SSE Riga Student Research Papers
2014 : 3 (159)

DISCOVERING THE POTENTIAL FOR INCREASED ECONOMIC COORDINATION: A CASE STUDY OF ESTONIA

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ISSN 1691-4643
ISBN 978-9984-842-79-0

November 2014
Riga

DISCOVERING THE POTENTIAL FOR INCREASED ECONOMIC COORDINATION: A CASE STUDY OF ESTONIA

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Abstract

This paper aims to identify the key industry in the Estonian economy and examine the potential for solving coordination failures in that sector. By employing various metrics such as the Leontief output multiplier that measure linkages as well as the analysis of various discrete parameters, we are able to determine the electronics sector as the key industry. After arriving at the most vital sector, we conduct several unstructured interviews with industry participants to study the presence of coordination failures. We identify the lack cooperation in addressing the issue of labour force competency and virtually non-existent cooperation in local Research and Development as the main coordination problems. Consequently, our research question is *What is the potential to enhance overall economic activity through improved coordination at a single industry level?* We find that the potential is moderate, yet noteworthy enough for sector participants to address the aforementioned issues. Finally, as the position of Estonia as a low-wage country is deteriorating, positive developments in the electronics industry are imperative to the sustainability of the sector.

Keywords: Estonian economy, key industry, industry importance, industry linkages, industry coordination, industry cooperation, coordination failure, Leontief multiplier, electronics sector

Acknowledgements

We express our sincere gratitude to our supervisor Lolita Čigāne for her aid in the conception of this paper and helping us guide the direction of our research. Not in the least does our recognition exclude her understanding and forthcoming disposition, both of which we greatly appreciate.

This paper would not be possible without the responsive and cooperative attitude of the participants of our conducted interviews. We write this in gratefulness for their help without which this research would not be possible and in equal hope that it will contribute to the well-being of their spheres of work and soundness of the overall economic climate of Estonia.

Finally, we give our fraternal thanks to our peers and professors at the Stockholm School of Economics in Riga for their constructive feedback which significantly contributed to the improvement of our work.

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1. Introduction

The purpose of the bachelor's thesis is to identify the vital industries through which overall economic activity could be improved in a country. In brief, some industries are more interlinked with others and, given that these links are strong enough due to the sector's size, the sphere can be considered a key sector. This pivotal part of the economy would then be a significant contributor, both directly and indirectly, to the domestic economy in terms of output, employment and other aspects. At the same time there can be shortcomings within this sector which individual economic agents would not alleviate due to various reasons such as the required investment being too large or the action simply not being profitable enough to be attractive to a single economic actor. In effect, a coordination failure from the point of view of the holistic economy can arise in the form of a situation where the benefit of investment to the whole economy and society notably exceeds the benefit to the private investor. Adressing such a structural issue would generally translate into a form of efficient stimulus for increased overall economic activity, competitiveness and growth. Thus, the relevance of the research lies in the identification of these key sectors and impediments to growth within them as a form of paving the way for their resolution as well as contributing to filling the gap of the lack of literature on the subject area for Estonia.

Research Question, Sub-Questions and Hypotheses

The research question of the bachelor's thesis is: **What is the potential to enhance overall economic activity through improved coordination at a single industry level?**

In effect, the research question is aimed at answering and essentially consists of two sub-questions that transform it into a more operational form. Hence, the sub-questions and their corresponding hypotheses are:

Which are the key industries within Estonia in terms of their level of linkages with other sectors and the strength of these links as well as their standalone importance within the economy?

- H: There are industries within Estonia that due to their strong links with other sectors and standalone importance within the economy can be considered as key industries.

To what extent are economic activity, growth and development in these key industries impeded due to obstacles which are not successfully addressed by individual economic actors?

- H: There are notable impediments to the development of a key sector that are not solved by individual economic agents.

While the role or discussion of the actor within the resolution process is outside the scope of this paper and will not be discussed in depth, some analysis of the form itself of the assistance necessary may be provided at the final stages of the research. Furthermore, there is a link between the state of the most vital industries and the perception of the well-being of the overall economy within the mentality of both investors and consumers. It affects the decisions on whether to consume, invest or save, as people look to the soundness of the most vital industries as an indication of what is to come and where are we now. One can then understand why in France there is a saying "When the car industry is doing well, everything is doing well".

2. Review of Literature

The literature review, being divided into three sections as well as an introductory part with definitions of key concepts and theories, carries a threefold purpose. Firstly and most importantly, it serves to increase understanding and provide a base of empirical evidence of industry linkages, how they translate into economic growth and the various methodological approaches used in measuring them. Secondly, it improves our knowledge about the nature of the coordination and underinvestment problems the study aims to identify. Thirdly, for a more general understanding of the topic and its relevance, we look at papers on impediments to industry growth (with respect to coordination failures) and works related to the Big Push model. In effect, the literature review part primarily focuses on the first sub-question of the study as it provides us with a ready toolkit from which to select the most applicable approach in quantifying industry inter-linkages in our research.

While we primarily make use of peer reviewed articles in scientific journals, a basic theoretical framework of development economics theory as found in the works of Todaro and Smith (2011) and Ray (1998) is kept in mind as a background for analysis. This is particularly the case with using the insight provided by the Big Push theory, analysing the role of externalities in economic development and impediments to growth within specific sectors (Easterly, 2002). Furthermore, we provide definitions at the start of the literature review to better familiarise the reader with frequently used concepts and theories within the paper.

2.1. Definitions

Industry Linkages

Industry inter-linkages are channels through which economic activity in one industry affects the level of economic activity in another industry. These links are typically divided into forward and backward linkages. How forward linkages typically function is that as one industry increases its output, the price of one unit of its output falls due an increase in supply which leaves an industry that uses the output of the former industry as an input in a better position in relation to the market. For example, an increase in the production of processed wood within a certain region makes the price of wood go down, which makes the local furniture producing enterprise more profitable, allowing it to make decisions and additional investments that, depending on their nature, would lead to one form or another of increased economic activity. Using the same example, backward linkages would be the furniture company expanding its market share or signing a new contract and then, in order to gain the necessary inputs, offering a higher price for wood which increases economic activity in wood production. Despite this illustration being a simplified depiction of the process, with some adjustments, it captures the essence of how linkages function. How this is relevant to our work is that by targeting the industry with the highest number of linkages while taking into account their intensity, we can pinpoint an industry in which growth would have a pronounced positive effect on the overall economy. (Todaro & Smith, 2011)

Externalities

Externalities are defined as benefits (if positive) or harm (if negative) to third parties not involved in a certain activity. For example, if a company is founded in a remote village and pushes the municipality (or even also participates financially) to build a better road so that it could transport its produce, all the village will benefit as the improved road will reduce commuting time and, in effect, increase disposable time that can be devoted to labour. Furthermore, the houses next to the road would typically increase in value and that may permit someone else in the village to pledge the house as collateral, take a loan and start his or her own business. In contrast, a negative externality would be the choice for someone in a neighbourhood not to keep the façade of their house in good shape, which would lower the value of nearby houses that might affect someone in the neighbourhood who is holding on to property to sell it to wait until prices go up again. As the person is planning to sell the property, he or she might not be interested in investing in keeping the house in good order which causes the "neighbourhood" angle of the real estate value calculation to drop even more. However, the problem with externalities is that unlike linkages they are far less easy to measure. Nevertheless, by familiarising ourselves with theoretical material, such as that of Klenow and Rodriguez-Clare (2005), and papers on empirical evidence, we can pinpoint some of these externalities within industries we consider. (Audretsch & Feldman, 1996)

The Big Push

The Big Push theory and the coordination failures it analyses is worth explaining as it presents a very prevalent form of an underinvestment trap. The theory, in its basic version by Paul Rosenstein-Rodan, is built on the economic conditions in which there is a choice for sectors to keep utilising traditional, not so productive technology or modernise and adopt increasing returns to scale technologies. This increase in supply would increase the profits of the given sector, part of which would be used to buy the output of industries with which it has a backward linkage; and decrease costs for industries that use the produce whose supply was expanded as an input, namely, with which it has a forward linkage. The main problem is that if only one sector undertakes this modernisation initiative, it will have difficulties selling its produce as the purchasing power of the economic sectors with which it is linked will not have expanded due to them still utilising the "traditional" technology. Hence, because all sectors would favour such a situation but do not make the first move since they would not be able to sell enough of their capacity, the full potential is left unrealized due to the benefit to the economy exceeding the benefit to a private investor who makes the decision. In effect, the theory states this barrier could be overcome with a "big push" that solves the coordination and information asymmetry problem by targeting the company with the largest and most intensive linkages and externalities. However, it must be noted that in the case of Estonia where some of the most successful companies and sectors rely heavily on foreign markets, some trade analysis would necessarily have to be incorporated into this framework. (Wang, 2013)

2.2. Industry Inter-Linkages and Importance

Valuable contribution to measuring inter-industry linkages has been made by Midmore, Munday and Roberts (2006) using financial data to form regional input-output tables in the Welsh economy. The study especially focuses on the impact of industries that have strong links to the rest of the regional economy through not only facilitating economic activity, but increasing competitiveness and development. This emphasis provided results that purchasing and sales linkages have strong effects on transferring both formal and informal knowledge, which creates positive spillovers in terms of productivity and increased technological progress. The informal knowledge part (social ties and professional networks) is stressed in particular as one that should be estimated with care as plays a vital role in industry interconnectedness. Furthermore, the strength of this supply and demand linkage is also an important determinant of overall output within the industries and, more importantly, the level of employment. The work also includes a valuable analysis on what is the potential for facilitating economic spheres that exhibit strong forward and backward linkages to other spheres. In effect, this analysis yields the results that care must be taken in economic facilitation as the most interlinked spheres are not the largest contributors to creating jobs; even within the extended effect of their linkages, economic activity can take a more intangible form and not extend to the broader society. Another very important aspect of the analysis is that it warns against the promotion of a single key sector without taking into account whether the spheres it is strongly linked with have the capacity to expand on their own, as well as the importance of skill endowments within the local labour force and international trade. Among the other conclusions, the study also suggests to evaluate the amount of value added generated by an industry that reached the domestic household level as an important measure of industry importance. (Midmore, Munday, & Roberts, 2006)

An important work on the origins of positive spillovers from dynamic inter-linkages among manufacturing industries in Italy has been carried out by Forni and Paba (2002). The study measures beneficial spillovers through comparing the effects of increased size and activity of a sector (using specialised labour as a proxy) on local labour systems. In brief, the main conclusion put forth is that these positive spillovers are especially prevalent and originate principally in industries of input-output connections with final stage industries being net producers of the spillovers and more upstream industries being more net receivers. Furthermore, the existence of clusters adds to the spillover effect and bring the largest benefit to such 3 dynamically linked sector groups, although not formal clusters, as footwear-textiles-leather, machinery-metal production and wood-furniture production. An interesting conclusion is that, contrary to many previous studies such as those by Henderson, Kuncoro and Turner (1995) and Audretsch and Feldman (1996), this relationship seems to hold regardless of the level of technological intensity within the sector. The narrow focus on linkages among manufacturing sectors might be an issue as it disregards the potentially significant positive effects of the links with the rest of the economy. Nevertheless, any additional positive effect on the economy would only add to the significance, yet, here, we merely cannot say which sector would carry more weight. Aside from depicting the interconnectedness and spillovers in the productive side of the economy, this study also provides valuable industry-specific conclusions. (Forni & Paba, 2002)

Research on the Indian economy by Bhardwaj and Chadha (1991) presents the importance of inter-sectorial links in the growth rates observed within an industry. The study takes a multi-sectorial viewpoint by analysing input-output differences and structural changes in industry linkages as industrial sectors develop over time. More importantly, through this analysis of historical data, it also highlights which economic sector growth and development was more dependent on internal demand rising and which – on export expansion, as well as providing broad data on the nature of forward and backward linkages of various spheres of the economy. This is valuable to our work as this provides us with a set of hypotheses for a number of economic sectors whose validity we can test in the case of Estonia. If the results are valid, we can determine which – internal linkage demand expansion or increase in exports – is the main driver of growth and, hence, the first place to look for coordination problems. Furthermore, the study describes the role of structural input-output changes within the context of growth facilitation through a domestic demand pull. On a last note, their work indicates to focus on especially intermediary inputs in analysing linkages, as an increased demand for or technological progress in them is described as a particularly prevalent force for development and positive technologic spillovers. (Bhardwaj & Chadha, 1991)

A study by Basher (1997) deals with identifying the linkages within the economy of Bangladesh to a large extent in pursuit of a very similar goal – measuring the potential to facilitate growth in the overall economy through promoting a key industrial sector. A great plus in terms of methodological framework of this study is that it employs various ways of measuring these linkages as well as classifies and describes in detail the linkages measured, also evaluating their strength and how it varies among industrial sectors. Once more confirming the results of the study by Forni and Paba (2002), there seems to be no significant discrepancy between the total amount of linkages within agricultural and non-agricultural sectors. What further sets this study apart is that it analyses the leakages of the potential linkages with the rest of the economy of sectors that create value primarily for export or are very small in comparison to imports in their sphere. Furthermore, the research highlights not the lack of demand in realising what would otherwise be linkages beneficial to the overall economy but solving supply side issues. As some it mentions the lack of infrastructure, technological disadvantage and other impediments to shifting up the production function of potential export sectors and other industries which have a potential for strong linkages with the rest of the economy. On a side note, the paper also recommends for an active role of the government in solving issues not addressed by the private investor. (Basher, 1997)

The work of Vogel (1994) aims to identify the role of the agricultural sector and its linkages with other spheres in economic development. It elevates the role of agriculture from, traditionally, a source of labour for industrialisation into the potential key sector in what can be rural area-led development of the whole economy. While this work is already much more focused on a single industry, it provides valuable insight into how progress in one sector can have positive spillovers to other spheres through a simultaneous demand and supply boost as well as an increase in industry linkages as the level of technological progress increases. This is a crucial aspect worth consideration as a demand pull from agriculture, or any domestic sector, especially if heavily interlinked, translates into reduced volatility of activity in other sectors through lessened dependence on terms of trade (export) and urban demand (demand source more susceptible to common shocks). However, another conclusion is the diminishing importance of agriculture in terms of forward links with the overall economy (which are not significantly strong to begin with) as the country becomes more developed; in effect, decreasing the role of agriculture and spheres that have backward-links to agriculture. Nevertheless, the study still proposes agriculture to be a vital industry through which to potentially promote economic growth via its predominantly strong backward linkages that increase in importance as the economy becomes more developed. (Vogel, 1994)

The study by Meller and Marfán (1981) analyses the importance of industries in relation to both direct and indirect employment generation in Chile and how it is affected by the size of the industry participant. While the study has been conducted for Chile, the measure of detail in which the authors of the study have described their methodological approach creates an opportunity to search for the necessary data for Estonia and test the validity of their findings and interpretation. A particularly interesting takeaway is the idea of considering indirect employment in quantifying forward and backward employment linkages among economic sectors. Furthermore, the study outlines the details of employment generation and how this changes relative to specific economic spheres, as well as yielding the conclusion that larger firms create jobs mainly through indirect linkages, while for most sectors the opposite holds true for smaller industries. Nevertheless, one of the main results of the research is that small industries clearly generate more total employment. (Meller & Marfán, 1981)

Another study, one by Shea (2002), is also focused on the effect correlation of growth among different industries has on employment rates. It also describes on the role of complementarities in the short-run comovement in activity among various spheres of the economy by using 3 models to capture the effect of complementarities on inter-industry linkages. In particular, the work stresses the positive job-creating effect of local spillovers where the comovement of industrial spheres is strongest, as opposed to aggregate spillovers. This is important as it indicates that volatility of employment is best explained by the rise and fall in activity within related sectors of the economy, often where both complementarities and input-output linkages can also be observed. From this spurs an interesting idea – the evaluation of the candidate industries in terms of which linkages and forms of complementarities (and in which directions) carry over positive shocks the most. (Shea, 2002)

In his paper, McGilvray displays that using a historical framework and perspective may lead to biased results since the dataset underestimates the importance of new industries. While this is slightly against our line of research as we discard the infant industry approach, the potential downward bias is worth keeping in mind when evaluating a new sector that has attained a relatively large market share and has come into our consideration. (McGilvray, 1977)

Furthermore, a study by Cella (1984) suggests that not only should the domestically produced goods and services be considered, but researchers should also take into account the products that are currently imported but have the potential of being manufactured domestically. The latter is especially valid for our paper since Estonia has a trade deficit and the results of this paper might help address this issue. (Cella, 1984)

On a last note, Hewings's (1982) work highlights the importance of social ties, networks and knowledge spillovers as he illustrates that by employing most technical models, typically both the creation of positive spillovers and negative externalities are largely downplayed. It is worth keeping this in mind as we search for our key industries so as not to overlook the potential externalities the sector may have on other firms and sectors, the environment and society. It is also worth mentioning that many development economics theories in reference to "hidden" characteristics of economic importance also suggest accounting for at least part of the externalities of a sector by analysing various metrics that estimate, for example, the environmental impact it has (Ray, 1998). While this is typically not the most vital step in determining a key industry, it is still very valuable as these less noticeable aspects of industries often translate into a more concealed form of coordination failure if one looks at it from the point of view of the overall economy (Todaro & Smith, 2011). (Hewings, 1982)

2.3. Investment Coordination

In his paper, Okuno-Fujiwara (1988) demonstrates that if a country is to efficiently promote a specific industry for the betterment of the overall economy, at least two conditions must suffice: (1) industries that have direct relations with other industries and (2) among the industries, at least one industry must possess the economies of scale effect. If the economy fails to meet one of these criterions, the coordination effect is bound to fail. Okuno-Fujiwara (1988) also points towards the post-war Japanese experience, in which domestic bankers, various company managers and government bureaucrats gathered to exchange information about domestic and foreign markets. Given the success of the Japanese rebuild, the latter illustrates how crucial is getting different involved parties together to share knowledge. As a last remark, the study mentions vertical integration as a possible solution as one of the means by which coordination failures can be avoided. (Okuno-Fujiwara, 1988)

The importance of communication is also stressed in the work by Ellingsen and Johannesson (2004), in which they conduct various hold-up experiments. They prove that underinvestment occurs only if the market participants fail to coordinate on an efficient equilibrium. For example, if communication is disallowed, less than a third of participants choose to invest, while if permitted, the investment rate rises to 80%. (Ellingsen & Johannesson, 2004)

In addition to communication, researchers have also analysed externalities caused by complementarities. The latter takes place if an investing firm, by lowering the prices of its products, raises demand for producers of other goods. This is a central theme for Baland and Fracois (1996) who discover that the presence of Hicks complementarity may lead to coordination failures. Interestingly enough, they claim that the largest benefits from coordination do not arise from the existence of mutually profitable investments under coordination, but rather from differences in production technology across sectors. According to their study, the gains to investing companies come at the expense of industries that produce Hicks substitutes, making this a zero sum exchange if mark-up rates are similar. But for a given unit of expenditure, demand reallocation to sectors with higher mark-ups increases the income multiplier of expenditure, thereby indirectly raising demand for the goods in other industries. In addition, their study also reveals that coordination generally raises social welfare in the society. (Baland & Fracois, 1996)

Although the research by Andrew Wood (2005) looks into the British brick industry, we believe there are valuable takeaways from his research. For instance, he believes that the reasoning behind coordination failures lies within firm heterogeneity, regional dimensions and in the prospects of growing through acquisitions. In his econometric model, Wood creates a variable that measures the proportional change of capacity of all rival firms during the last year. If the coefficient on this variable is positive, then the firm is more likely to increase its capacity based on the expansionary decisions taken by competing firms, creating an adapted form of Big Push pressure. This approach can also be utilised in defining variables since this method allows us to read the investment strategies of firms in a highly competitive environment. In addition, the study states that the construction industry is especially volatile, thereby making the pre-emption strategy a potentially risky one. Furthermore, Wood proves that firm size is an important factor in reacting to investment opportunities since larger firms possess more resources devoted to market research and trend analysis. Lastly, this paper suggests that companies are able to avoid unwarranted clustering of expansions that risk excess capacity, but discrepancies lie within regional and national level. A ubiquitous concept that applies well to Estonia as well, as finding financing, investment opportunities and export partners in Tallinn is much easier than in the rural area. (Wood, 2005)

2.4. The Big Push Model

An interesting point of view to look at our research and its implications is the Big Push theory developed by Paul Rosenstein-Rodan. While the framework is not employed as a central piece of our study, the literature we refer to on economic coordination is very often closely linked to the Big Push framework. In effect, the theory serves as both a starting background for looking at coordination problems and as an aid in explaining how investment coordination can be very advantageous for domestic industries. (Todaro & Smith, 2011)

First off, it is worth mentioning that the model had somewhat fallen out of favour until 1989 when Murphy, Shleifer and Vishny (1989) proved that an industrializing firm has the potential of for raising the demand for products of other sectors through channels other than the contribution of its own profits to demand. They found that the presence of strong linkages between companies may yield a situation where coordinated modernisation would greatly benefit the economy as a whole (including the inter-linked firms individually) while investment is not profitable for any single individual firm initially. Most importantly, these authors focus on the application of the theory on the company level which is very valuable to us as we analyse coordination at the industry level. (Murphy, Shleifer, & Vishny, 1989)

Morck and Nakamura (2007) explain that the primary reason for coordination problems under the Big Push theory are typically due to the "hold-up" issue; namely, that first movers are reluctant to undertake investments due to asymmetric information and adverse selection. These two aspects are very much worth keeping in mind within the context of our research as they are two directly identified reasons that may signal to potential coordination failures. In the worst case scenario, nobody invests and employment, trade and economic welfare are not created. Rosenstein writes that these shortcomings could be addressed through centralized capital investments, which would remove the barriers of adverse selection. (Morck & Nakamura, 2007)

Finally, Magruder (2011) displayed that even minimum wages can lead to a Big Push through increasing formal employment and domestic product demand. The latter is quite logical since if local firms pay higher wages, then the labour force has more disposable income, thereby leading to market expansion. On the other hand, de Fontenay (2004) demonstrates, based on data from the Honduras, that if an industry possesses an agent with strong strategic market power, then the cost of the Big Push is also lowered. If the institutions within the industry are weak, then coordination may become eventually unaffordable and many Pareto-efficient Big Push policies may not be implemented. (Magruder, 2011)

3. Methodology

Outline of the Methodological Approach

We choose Estonia (a country of origin of one of the authors) as the case study as it increases our access to information for our research, in effect ensuring better triangulation through a larger diversity of sources. While in practice this advantage will also be present in discarding the otherwise possibly hampering language barrier, we find the most pronounced benefit in gathering information during the interview stage with industry representatives and government officials. Furthermore, this increased accessibility of information will also help us obtain sources through the networks of the author(s) and aid us in terms of flexibility, as we can adapt more quickly to which sector and issue we pursue further as we carry out our research. In addition, during our literature review we did not find literature that examines the key sector/coordination aspect of the Estonian economy and, hence, we perceive it as a valuable contribution to fill the literature gap in performing the analysis on Estonia.

The methodology of the research, just like the research itself, is two-part. The first part consists of the analysis of various quantitative parameters that help us pinpoint the key industries within the Estonian economy. In effect, we employ a purposive sampling study design and, on that account, also set an economic sector/industry like agriculture, forestry or air transport as the unit of analysis, with an economic sector consisting of all the aggregated figures of all the firms belonging to it. The second part deals with the more in-depth examination of the shortlisted economic sectors and determining the level of coordination in them. To achieve the latter, we mainly utilise interviews with industry representatives, industry-level associations and government officials connected to these sectors. Furthermore, the interviews are unstructured in order to utilise the full potential for flexibility of qualitative research. In addition, the conclusions and reiterative examination of the quantitative analysis is used to back analysis in the 2nd part of our research with hard data whenever possible.

Consequently, at the first quantitative data stage of our analyses we rely upon the database Statistics Estonia, the central statistics bureau of Estonia, which is accessible to the general public. Moreover, we use a time frame of preferably the last 3 years (or more where necessary) to avoid biased results and be able to observe historical trends, provided that data for this timespan is available. Lastly, the qualitative data used in the second part of our research originates in the interviews conducted.

3.1. Key Industry Analysis

As mentioned beforehand, the first part of the study is composed of pinpointing industries which have the largest impact on the whole economy using a quantitative analysis. In order to do so, we have chosen a set of selection criteria based on parameters that measure what we may call "systemic" importance and, afterwards, those that evaluate stand-alone importance within the economy. Concerning the relative weights we assign to each parameter, two things must be kept in mind. Firstly, the most vital aspect is the level of linkages; hence, only sectors scoring better than the rule of thumb in backward and forward linkages as well as showing good scores in the total output multiplier will even be considered for further analysis. Secondly, while the evaluation of stand-alone parameters is somewhat of a judgement call, at all times we keep in mind the limitations and biases of each metric as well as consider the relative differences in between sectors under consideration in each separate parameter.

3.1.1. Measuring Systemic Importance

We measure the system-wide importance of an industry based upon its linkages with other sectors. In a nutshell, the industry with the most linkages and large enough size for the impact to be significant is considered the key industry since it involves the largest (and most influential) number of connections. Thus, we set our main cut off point from which we start a more in-depth analysis of industries (as we cannot reasonably analyse all sectors) as a high level of inter-linkages with other industries. Why this makes even more sense is that even the largest by GDP, highest export and workplace-generating industry is invaluable for the attempted task in this paper, as we aim to capture an industry of systemic importance whose actions send the strongest economic ripples through the system and not just exist as an island of sound economic features. Thus, in order to measure the level of linkages, we use the Leontief matrix and multipliers derived from it as our main tools of analysis.

The Leontief Matrix

If you compare the economy to a little pond, then any alterations in the economy will have similar effects to a drop of water in a still pond. Any disturbances will lead to direct change in the purchasing patterns of affected entities, thereby causing the primary "ripple". Now the suppliers of the firms have to react and alter their production, leading to a second "wave". Not surprisingly, the sub-suppliers now have to take action and revisit their strategy. Eventually these steps are undertaken iteratively until a new equilibrium is reached. Therefore, the "ripple" effect can be broken down into three components: (1) a direct effect in the form of the initial economic disturbance; (2) an indirect effect through suppliers adjusting to the new circumstances; (3) an induced effect in the form of the change in consumer spending that comes from changes in labour income. (D'Hernoncourt, Cordier, & Hadley, 2011)

Based on this idea, Wassily Leontief devised the framework in which each industry is affected by demand within the system (selling to other industries) and demand from outside the system. If this process is repeated many times, then the model represents the economy as a series of linear equations, also known as the input-output matrix, which can be created by calculating vector values. From it, the Leontief matrix is derived, which has been widely used in papers all over the world to find key industries of an economy. (Smith, 1949)

However, arriving at the vector values and coefficients that constitute the Leontief matrix is not an easy task by any measure. The calculus requires multiple quite difficult statistical steps, such as performing the RAS procedure to eliminate negative values, preliminary adjustments to supply and accounting for the secondary products. In addition, it involves repetitive iterations that are very time and effort-consuming such as adjusting for commercial mark-ups, transportation costs, taxes and subsidies – a lot of which we do not have access to due to confidentiality regarding firm data. Taking all of this into account, we have decided not to undertake the statistical and mathematical analysis ourselves, but to rely on a ready Leontief matrix as can be found in Statistics Estonia. (Dedegkajeva & Parve, 2005)

In effect, in our research we rely on the Leontief matrix that was calculated for the Estonian economy in 2010. However, there is no reason for concern as the coefficients are typically quite stable for at least 5-6 years, unless there have been significant structural changes in the economy (Dumaua, 2010). Therefore, we briefly describe in the following chapters the methods that employ the Leontief matrix for determining the linkage level of an industry.

Leontief Total Output Multiplier

By summing up all the elements from the jth column, we are able to indicate the total production from all sectors created from one unit final demand of sector j's output. In other words, the output multiplier (the sum of all elements from one column) shows the final value of new sales generated in the economy for each monetary unit increase in final demand. The popularity of the method rests in its simplicity as the column sums of the inverse matrix can be used to measure the power of dispersion of each corresponding sector. The power of dispersion essentially shows how much does a single sector rely on the entire economy. Therefore, the sectors that display high values or coefficients can be considered as the key industries in terms of linkages. (Jodar, 2011)

Backward and Forward Linkages

Two kinds of more specific measures of economic linkages between industries can be obtained from the Leontief matrix. The first are the backward linkages (BL_j) which can be calculated with relative ease. Whereas the second - forward linkages (FL_j) involves a more complex approach. Various studies have put forward two frameworks for identifying the forward linkages – either through the Ghosh inverse or the Leontief matrix, with both approaches having been employed in numerous studies. However, for the fluidity and cohesion of our study, we decide to also calculate the forward linkages from the Leontief matrix. All the symbols used in the equations are explained in Figure 2. (Reis & Rua, 2006)

The average normalized backward linkages are calculated as follows:

$$\mathrm{B.j} = \sum_i b_{ij}/n$$

Figure 1 (Created by the authors)

B_{ij} – coefficient of Leontief Inverse
$B._j$ – average backward multiplier of sector j
n – number of industries
$B._i$ – average forward multiplier of sector 1
$V._j$ – backward coefficient of variation of sector j
$V._i$ – forward coefficient of variation of sector i

Figure 2 (Created by the authors)

Hence, if a sector increases its output, then there is increased demand for the sectors whose output is consumed by that sector, thereby the meaning backward linkage (Reis & Rua, 2006).

The average normalized forward linkages are calculated as follows:

$$\mathrm{B.i} = \sum_j b_{ij}/n$$

Figure 3 (Created by the authors)

If our sector is connected not only backwards, then its increased output will be used as an input for production for other industries with which it is linked forwardly (Reis & Rua, 2006). This connection is referred to as a forward linkage. To normalize the coefficients, they are divided by the average industry multiplier (Humavindu & Stage, 2013).

In evaluating the backward and forward linkages, the general rule of thumb to bear in mind is 1, which implies that if either $BL_j \succ 1$ or $FL_j \succ 1$, then an output increase of 1 unit in the industry will generate a higher than average increased activity through its high linkages with its suppliers or sectors that use its goods. For the industry to be named “key”, typically both of its linkages should at least exceed 1. (Reis & Rua, 2006)

Income Multiplier

The income multiplier, as the name implies, helps translate the impacts of changes in final demand to changes in spending by accounting for both direct and indirect effects (D’Hernoncourt, Cordier, & Hadley, 2011). In order to arrive at the income multiplier, one needs to start from a direct requirement matrix, an intermediate matrix in calculating the Leontief matrix, which shows information on both employee compensation and total inputs (Dumaua, 2010). The calculation can be undertaken in three steps: (1) dividing employee compensation by total input of an industry to obtain an income coefficient; (2) multiplying the column elements of the Leontief matrix with the income coefficient and (3) summing up all the products to attain the income multiplier.

Knowing the income multiplier helps us to understand how much does a one monetary unit change in the final demand affect the additional household income (Dumaua, 2010).

However, results ought to be interpreted with care as these multipliers only work under a certain set of assumptions. For instance, the empirically derived multipliers such as the income and employment multiplier represent the period for which they have been calculated – meaning also that they are sensitive to cyclical variations. Hence, during the boom and bust season the multipliers can overestimate the actual effect. (University of Washington, 2002)

Employment Multiplier

Similarly, the employment multiplier illustrates how many incremental jobs are added in the whole economy due to a one-unit increase in each sector's output (Dumaua, 2010). What must also be noted is that it takes into account the "ripple" effect and, hence, shows indirect as well as direct employment generation, as suggested by Meller and Marfán (1981). Again, the multiplier can be calculated in three steps: (1) dividing total employment by the gross value added to obtain the employment coefficient; (2) multiplying the coefficient with the column elements of the Leontief matrix; (3) summing all Leontief matrix column elements.

Furthermore, it must again be noted that the same limitations from multiplier assumptions and biases in interpretation mentioned under the income multiplier apply here as well.

Coefficients of Variation (Measuring Dispersion)

From the backward and forward linkages we are able to highlight which sectors are tightly linked with others. However, there is a possibility that even though the industry is closely connected to other industries, then the linkages may not be widely dispersed and are concentrated between just a handful of sectors. The coefficients display the degrees of sectorial skewness in input procurement and output delivery (Humavindu & Stage, 2013).

The coefficients of Variation for the BL_j are calculated in the following manner:

$$V._j = \frac{\sqrt{\frac{1}{n-1} \sum_i (b_{ij} - B.j)^2}}{B.j}$$

Figure 4 (Created by the authors)

The coefficients of variation for the FL_j are calculated as follows:

$$V_{\cdot i} = \frac{\sqrt{\frac{1}{n-1}\sum_i (b_{ij} - B.i)^2}}{B.i}$$

Figure 5 (Created by the authors)

Furthermore, the coefficients are normalized by dividing the results with the industry averages. Yet again, the critical value in both directions is 1, implying that the lower the coefficients of variation score, the more evenly that sector's input purchases and sales are spread throughout the different sectors of the economy (Humavindu & Stage, 2013). On the other hand, high results indicate interaction only with a limited number of other industries.

However, it is of paramount importance to mention that these coefficients may lead to biased results if the economy is largely dependent on exports. In that case, even industries whose backward and forward linkages are well above the average may seem to have very concentrated linkages with a small number of other sectors. (Humavindu & Stage, 2013)

3.1.2. Measuring Discrete Importance

After prioritising several economic sectors based on their linkages with the whole economy, we study them more in depth based on their stand-alone economic importance. The aspects we analyse are as follows: share in GDP; share in industrial production; share in export generation (trade balance) and share in value-added.

Furthermore, we employ a set of parameters to evaluate sectors under consideration in terms of the value they hold for the broader public: employment generation; labour productivity and the wage level.

Finally, we analyse how well our given spheres at that point fare in terms of their externalities. More specifically, we look at negative externalities which we proxy with environmental impact. In order to do so, we use three measurements to better capture where our industries stand in this regard: air pollution; waste generation and contribution to the depletion of the ozone layer.

3.2. Identifying Coordination Problems

The evaluation of the level of coordination, as mentioned previously, will be performed for a small amount of sectors short-listed up to this phase on the basis of information gained from interviews. In order to do so more efficiently, the authors employ the NVivo 10 software to summarize interview data and draw conclusions. In addition, closer examination of the results of the key industry selection phase as well as their integration into the interview process will be carried out in order to gain a better understanding of the sectors under question.

3.3. Limitations

Although it is possible that there is some industry, currently minuscule in size, whose facilitation could really make the economy bustle; such an adapted form of infant industry analysis will not be pursued mainly due to its politically sensitive nature. On that note, economic policy objectives such as energy security or the promotion of an industry as part of a means to an end at the higher political level (for example, agriculture for preserving an aspect of culture) will not be taken into account as such considerations are prone to change and lie beyond the scope of our research. Furthermore, infrastructure and education as separate sectors will not be looked at as potential “spheres” of the economy. The argument for this is that their effects on the overall economy are undisputedly positive and wide-ranging on a general level. What is more, international factors such as the trends in raw material or output product prices will not be looked into with the only argument to show for it that a sound-functioning sector would be able to specialise so as still to maintain profitability as well as that evaluating this aspect would lie beyond the scope of our research question.

Moreover, the issue of distortions to monopolistic competition will not be considered up to the coordination problem analysis phase where the structure of the economic sectors on the firm level will be considered. Also, if the presence of one or several dominant market participants does prove to be true, it will be accounted for in our further analysis and conclusions, as well as examined as a possible source of impediments to coordination.

Finally, it is worth at least briefly considering the concept of the “optimal” level of linkages in analysing the economy and in interpreting the results of this research. Namely, the sectors that are the main driving engines of economic activity are simultaneously the same that have the largest adverse effect during economic crises. Despite this possible double-edged effect, the purpose of our research is to identify coordination problems whose resolution would greatly benefit the overall economy, something that relies on a sector having strong linkages.

4. Determining Key Industries

4.1. Industry Linkage Analysis

Backward and Forward Linkages

Previous papers claim that only sectors that have higher than average linkages in both directions should be called key industries and we closely follow such an approach judgment (Humavindu & Stage, 2013). Hence, as mentioned before, the first and main step in determining the key industries is looking at the linkages between sectors in order to narrow down the list of sectors for further inspection. As we can observe from Table 1, altogether 10 industries have both backward and forward linkages above 1; 1 being the general rule of thumb (Humavindu & Stage, 2013). In effect, we find that the manufacture of computers, electronics and optical products, electrical equipment, basic metals, fabricated metal products and chemicals score the highest in terms of connectedness in this order respectively. After the fifth-best performing industry, there is an apparent cut-off point as starting from the sixth-best industry either one of the linkages is at a very poor level or both do not adequately high scores for both linkages if compared to the top 5 performers. Hence, it is based on such argumentation and judgement that we proceed with the analysis of the top 5 performers.

Total System-Wide Linkages

We next turn to the total output multipliers depicted in Table 1 to measure the total linkages with the economy or, in other words, the impact of one monetary unit change in the final demand for an industry on the total output of all industries, including the sector itself (Reis & Rua, 2006). Consequently, the multipliers of the manufacture of computers, electronics and optical products and the manufacture of electrical equipment score the highest, while the manufacture of basic metals, fabricated metal products and chemicals and chemical products follow with some distance in the order listed.

This implies that if the demand for computers, electronics and optical goods were to go up by one monetary unit, the economy as a whole would produce goods worth of 4.8469 monetary units. In effect, this helps us understand the relative strength of the linkages which indicate a higher capability of a given sector to have a stronger effect on the economy (Dumaua, 2010). As already stressed in the methodology part, the total output multiplier is perhaps the most vital metric in discovering the key industry within an economy in our analysis.

Income Multiplier

In terms of generating income, we can immediately notice from Table 2 that not only does the manufacture of computers score the best relative to the other four sectors but it also exhibits the best score in the overall economy rankings. Interestingly enough, it is next followed by basic metals, with quite a gap yet still holding the overall 3rd place within the economy. The manufacture of chemicals follows with a pronounced drop in both absolute terms and rank-wise at the 10th place, with fabricated metal products just below it at the 11th place. The list ends with electrical equipment at the 15th position, which is twice as bad of a score in absolute terms as the manufacture of computers but still a decent score overall.

These results are quite crucial as they indicate that, for example, a one monetary unit increase in the final demand for the manufacture of computers would add 0.8769 to the overall income within the economy.

Employment Multiplier

We can see in Table 3 that, in terms of the employment multiplier, out of the five industries manufacture of computers scores the highest. It is followed by fabricated metal products, basic metals, electrical equipment and chemicals – all with similar gaps in between. Hence, if all of these sectors would undertake an equal investment, then the most jobs would be created by the fabricated metal products industry. The results are hardly surprising since the lowest-wage, an aspect we touch upon later in our analysis, and most labour-intensive sector would typically emerge as the key sector according to this metric (Humavindu & Stage, 2013).

Coefficients of Variation

A high Coefficient of Variation (CoV) indicates that a sector relies heavily on a small number of other industries, whereas a low CoV implies dependence from numerous other sectors (Reis & Rua, 2006). Our analysis, as can be found in Table 4, shows that none of the top five industries boast a CoV less than 1, implying that no sector has widely dispersed linkages and the connections are mostly with a relatively small number of industries. However, it is worth bearing in mind that the high share of export (more than 90% of GDP in 2012) in the Estonian economy provides a downward bias for the figures, just like almost all industries, as the CoV does not account for exports (Trading Economics, 2014). Therefore, we do not place strong emphasis on this parameter in our analysis, especially as all our sectors score above 1.

4.2. Industry Stand-Alone Analysis

4.2.1. Main Parameters

GDP

First off, the five industries shortlisted through analysing their linkages with other industries are examined with respect to their sheer weight within the economy. In other words, we look at their share in total output in Table 5 to assess the power with which the changes in their operations have an impact on the landscape of the economy. We find that the manufacture of computers is clearly the leader in this sense with an almost twice as large of a value of total output as the next sector – fabricated metal products. What is more, even in the overall rankings the manufacture of computers takes the 7th place among all other sectors, with the top runners including such dispersed spheres as retail, wholesale, warehousing and support activities for transport (Statistics Estonia, 2013). These then also after a very large gap are followed by manufacture of electronics and the chemicals sector with practically identical scores. Basic metals, on the other hand, lags behind heavily with a figure more than ten times smaller than that of the electronics and chemicals sectors.

Industrial Production

It is also worth analysing the weight of our sectors in industrial production, an often emphasised cornerstone of a productive, export-generating economy and, more topically, as an essential feature to economic recovery and stability. While we try to avoid the domain of economic policy, we find that employing industrial production as another parameter to help us choose an industry is acceptable as all the sectors under consideration fall under manufacturing. Consequently, from Table 6 we can see that the manufacture of computer, electronic and optical products comes first with the striking trend of tripling its share in industrial production since 2009, an increase based primarily on its own growth. What makes it all the more noticeable is that none of the other 4 sectors exhibit noteworthy growth relative to other industries over time. At a greatly smaller level of output it is followed by fabricated metal products, after which electrical equipment and chemicals yield similar figures approximately twice as low as fabricated metals. Finally, basic metals perform worst standing at a tenth of the figure of the previous two considered.

Export Generation

An important aspect to look at is the capacity to generate exports, which we analyse using the current and historical trade balances of the sectors under consideration. As can be seen in Table 7, there are marked differences between what figures our so far shortlisted industries yield. In a nutshell, fabricated metal products and electrical equipment are among the economy-wide leaders and rank next to each other with a quite an insignificant difference. Computer, electronic and optical products is not far behind with only a slightly lower score, but still standing at the overall 6th rank in importance. The manufacture of chemicals, however, is located very much down the list with an insignificantly positive trade balance. Lastly, basic metals has by far the lowest performance by being one of the sectors of the whole economy with the most negative trade balance, miles away from the other four sectors. As we can see from Table 8 that depicts the historical evolution of the 5 sectors over the years, there have been no dramatic changes over the years with mostly the three current top sectors interchanging positions as the figures do stand relatively close to one another.

Research and Development

If we take a quick look at Table 9, we see that electrical equipment has the highest score, followed with some distance by chemicals with both sectors taking the overall 5th and 6th ranks respectively among all the sectors in the economy. They are then followed by the manufacture of computers with a twice as low of a figure as that of electrical equipment, but still at a good – 8th overall position. Both metal sectors score very poorly in this degree, with at least 10 times lower expenditures on R&D as electrical equipment. What must also be noted is that when we examine the historical trends, we see that R&D has quadrupled in electrical equipment since 2009, somewhat fluctuated around its current level in chemicals and went down substantially in fabricated metals.

Value-added

While we would ideally like to also follow the advice of Midmore, Munday and Roberts (2006) by looking at the value-added aspect in terms of what reaches the household level, due to a lack of data we make due with a general evaluation how much they contribute to the whole economy. Doing this, however, is not straightforward as the Statistics Estonia database, from which we draw almost all of our data, provides a sufficient disaggregation by industry only up to the year 2009 and afterwards groups together the two metal-related sectors which we wish to consider separately. As a result, if we look at the latest data of 2012 from Table 10, we see that the largest value added of the 4 sectors comes from the one hindering our interpretation, namely, basic metals and fabricated metal products. Furthermore, electrical equipment and computers, electronic and optical products come next with a strong drop, followed by chemicals with, again, quite a gap. The historical trend also seems to support the current ranking with only the two electronics sectors interchanging rankings. Yet to better understand which of the two metallic sectors create the largest share of the value added, we look at Table 11 which displays an older statistic which has these sectors noted down separately. We then see that fabricated metal products take up the lion's share (over 97%) of the combined figure of the value added for both industries. What is more, even as a stand-alone figure, the manufacture of basic metals comes last with a huge break between its result and that of the previously worst performing sector – manufacture of chemicals.

Regarding the relatively low figures of value added, it must be noted that the more interlinked the sector is to the domestic economy, the lower its isolated coefficient of value-added due to deriving a lot of its value from outputs of other industries. Nevertheless, even industries with low scores are still often regarded as part of the high value-added end due to their role, often the final stage, in creating a product of high value domestically. Hence, as our study is primarily focused upon the aspect of linkages within the industry and boosting economic activity as a whole on the basis of a single sector, we don't search explicitly for industries that create all of the value without major interaction with other sectors. Rather, we prioritise the sectors out the already shortlisted industries which fare relatively better in this metric.

4.2.2. Social Parameters

Employment

What regards employment, it clearly visible from Table 5 that fabricated metals is a clear leader in this sense with more than twice as high number of employees than the next two industries – both electric product sectors which yield very close results. The manufacture of chemicals again follows with a twice lower score and basic metals show a very meagre figure – one 36 times lower than that of fabricated metals. Furthermore, this order of significance appears to hold quite firmly if we examine the figures in preceding years.

Labour Productivity

On a related note, it is interesting to examine the labour productivity parameters among our selected industries to account for how productive are their respective employees in generating value. In Table 5 we find that the largest levels of labour productivity per employee can be found in the computers and electronical products sector, followed with a large gap by chemicals and then by basic metals and electronics with sizeable gaps between them. What is interesting is that, despite appearing to be the most capital intensive industry of the five, fabricated metals comes last at almost four times as low of a level of productivity as in the manufacture of computers and electronical products. And while in the case of fabricated metals this can partially be explained by the industry also being the largest employer of the list as discussed previously, the same logic cannot be applied when looking at the manufacture of computers and the manufacture of electronics having almost the same amount of employees but labour productivity levels that differ three-fold.

Wages

On a whole, the aggregate wage level in manufacturing has been consistently just below the average wage in Estonia for the last 4 years or so (Statistics Estonia, 2013). Yet we find in Table 12 that there are quite sizeable differences among our five sectors – electronics, chemicals and fabricated metals have an average gross monthly wage of around 1100€. Furthermore, the manufacture of computers has an even lower average wage – around 900€ and basic metals, which does not have data available for the last two years, stood at just below 700€ in 2009 – the lowest figure then.

4.2.3. Externalities

When speaking of externalities, we choose to inspect the selected economic sectors with reference to their effect on the environment as our primary way of estimating their negative externalities. Firstly, we take a look at Table 13 where we can see the extent to which these sectors harm the environment through air pollution. The chemicals sector appears to be the main pollutant, while fabricated metals seems to be next in line by scoring very poorly on almost all the indicators. For example, besides scoring very bad on other measurements as well, the sector of chemicals has a higher carbon monoxide and solid particle emissions level than the other industries under consideration combined. Moving on, basic metals and the manufacture of electrical equipment seem to be quite even, as each has larger emissions in some components (sulphur dioxide for basic metals and solid particles and volatile organic compounds for electrical products) yet not as severely as fabricated metals and chemicals. Finally, the manufacture of computers seems to score the best among the five.

Furthermore, if we look at total waste generated by economic activity (Table 14), we see that both metal sectors create the largest amount of total waste while both electronics sectors have a much lower combined figure followed by an even lower one for the chemicals sector. Nevertheless, it must be noted that the chemicals sector creates the largest amount of hazardous waste of the three, an aspect that deteriorates its standing.

Lastly, what must also be noted is that among the five industries, only the manufacturing process of chemicals contributes significantly to the production of gases and organic compounds that have a gravely adverse effect on the depletion of the ozone layer (Statistics Estonia, 2008).

4.3. Conclusions

First of all, the manufacture of basic metals appears to perform strikingly more poorly than the other four in most fields, such as trade balance, share in value added, R&D expenditures, industrial production as well as socially-oriented figures like employment generation and the wage level. Furthermore, basic metals are average at best in terms of its externalities and its small overall industry size also deteriorates its status as a key industry. Therefore, despite good figures in both the employment and income multipliers (relative to the other four sectors, as all five rank well on an overall scale), we drop basic metals as clearly inferior to the other four in our list of candidates for key industry coordination analysis.

Furthermore, it is clear that manufacture of chemicals stands apart from the sectors left by a gap that is not present in between both industries of electronics and that of fabricated metals. For instance, comparing to the other three, over the years it has constantly performed very poorly in its trade balance, has the lowest level of direct employment generated as well as the lowest employment multipliers. And even in such parameters as total industry linkages and industrial production where it fairs relatively well to other industries, it is still the last among the four. What is more, the chemicals sector is clearly the most hazardous to the environment by not only having the largest adverse impact both in terms of air pollution and generation of hazardous waste, but also being the only of the four that has a pronounced negative effect by contributing to the depletion of the ozone layer. Hence, we decide that having a good level of R&D expenditures is not enough to justify keeping this industry in our list of key industries under consideration.

As a result, we are left with three industries: manufacture of electrical equipment; manufacture of computers, electronics and optical products and manufacture of fabricated metals. And while each of these industries fares better in some statistics and worse in others, we find that the gap between them is too small for us to be able to discard one of them. In fact, we believe such an act to be imprudent as it would limit our capabilities to effectively research coordination problems if information and data proves inaccessible for one reason or another at one industry or if it has a very high level of coordination as it stands. With this we answer our first sub-question that **the manufacture of electrical equipment; manufacture of computers, electronics and optical products and manufacture of fabricated metals are industries within Estonia that due to their strong links with other sectors and standalone importance within the economy can be considered as key industries.** It is therefore in this light, that we proceed to analyse them further in terms of their level of coordination.

5. Analysis of Industry-level Coordination Problems

Having identified our three sectors, we began to research their industry structure more in depth and contacted the representatives of businesses, associations as well as people from the public sector who could give us another perspective on their operations. The most notable piece of information that we received straight away from our interview with a representative from an association deeply involved with electronics-related companies was that there is hardly any real-life further distinction between businesses once you arrive at the general "electronics" classification. Moreover, he suggested merging both of our sectors to ease analysis as he attested to the high level of connections, economic exchange and similar problems both of them are facing. Before we made this decision, however, we contacted the Ministry of Economic Affairs of Estonia for a statistical overview of our three spheres of interest. Surprisingly enough, when asked for data concerning both electronics sectors, the Ministry representative could only provide us with a combined data set, coinciding with the view of the association that they also do not differentiate between more specific business types within the broader electronics sphere. As a consequence, we followed their advice and, thus, merged the manufacture of computers, electronics and optical products and the manufacture of electronic equipment into one industry – electronics, which we consider further for coordination analysis.

What concerns the communication process itself, both the individual firm and association representatives from the joint electronics sector were very willing to set up interviews, share their opinion and generally were very cooperative towards our coordination analysis. With the fabricated metals industry it was not all that easy to engage with firm participants and our preliminary correspondence and attempts to set up interviews were somewhat one-sided.

As a result, while we could attempt to look for more advanced channels through which we could contact the fabricated metals sector and proceed with our analysis of this sector as well, we decided to concentrate all of our efforts on a more in-depth examination of the electronics sectors. The main argument behind our decision being that both underlying sectors combined considerably outweigh the fabricated metals industry in terms of the new combined sector's stand-alone parameters as well as retaining its superior standing in terms of linkages. Hence, we continue with the analysis of the electronics sector.

5.1. The Electronics Sector

First off, as we examine the firm-level disaggregated statistical tables, it is immediately obvious that there is one dominant player in the industry – Ericsson and several other very large companies that together take up the lion's share of the sector. This is an important aspect to consider, as many interviewees have expressed the notion in line with de Fontenay's (2004) findings that often the participation of a single industry in a certain project or initiative can severely increase the political lobby power and efficiency of the proposal. What is more, many firms, including some of the largest, are subsidiaries of multi-national corporations (MNCs) and thus the decisions regarding many aspects of their operations come from their respective MNC's headquarters. Lastly, it is very typical for the electronics companies operating in Estonia to export as much as over 90% of their output.

Furthermore, the operations of most electronics companies in Estonia are very specific relative to one another, despite most of them taking up the lower value-added position of the global electronics supply chain. In effect, one company differs substantially in its operations, and therefore required skill-set for employees. Furthermore, what often impedes joint efforts of representation both locally and abroad for finding export partners or suppliers is that some companies sell their produce to businesses as components of production, some sell to consumers and some serve as parts of complicated MNC supply chains. As a side note, many MNC local divisions also prefer to use their MNC channels of marketing which further decreases room for coordination, as well as potentially reduce the positive spillovers of both formal and informal knowledge associated with shared sales networks (Midmore, Munday, & Roberts, 2006).

Regarding the supply side, although many company representatives have expressed their willingness to switch towards using more local suppliers in such spheres as plastics and metal components, they are unable to do so due to a lack of capacity of local companies. In effect, they remain with their suppliers originating in MNC networks, despite, as one interviewee mentions, the potentially lower cost due to a closer distance and higher quality they typically receive from local producers. However, we choose not to analyse this further as an industry-based coordination problem, as it concerns the links between various different industries (electronics, metals, plastic products) and is arguably a matter of supply and demand as the problem would not exist if local firms could supply sufficient quantities.

Another important aspect to consider is the level of coordination in the electronics sector at the association level as it is an already existing form of inter-firm coordination. It serves mainly as a platform for networking; it occasionally communicates with the government and expresses the needs of the sector; it represents its participants' interests in exhibitions; it provides joint trainings. As already mentioned beforehand, the MNC aspect makes some association activities more complex.

What must also be mentioned is that there are various cluster programs, which Forni and Paba (2002) indicate as typical catalysts for positive spillovers, as well as joint projects on-going between several industry participants as well as educational institutions that many interviewees see as bringing visible synergies and good results. However, all of the industry participants interviewed still express concern over the quality of education despite whatever arrangements might exist currently, as discussed more in depth later in this chapter.

All in all, we could say that the industry does already possess quite a reasonable amount of effort to coordinate interests for the mutual benefit to the firms involved. However, the presence of one dominant actor as well as most of the largest companies belonging to MNC structures does pose impediments to cooperation on a local level for more efficient outcomes in terms of their subsidiaries in Estonia. Furthermore, we must also point out that the nature itself of many of the businesses involved in the electronics sector of Estonia creates significant limitations and obstacles to coordinated action even if almost every firm faces similar problems.

5.2. Coordination Problems

Education and Labour

By and large, a shortage of a competent labour force was indicated as the biggest issue the industry is facing. The interviewees highlighted the lack of practical knowledge of fresh graduates and stressed that currently universities are concentrating too much on the theoretical side. And although all of the respondents stated that some form of cooperation, depending on the location of the firm, exists with all the major universities in Estonia, the firms are not eager to cooperate with each other in this matter. What happens is that instead of merging their efforts and lobbying their problem on the government level through the association, firms attempt to tackle the matter of education individually, meaning that enterprises are not coordinating their action. In effect, the widespread approach of individually training and preparing the future employees (often from, as they put it, ground zero) drains each firm's resources which could be spent more effectively in actual production.

From what we have learned from the interviews, we strongly believe that despite some set-backs that come from some MNC divisions using their own "employee supply chains" and trainings, the big issue here is the fragmented structure of the sector. Namely, most of the companies have their own niche in production, which means that every company needs qualified engineers and machine operators with a very specific set of skills. At a glance it would seem like this factor restrains coordinated efforts in resolving the issue and the in-house trainings and bilateral university deals must continue. Yet it becomes obvious that the current uncoordinated effort can hardly produce the most optimal result in terms of education meeting the market needs as every company lobbies for its own specific needs and this leaves out the demand for skills required by other companies. For example, each individual firm has a smaller say than if many companies were to lobby this issue together, meaning that its interests could be better represented if they combined their efforts. In addition, whatever demands are half-satisfied; those of other companies are left out at the same time as the firm argues only for its own position. We use the strong wording of "half-satisfied" believing that the situation that almost all interviewees indicated having a lot of bilateral agreements with universities and yet a very bad situation with the level of skills among new employees as highly undesirable from all points of view.

As a consequence, a clear suggestion here would be to establish a working group for creating a common concept of what skills are required and the general direction of education necessary as well as possibly coordinated mentorship arrangements that could be efficiently distributed among educational facilities.

Research and Development

What is more, respondents stated that in terms of R&D, cooperation is practically non-existent. As a side note, there are some cluster projects that also include universities, yet they operate on a small scale and lack coordinated investment that would give them the resources to carry out more substantial R&D projects such as prototype testing. The majority of the Estonian electronics companies are subsidiaries of large MNCs; therefore, product development is rarely located in Estonia. As one firm put it, the knowledge in their MNC group's network is already available and involving somebody from the outside is not necessary because the competence is available to them. However, despite the MNC close circuit operating style, some representatives said that the willingness for joint R&D locally is there, but yet again the lack of resources in terms of local experts and abilities to deliver at larger volumes is holding this initiative back. Furthermore, they mentioned various benefits such as being able to quickly adapt to changes in product design and relatively lower costs of having an R&D centre in Estonia. Several company representatives also expressed bright outlooks about the future, saying that the sector in Estonia has "accustomed" itself with its current position in the supply chain and could start growing towards more value-added and knowledge-intensive operations. Yet in order to move up in the value chain and move to product design instead of more simple tasks such as contract manufacturing, one cannot overstress the role of domestic R&D.

In essence, we find that these shortcomings in coordinating technical development are eventually going to pose serious impediments for the electronics industry to start producing higher value-adding goods and moving up in the global value chain. What is more, the lack of coordination in this matter is clearly not the most efficient equilibrium as many firm representatives have expressed their support for expanded local R&D possibilities and attested to how they would clearly benefit from such a step, yet would not undertake it on their own.

5.3. Summary

As one interviewee stated, the stronger roots in terms of common R&D, inter-company cooperation in addressing industry needs and local suppliers companies of the electronics sector have in Estonia, the less likely they are to become passive recipients of external shocks and decisions. And while there is already some cooperation happening at the association and bilateral relationship level, we would greatly encourage seriously discussing the potential of a more coordinated stance regarding education as well as more integrated efforts regarding local R&D possibilities. Hence, with this we answer our second sub-question, stating that **there are notable impediments (education and R&D) to the development of a key sector (electronics) that are not solved by individual economic agents.**

6. Conclusions

Our aim was to identify the key industry in the Estonian economy and examine the potential of solving coordination failures in that sector. For the purpose of clarity, we structured our work into two parts with corresponding sub-questions and hypotheses.

The first part serves to identify the most vital industries, for which we used a range of quantitative metrics that measure linkages, such as the output multiplier as well as the strength of backward and forward linkages an economic sector has. In addition, stand-alone data such as contribution to GDP, employment and export generation were used for complementary analysis in order to attain a more comprehensive picture of the sectors under consideration. Hence, we are not able to reject our first hypothesis of there being key industries in the Estonian economy as our analysis determined three sectors: fabricated metals, electrical equipment and computers, electronics and optical products as the most vital economic spheres. Out of the three, we chose to proceed with the analysis of the two electronics industries as one sector, due to it considerably outweighing the fabricated metals industry in terms of linkages and discretionary parameters when combined.

After identifying the electronics sector as the key industry, we proceeded with the second, qualitative analysis part by conducting unstructured interviews with industry participants to gain a more in-depth view of the sector at the business level, evaluate the level of cooperation and study potential coordination failures. Consequently, we found that the lack of coordination in education in terms of the labour market is a noticeable impediment to the electronics industry. In addition, practically non-existent cooperation in domestic R&D further constrains the capabilities of the sector to move higher up in the global electronics value chain. Taking all of the latter into account, we cannot reject the second hypothesis about impediments to the key industry.

Finally, we find that the potential for improved cooperation in the electronics industry is moderate, yet still considerable enough for the companies to address the existing coordination problems. Furthermore, the resolution of these impediments would lead to a markedly beneficial effect on the overall economy of Estonia due to electronics' key role. In conclusion, since Estonia is slowly losing its advantage of being a low-wage country for labour-intensive industries, such positive developments are of paramount strategic importance as otherwise the sustainability of the electronics sector in Estonia might become increasingly vulnerable.

References

Audretsch, D. B., & Feldman, M. P. (1996). R&D Spillovers and the Geography of Innovation and Production. *American Economic Review*, 630-640.

Baland, J.-M., & Fracois, P. (1996). Investment Coordination and Demand Complementarities. *Queen's Economics Department Working Papers.*

Basher, A. (1997). Linkages and Leakages : A Sectoral Tracking in Bangladesh Economy. *The Bangladesh Development Studies*, 71-94.

Bhardwaj, R. N., & Chadha, R. (1991). Sources of Growth and Inter-Industry Linkages in Indian Economy with Special Reference to the Manufacturing Sector*. *Indian Economic Review*, 189-219.

Cella, G. (1984, January). The Input-Output Measurement of Interindustry Linkages. *Oxford Bulletin of Economics and Statistics*, pp. 73-83.

D'Hernoncourt, J., Cordier, M., & Hadley, D. (2011). *Input-Output Multipliers – Specification Sheet and Supporting Material.* Brussels: Spicosa Project Report.

de Fontenay, C. C. (2004). The Dual Role of Market Power in the Big Push: From Evidence to Theory. *Journal of Development Economics*, 221-238.

Dedegkajeva, I., & Parve, R. (2005). Compilation of Product-by-Product Input-Output Table for Estonia. *15th International Conference of Input-Output Techniques.* Beijing.

Dumaua, M. B. (2010). *Input-Output Multiplier Analysis for Major Industries in the Philippines.* Manila: 11th National Convention on Statistics.

Easterly, W. (2002). *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics.* Cambridge: MIT Press.

Ellingsen, T., & Johannesson, M. (2004). Is There a Hold-up Problem. *Scandinavian Journal of Economics*, 475–494.

Forni, M., & Paba, S. (2002). Spillovers and the Growth of Local Industries. *The Journal of Industrial Economics*, 151-171.

Henderson, V., Kuncoro, A., & Turner, M. (1995). Industrial Development in Cities. *Journal of Political Economy*, 1067-1090.

Hewings, G. J. (1982, June). The Empirical Identification of Key Sectors in an Economy: A Regional Perspective. *The Developing Economics*, pp. 173-195.

Humavindu, M. N., & Stage, J. (2013). Key Sectors of the Namibian Economy. *Journal of Economic Structures*, 1-15.

Jodar, E. (2011). *Key Sectors in Greenhouse Gases Emissions in Switzerland: An Input-Output Approach.* Barcelona: Autonomous University of Barcelona.

Klenow, P. J., & Rodriguez-Clare, A. (2005). *Handbook of Economic Growth.* Elsevier B.V.

Magruder, J. R. (2011). Can MinimumWages Cause a Big Push? Evidence from Indonesia. *Journal of Development Economics*, 48-62.

McGilvray, J. W. (1977). Linkages, key sectors and development strategy. *Structure, System and Economic Policy*, lpp. 49-56.

Meller, P., & Marfán, M. (1981). Small and Large Industry: Employment Generation, Linkages, and Key Sectors. *Economic Development and Cultural Change*, 263-274.

Midmore, P., Munday, M., & Roberts, A. (2006). Assessing Industry Linkages Using Regional Input–Output Tables. *Regional Studies*, 329–343.

Morck, R., & Nakamura, M. (2007). Business Groups and the Big Push: Meiji Japan's Mass Privatization and Subsequent Growth. *NBER Working Paper Series*.

Murphy, K. M., Shleifer, A., & Vishny, R. W. (1989). Industrialization and the Big Push. *The Journal of Political Economy*, 1003-1026.

Okuno-Fujiwara, M. (1988). Interdependence of Industries, Coordination Failure and Strategic Promotion of an Industry. *Journal of International Economics*, 25-43.

Ray, D. (1998). *Development Economics.* Princeton: Princeton University Press.

Reis, H., & Rua, A. (2006). *An Input-Output Analysis: Linkages vs Leakages.* Lisbon: Working Papers.

Shea, J. (2002). Complementaritiesa nd Comovements. *Journal of Money, Credit and Banking*, 412-433.

Smith, H. M. (1949). *Leontief's Input-output Studies as a Basis for Specific Multipliers.* Chicago: University of Chicago.

Statistics Estonia. (2008, May 29). *EN204: USE OF SUBSTANCES THAT DEPLETE THE OZONE LAYER BY ECONOMIC ACTIVITY*. Retrieved February 2, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2012, October 29). *EN068: WASTE GENERATION BY KIND OF WASTE AND ECONOMIC ACTIVITY (EMTAK 2008)*. Retrieved February 14, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, March 1). *FS008: ENTERPRISES' VALUE ADDED AND PRODUCTIVITY MEASURES BY ECONOMIC ACTIVITY (EMTAK 2008) AND NUMBER OF PERSONS EMPLOYED*. Retrieved February 14, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, June 17). *WS5241: AVERAGE MONTHLY GROSS AND NET WAGES (SALARIES) BY ECONOMIC ACTIVITY (EMTAK 2008 DIVISIONS)*. Retrieved February 14, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, October 4). *EN027: POLLUTION OF AIR FROM STATIONARY SOURCES BY ECONOMIC ACTIVITY (EMTAK 2008) AND COUNTY*. Retrieved February 14, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, October 10). *FT02: EXPORTS AND IMPORTS OF GOODS BY ECONOMIC UNIT'S SITE OF REGISTRATION, ECONOMIC ACTIVITY (EMTAK 2008) AND CN COMMODITY SECTION*. Retrieved February 12, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, July 2). *IN001: INDUSTRIAL PRODUCTION AT CURRENT PRICES BY ECONOMIC ACTIVITY (EMTAK 2008)*. Retrieved February 12, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, September 9). *NAA045: VALUE ADDED BY ECONOMIC ACTIVITY (EMTAK 2008)*. Retrieved February 12, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, November 6). *NAA046: VALUE ADDED BY ECONOMIC ACTIVITY (EMTAK 2008 DIVISIONS)*. Retrieved February 12, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, December 30). *NAT0007: INPUT COEFFICIENTS, DOMESTIC OUTPUT AND IMPORTS*. Retrieved February 14, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, December 30). *NAT0009: INVERSE COEFFICIENTS, DOMESTIC OUTPUT AND IMPORTS*. Retrieved February 14, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, December 3). *RD027: INTRAMURAL R&D EXPENDITURE IN BUSINESS ENTERPRISE SECTOR by Year, Economic activity (EMTAK 2008) and Kind of expenditure*. Retrieved February 12, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Statistics Estonia. (2013, June 17). *WS5211: AVERAGE MONTHLY GROSS AND NET WAGES (SALARIES) BY ECONOMIC ACTIVITY (EMTAK 2008)*. Retrieved February 14, 2014, from Statistics Estonia Statistical Database: http://pub.stat.ee/px-web.2001/Dialog/statfile1.asp

Todaro, M. P., & Smith, S. C. (2011). *Development Economics*. Boston: Addison Wesley.

Trading Economics. (2014, February 12). *World Bank Indicators: Estonia: National Accounts: Exports of Goods and Services*. Retrieved February 14, 2014, from Trading Economics Web site: http://www.tradingeconomics.com/estonia/exports-of-goods-and-services-percent-of-gdp-wb-data.html

University of Washington. (2002). *I/O Multipliers*. Retrieved February 14, 2014, from University of Washington Supporting Pages: https://faculty.washington.edu/krumme/systems/multp.html

Vogel, S. J. (1994). Structural Changes in Agriculture: Production Linkanges and Agricultural Demand-Led Industrialization. *Oxford Economic Papers*, 136-156.

Wang, P. (2013, Februrary). Big Push Theory. St. Louis, Missouri, United States of America. Retrieved October 28, 2013, from http://pingwang.wustl.edu/Econ472/Growth%20Development-VI.pdf

Wood, A. (2005). Investment Interdependence and the Coordination of Lumpy Investments. *Applied Economics*, 37-49.

Appendix

Figure 6

Figure Depicting a List of Primary Questions Used in Interviews

1) Is there a general perception in the society that there are industries that are more vital than others in the public sector? What about the broader society – do you think one form or another of such a perception exists?
2) What would you say are the characteristics of economic sectors that bear more weight within the economy, what are their most vital properties?
3) What is the general attitude of the public sector towards what we could call the largest or perhaps leading industries?
4) Is there to your knowledge a department of the public sector or perhaps a research institute that has investigated potential coordination failures within the Estonian economy on the industry level?
5) Do you remember and could you name some examples of coordination failures from the past that involved the electronics industry?
6) If yes, then how were those issues solved?
7) What are the biggest "bottlenecks" in the electronics industry?
8) When do you believe is it easier to solve industry coordination problems?
9) How would you rate the current inter-industry effort and interaction to solve problems related to the industry by multiple industry participants?
10) Do industry associations and other platforms for interaction play a large role?

Note. As the interviews were unstructured, the interview questions were adapted to the conversation; hence, these primary questions act as guidelines for investigating various spheres of concern that could then be inquired into more in-depth. Probes for each question are not mentioned in the list.

Source: Created by the authors

Table 1

Table Depicting Leontief Backward Linkages, Forward Linkages and Total Output Multipliers

Sector No	Sector	Backward linkages		Forward linkages		Total output	
		Rank	Multiplier	Rank	Multiplier	Rank	Multiplier
17	**Manufacture of computers, electronics and optical products**	**1**	**1,976953197**	**4**	**1,919143003**	**1**	**4,846851**
18	**Manufacture of electrical equipment**	**2**	**1,453713017**	**11**	**1,579855879**	**2**	**3,564035**
15	**Manufacture of basic metals**	**3**	**1,338230438**	**2**	**2,592527946**	**3**	**3,280909**
16	**Manufacture of fabricated metal products, except machinery and equipment**	**4**	**1,335173347**	**9**	**1,680755016**	**4**	**3,273414**
11	**Manufacture of chemicals and chemical products**	**5**	**1,306658581**	**1**	**2,724347345**	**5**	**3,203505**
5	Manufacture of food products, beverages and tobacco products	7	1,281387717	21	1,028149754	7	3,141549
13	Manufacture of rubber and plastic products	8	1,275012490	16	1,230718055	8	3,125919
26	Sewage, waste collection, treatment and disposal activities	11	1,236628154	10	1,672687299	11	3,031813
19	Manufacture of machinery and equipment (not elsewhere classified)	14	1,196755857	19	1,076029779	14	2,934059
34	Warehousing and support activities for transportation	24	1,059661134	3	2,526757267	24	2,597947

Note. The table depicts only sectors for which both the backward and forward linkages exceed 1 – the rule of thumb for considering them as key industries in terms of linkages. The total requirements multiplier ranking indicates the rank of a sector relative to sectors listed.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 2

Table Depicting the Income Multipliers of Short-listed Economic Sectors

Sector No	Sector	Income multiplier	Rank
17	Manufacture of computers, electronical and optical products	0,8769	1
15	Manufacture of basic metals	0,6661	3
11	Manufacture of chemicals and chemical products	0,5279	10

16	Manufacture of fabricated metal products, except machinery and equipment	0,5179	11
18	Manufacture of electrical equipment	0,4372	15

Note. The ranking is absolute and indicates the rank of a sector as in 2012.

Source: Created by the authors with figures calculated using data extracted from (Statistics Estonia, 2013) and (Statistics Estonia, 2013)

Table 3

Table Depicting the Employment Multipliers of Short-listed Economic Sectors

Sector No	Sector	Employment multiplier	Rank
17	Manufacture of computers, electronical and optical products	0,1907	1
16	Manufacture of fabricated metal products, except machinery and equipment	0,1525	2
15	Manufacture of basic metals	0,1387	3
18	Manufacture of electrical equipment	0,1320	4
11	Manufacture of chemicals and chemical products	0,1316	5

Note. The ranking is relative to the other sectors listed.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013) and (Statistics Estonia, 2013)

Table 4

Table Depicting Leontief Backward and Forward Linkage Coefficients of Variation

Sector No	Sector	Rank	Coefficient of variation (backward linkage)	Rank	Coefficient of variation (forward linkage)	Sum	Rank (Sum)
16	Manufacture of fabricated metal products, except machinery and equipment	2	1,169735922	2	1,354947583	4	1
18	Manufacture of electrical equipment	4	1,221787979	1	1,312826922	5	2
11	Manufacture of chemicals and chemical products	1	1,156865383	5	1,731502607	6	3
15	Manufacture of basic metals	3	1,171107388	4	1,688578651	7	4
17	Manufacture of computers, electronics and optical products	5	1,429070841	3	1,449609843	8	5

Note. All rankings are relative to the sectors listed. The sum indicates the standing of the sector relative to both coefficients.

Source: Created by the authors using coefficients calculated from data extracted from (Statistics Estonia, 2013)

Table 5

Table Depicting Employment, Production Value and Labour Productivity Figures of Short-listed Economic Sectors

Sector No	Year	Sector	Number of persons employed	Production value, thousand euros	Labour productivity per person employed on the basis of turnover, thousand euros
11	2010	Manufacture of chemicals and chemical products	2285	334687,3	159,5
15		Manufacture of basic metals	390	39589,6	104,7
16		Manufacture of fabricated metal products, except machinery and equipment	11068	820451,7	76,9
17		Manufacture of computer, electronic and optical products	5542	900325,9	165,5
18		Manufacture of electrical equipment	4344	377177,9	92,6
11	2011	Manufacture of chemicals and chemical products	2401	497737,4	215,4
15		Manufacture of basic metals	389	42308,6	127,4
16		Manufacture of fabricated metal products, except machinery and equipment	11715	1046538,9	93,2
17		Manufacture of computer, electronic and optical products	5789	1641943,5	287,4
18		Manufacture of electrical equipment	4780	479368,3	105,5
11	2012	Manufacture of chemicals and chemical products	2487	509188,6	220,7
15		Manufacture of basic metals	330	40259,5	144,7
16		Manufacture of fabricated metal products, except machinery and equipment	12095	929493,9	84,4
17		Manufacture of computer, electronic and optical products	5690	1728495,2	306,9
18		Manufacture of electrical equipment	5113	500730,8	107,3

Note. Labour productivity per person employed is calculated in the following way: (turnover + operating subsidies) / persons employed.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 6

Table Depicting Composition of Industrial Production by Short-listed Economic Sectors

Sector No	Sector	2009	Percentage of total	2010	Percentage of total	2011	Percentage of total	Rank
17	Manufacture of computer, electronic and optical products	353,2	5,66%	874,3	10,83%	1625,1	16,07%	1
16	Manufacture of fabricated metal products	602,4	9,65%	759,4	9,40%	948,3	9,38%	4
18	Manufacture of electrical equipment	310,2	4,97%	362,0	4,48%	462,7	4,58%	6
11	Manufacture of chemicals and chemical products	261,2	4,19%	323,0	4,00%	453,8	4,49%	7
15	Manufacture of basic metals	22,6	0,36%	38,0	0,47%	42,8	0,42%	23

Note. The ranking is absolute and refers to the level of industrial production in 2011.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 7

Table Depicting Trade Balances of Short-listed Economic Sectors in 2012

Sector No	Sector	Exports	Imports	Trade balance	Rank
16	Manufacture of fabricated metal products, except machinery and equipment	491555823	277219315	214336508	3
18	Manufacture of electrical equipment	578095831	369956684	208139147	4
17	Manufacture of computer, electronic and optical products	1640370597	1450053861	190316736	6
11	Manufacture of chemicals and chemical products	374631906	371419549	3212357	29
15	Manufacture of basic metals	32579821	42217564	-9637743	70

Note. The ranking is absolute and refers to the trade balance.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 8

Table Depicting Historical Trade Balances of Short-listed Economic Sectors

Year	Sector No	Sector	Exports	Imports	Trade balance	Rank in year
2010	11	Manufacture of chemicals and chemical products	235271336	203746610	31524726	4
	15	Manufacture of basic metals	32068710	35320968	-3252258	5
	16	Manufacture of fabricated metal products, except machinery and equipment	387889159	182462547	205426612	1
	17	Manufacture of computer, electronic and optical products	869374642	805057646	64316996	3
	18	Manufacture of electrical equipment	434236032	294030974	140205058	2
2011	11	Manufacture of chemicals and chemical products	355329140	347734192	7594948	4
	15	Manufacture of basic metals	34180042	42373226	-8193184	5
	16	Manufacture of fabricated metal products, except machinery and equipment	492282172	232869044	259413128	2
	17	Manufacture of computer, electronic and optical products	1657832945	1392354397	265478548	1
	18	Manufacture of electrical equipment	534326751	347786764	186539987	3
2012	11	Manufacture of chemicals and chemical products	374631906	371419549	3212357	4
	15	Manufacture of basic metals	32579821	42217564	-9637743	5
	16	Manufacture of fabricated metal products, except machinery and equipment	491555823	277219315	214336508	1
	17	Manufacture of computer, electronic and optical products	1640370597	1450053861	190316736	3
	18	Manufacture of electrical equipment	578095831	369956684	208139147	2

Note. The rankings indicate the rank of a sector relative to the other sectors listed in each year and refer to the trade balance.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 9

Table Depicting Research and Development Expenditures of Short-listed Economic Sectors

Sector No	Sector	2009	2010	2011	2012	Rank
18	Manufacture of electrical equipment	1146,8	1615,8	4046,2	4383,9	5
11	Manufacture of chemicals and chemical products	2638,3	3285,3	1541,1	3539,9	6
17	Manufacture of computer, electronic and optical products	3041,2	2887,8	2929,4	2319,9	8
16	Manufacture of fabricated metal products, except machinery and equipment	846,3	383,5	371,2	226,8	21
15	Manufacture of basic metals	0	0	0	0	27

Note. Unit: thousands of euros. The sectors under consideration are bolded. The ranking is absolute and indicates the rank of a sector as in 2012.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 10

Table Depicting the Contribution to GDP of Short-listed Economic Sectors

Year	Sector No	Sector	Value at current prices, million euros	Share in value added at current prices, percentages	Rank in year
2010	11	Manufacture of chemicals and chemical products	96,12300	0,76683	4
	15+16	Manufacture of basic metals and fabricated metal products, except machinery and equipment	239,49020	1,91055	1
	17	Manufacture of computer, electronic and optical products	123,78400	0,98750	2
	18	Manufacture of electrical equipment	105,15910	0,83891	3
2011	11	Manufacture of chemicals and chemical products	120,78980	0,85273	4
	15+16	Manufacture of basic metals and fabricated metal products, except machinery and equipment	266,44400	1,88100	1
	17	Manufacture of computer, electronic and optical products	174,36270	1,23094	2
	18	Manufacture of electrical equipment	133,52270	0,94262	3
2012	11	Manufacture of chemicals and chemical products	113,68360	0,74988	4
	15+16	Manufacture of basic metals and fabricated metal products, except machinery and equipment	231,53930	1,52728	1

	17	Manufacture of computer, electronic and optical products	136,04260	0,89737	3
	18	Manufacture of electrical equipment	139,27460	0,91869	2

Note. The rankings are relative to the other sectors listed in each year.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 11

Table Depicting the Disaggregated Contribution to GDP of Short-listed Economic Sectors in 2009

Sector No	Sector	Value at current prices, million euros	Share in value added at current prices, percentages	Rank
16	Manufacture of fabricated metal products, except machinery and equipment	207,25450	1,71168	1
17	Manufacture of computer, electronic and optical products	92,47319	0,76372	2
18	Manufacture of electrical equipment	91,16014	0,75288	3
11	Manufacture of chemicals and chemical products	65,05295	0,53726	4
15	Manufacture of basic metals	6,18933	0,05112	5

Note. The ranking is relative to the other sectors listed.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 12

Table Depicting Wage Levels of Short-listed Economic Sectors

Sector No	Year	Sector	Average monthly gross wages (salaries), euros	Rank in year
11	2010	Manufacture of chemicals and chemical products	927	3
15		Manufacture of basic metals	684	5
16		Manufacture of fabricated metal products, except machinery and equipment	930	2
17		Manufacture of computer, electronic and optical products	764	4
18		Manufacture of electrical equipment	934	1
11	2011	Manufacture of chemicals and chemical products	1020	2-3
15		Manufacture of basic metals	...	...
16		Manufacture of fabricated metal products, except machinery and equipment	1020	2-3
17		Manufacture of computer, electronic and optical products	813	4
18		Manufacture of electrical equipment	1028	1
11	2012	Manufacture of chemicals and chemical products	1097	1
15		Manufacture of basic metals	...	...
16		Manufacture of fabricated metal products, except machinery and equipment	1079	2
17		Manufacture of computer, electronic and optical products	879	4
18		Manufacture of electrical equipment	1044	3

Note. The rankings are relative to the other sectors listed.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 13

Table Depicting Air Pollution Generated by Short-listed Economic Sectors

Sector No	Sector	Nitrogen oxides	Sulphur dioxide	Carbon monoxide	Solid particles	Volatile organic compounds
11	Manufacture of chemicals and chemical products	40,14031	3,04498	315,6114	76,93835	91,7787
15	Manufacture of basic metals	0,63617	2,9468	69,25217	8,7208	1,50209
16	Manufacture of fabricated metal products, except machinery and equipment	30,25598	1,40034	25,39871	17,6008	107,7911
17	Manufacture of computer, electronic and optical products	2,36078	0	2,34078	0,47642	20,2089
18	Manufacture of electrical equipment	4,12942	1,73483	4,97775	14,71529	48,00139

Note. Unit: tons.

Source: Created by the authors using data extracted from (Statistics Estonia, 2013)

Table 14

Table Depicting Waste Generated by Short-listed Economic Sectors

Sector No	Sector	2008		2010	
		Total waste	Total non-hazardous waste	Total waste	Total non-hazardous waste
11+12+13	Manufacture of chemical, pharmaceutical, rubber and plastic products	43352	37646	30144	24622
15+16	Manufacture of basic metals and fabricated metal products	68441	62208	54426	52094
17+18+20+21	Manufacture of computers, electronic and optical products, electrical equipment and transport equipment	42427	41360	33662	32797

Note. Unit: tons.

Source: Created by the authors using data extracted from (Statistics Estonia, 2012)