082	0.0032	832	539	6.8	1.7
Metal	10,178	22,921	77.4	74.9	0.0076	0.0033	-29	-156	-0.2	-0.5
Non metallic mineral	2,785	5,834	44.4	30.8	0.0159	0.0053	-450	-1,417	-7.2	-7.5
Machinery and Equipment	4,935	18,052	15.5	71.9	0.0031	0.0040	-1,013	-16,290	-3.2	-64.9
Transport Equipment	5,303	13,456	4.9	5.0	0.0009	0.0004	938	1,552	0.9	0.6
Total	99,487	219,009	488.1	585.6	0.0485	0.0359	-5,059	-35,120	-7.3	-95.0

Source: own calculations

*From the ISIC classification the following categories are extracted: Food (food beverages and tobacco), Textile (Textiles, textile, leather and footwear), Wood products (Wood and of wood and cork), Pulp, paper (Pulp, paper, printing and publishing), Chemical (Chemical, rubber, plastics and fuels), Metal (Basic metal and fabricated metal), Non metallic mineral (stone ect.), Machinery and Equipment, Transport Equipment.