Identifying Technological Capabilities with Different Degree of Coherence: The Challenge before Latecomer Companies to Enter the International Markets

The paper introduces the notion of coherence of technological capabilities. It argues that in analysing technological capabilities (TC) the analysis needs to go beyond investigation of individual capabilities and should take into account the level of coherence among constituent capabilities. The phenomenon of different degree of coherence of TC is detected while exploring the TC in Bulgarian software companies. Significant differences emerge between the TC of domestic-oriented vs. export-driven companies in the accumulation of individual capabilities. But it is the analysis of the coherence of TC, which proved capable to capture the real differences in capability accumulation: strong coherence occurs only in 'export' TC. This analysis revives the discussion about the prospects for developing latecomer software industries. Based on the results the study contests the 'walking on two legs' hypothesis and also points that the optimistic forecasts about the possibilities for leapfrogging by the latecomer countries by developing indigenous software industries have been overestimated.

Keywords: technological capabilities, software industry, leapfrogging

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1. Introduction

In the last two decades a group of studies has been emphasising that the information technologies (ITs) present a 'window of opportunities' for latecomer countries to catch-up by developing indigenous software industries [1]. It has been outlined that the availability of skilful human capital creates a solid base for development of an IT industry by the latecomers. The software industry is, in principle, low-capital but knowledge and skill-intensive industry, and the international market for software is big and growing [2]. For this reason, the discussion about developing indigenous software industries in the latecomer context has gained particular attention both in academic and policy literature for more than a decade [3].

However, developing a software industry in a latecomer or less-advanced context is not a straightforward task. To be successful and sustainable in time the development of the industry needs to involve accumulation of technological capabilities. Technological capabilities for software development are difficult to accumulate in a latecomer context, and the difficulties arise from the very nature of technological knowledge and the complexity of the learning process in a latecomer context. The success in building capabilities depends entirely on the latecomer companies' deliberate efforts to upgrade, and in this sense, development of technological capabilities is a challenge for the latecomers. Very few latecomer companies have managed to enter the international markets and this fact amplifies the need to scrutinise the technological capabilities, which the companies have been able to develop.

Studies about technological development in latecomer context have been predominantly focusing on companies that have been successful in building technological capabilities but little research has been done to compare these with companies that are half way through the process. This paper takes a journey into that direction. Investigating the complexity in technological capabilities building, the paper analyses the differences in accumulation of technological capabilities between companies that have managed successfully to build technological capabilities (export-driven companies) and those that are still under way (domestic-oriented companies). The main proposition advanced is that if we are to make a comprehensive account of the technological capability building the studies need to explore not only the accumulation of individual capabilities but also (and more importantly) the coherence among capabilities constituting technological capability. The paper introduces the notion of coherence of technological capabilities and applies it empirically, which has not been done in the literature so far.

The paper is structured as follows. The following two sections lay the theoretical background of the research: section 2 makes an overview of the concept of technological capabilities building and section 3 introduces the notion of coherence of technological capabilities. Section 4 presents the methodology of the study. Section 5 makes an overview of development of the Bulgarian software industry. The analysis in section 6 explores the accumulation of individual technological capabilities in the domestic-oriented vs. the export-driven companies. Section 7 investigates the level of coherence of the 'domestic' vs. the 'export' technological capabilities. The final section 8 concludes by bringing back the debate about prospects for development of latecomer software industries and outlines directions for further research.

2. The concept of technological capabilities building

It has been acknowledged that to be successful and sustainable over time the technological development in a latecomer or less-advanced context needs to involve technological capabilities building [4]. Technological capabilities building involve a deliberate process of learning and technology upgrading by the latecomer companies directed at the accumulation of knowledge and skills and their commercial application.

Being the driving force in the process of technology upgrading in the latecomer companies, the accumulation of technological capabilities deserves considerable attention for understanding the complexity in the process of technological development in the latecomer context.

The technological capabilities can be defined as 'the great variety of knowledge and skills which firms need so that they can acquire, assimilate, use, adapt, change and create technology' (Ernst, et al, 1998, p. 17).

In defining the technological capabilities the studies encompass the wide array of skills and abilities, which the latecomers need to build in order to develop mastery over the new technologies. These involve the capabilities to acquire and use new technologies, but also, and more importantly, the capabilities to generate innovation to a certain degree – from generation of incremental change and modification in acquired technologies to introducing new technologies [5].

Building technological capabilities is by no means a passive, mechanistic or automatic process. Rather, it is a deliberate process of learning and accumulation of various knowledge and skills, and their combination, in attempt to develop mastery over

the new technologies [6]. The initiation of a process of technological capabilities building comes as a result of a deliberate learning effort by the latecomer companies aimed at technological upgrading. Building knowledge and understanding about modern technologies is a cumulative, firm-specific and context-specific process, and it requires accumulation of tacit and codified knowledge, in order to develop mastery over new technologies [7].

Being embedded in a latecomer context, the latecomer companies face challenges in building technological capabilities for a couple of reasons. First, being away from lead-users, the latecomers do not have access to information and knowledge about the latest technological developments. Second, the demand on the latecomer domestic market is less sophisticated technologically than the demand on the lead markets, which makes it difficult for the domestic market to become a training ground for technological capabilities building, which subsequently to be deployed on the international markets. Third, the domestic research and education infrastructure often does not provide the latecomers with well-trained graduates, and also information and knowledge about the frontier technological developments. All these make the process of technological capabilities building a difficult task for the latecomer companies.

Studies about technological development in latecomer context have been predominantly focusing on companies that have been successful in building technological capabilities [8]. They have outlined key features underlying the successful technological development in latecomer companies, like for example deliberate and focused efforts to learn and upgrade, expeditious learning, integrative learning efforts, strategic thinking, etc. However, little research has been done to compare the successful companies with

ones that are half way through the process. A study has revealed that companies that actively invest in technological upgrade perform significantly better than companies that do not place deliberate efforts to upgrade [9]. Another study [10] has outlined the differences in capability accumulation by contrasting advanced and latecomer companies and had portrayed the difficulties in technological capability building in latecomers. But further research is to be undertaken to scrutinise the differences between the capability accumulation in successful and less successful latecomer companies. This paper heads in this direction by suggesting that in investigating the technological capabilities building the studies need to take into account the coherence of technological capabilities.

3. **The notion of coherence of technological capabilities**

Studies outline that clear stages emerge in the process of technological capabilities building: the latecomers begin with building basic capabilities and later on embark on building more sophisticated capabilities, which would allow them to introduce changes in the technologies and eventually to innovate [11].

The research emphasises that a clear sequence occurs between these stages of development of technological capabilities. Having accumulated basic capabilities, and deepened and broaden further their skills, the latecomer companies attempt to build higher level capabilities, which would allow them to 'move upwards' the technological ladder [12]. Building upon a foundation of basic production capabilities, the latecomer companies need to develop deeper engineering skills. Learning-by-doing and learning by imitating are the major drivers in this stage, backed up by reverse engineering efforts. Once the latecomer company has developed ample engineering skills, it has the potential

to move on to the next stage of technological capabilities of initiating minor and major changes to the technology. To do so, the latecomer companies need to further broaden and deepen their capabilities, and acquire additional knowledge and skills, which would allow them to develop a set of 'higher level' capabilities of initiating minor and major changes to the technology. The final stage in the process of technological capabilities building involves reaching mature capabilities, which allow the companies to innovate themselves.

In this sense, we can envisage the process of technological capabilities building as a process of developing a set of essential capabilities to manage new technologies, followed by a process of acquiring deeper and broader knowledge and skills to develop 'higher level' technological capabilities of introducing minor and major change, and eventually reaching mature technological capabilities enabling the latecomers to innovate and introduce new technologies themselves. The transition from simple OEM/subcontracting to ODM (own design manufacture) and in some instances, to OBM (own brand manufacture) is an example of climbing the technological ladder. This has been the logic of the transition from imitation to innovation, which the successful latecomers in East Asia managed to perform [13].

While deepening the technological capabilities, the latecomer companies pass through subsequent stages of technological sophistication, which can be pictured as a 'technological ladder'. In this sense, we can portrait the process of technological capabilities building as a subsequent process of developing capabilities with higher level of technological sophistication.

The notion that latecomer companies need to 'climb up' the technological ladder suggests that different companies occupy different positions in the technological ladder. In other words, the latecomer companies have different success in their attempts to build technological capabilities, which reflects on the degree of sophistication of the accumulated technological capabilities. Following that perspective we can distinguish different levels of accumulation of technological capabilities, when we analyse the technological capabilities in the latecomer companies, which would be an indicator of different levels of technological maturity among companies.

Building technological capabilities is a cumbersome task, as technological capabilities encompass an array of skills and abilities with high complexity. Development of a mastery over a whole set of skills and capabilities is not an automatic process, and this is particularly difficult in the case of highly intricate skills. It may well happen that the latecomer companies succeed to develop some of the skills and abilities in the set better than others. This will result in a situation, where latecomer companies have developed different abilities to a different degree. Subsequently, disparity may occur among the degree of development of the capabilities constituting the set.

Disparity among the level of development of the capabilities in the set, in result will produce 'looseness' of the fit among the capabilities in the set. Respectively, a set of capabilities, which are all developed to a high degree, can be expected to generate a high level of 'tightness' of the fit. In other words, depending on the degree of development of the constituent capabilities in the set, different level of coherence will accrue in the technological capabilities. We define these phenomena as different levels of coherence of technological capabilities.

Are different levels of coherence of technological capabilities manifest in practice? This question has not been addressed in the literature so far. Studies have emphasised that technological capabilities building involves development of an array of skills and capabilities. The research has been directed at the type of capabilities, which the latecomer companies need to develop. Studies about technological capabilities have adopted both qualitative and quantitative assessment, but none of them have detected so far the phenomena of different levels of coherence of technological capabilities. A few comparative studies have been undertaken exploring technological capability building. Some of them focus on the development of individual capabilities and comparison between different companies [14], or different industries [15], or search for contrast between capabilities of developed and developing countries [16]; others compare domestic-oriented vs. export-driven companies [17]. But so far, no study had identified different levels of coherence of technological capabilities, which is done by this paper.

4. Methodology of the study

Exploring the coherence of technological capabilities in a latecomer software industry presents another challenge. So far, studies analysing the process of technological capabilities have been predominantly focussed on the industrial sector, studying development of the electronics industry [18], textiles [19], pulp and paper industry [20], steel industry [21], telecommunications [22], etc. As the predominant part of the studies have been directed at exploring technological capabilities in industrial sector, the analytical framework developed in the field so far has been reflecting the specifics of the industrial sector. However, a study investigating the technological capabilities in a

latecomer software industry needs to take into account the specifics of the software industry.

Very few studies have been exploring the development of a latecomer software industry, placing capabilities as a point of analysis [23] but none of them had placed the analysis of the capabilities within the discussion of technological capabilities building. Few studies [24] had attempted to provide an analytical framework for analysing technological capabilities but these attempts remained with no success (for a critical review see [25]).

Further, an earlier study had investigated the capabilities that software companies need to master [26]. However, this study analyses the European software industry, and thus, it explores a software industry in developed countries context. Development of a latecomer software industry is rather different from that in developed countries context. To develop successfully, latecomer companies need to compensate for the environment, in which they are embedded in, and to do so, they need to put deliberate efforts in developing an array of technological capabilities, starting from the basic technical capabilities. In analysing the capabilities, which European software companies possess, Torrisi has outlined five capabilities: capabilities in mathematics, computer science, system engineering, experience with application server, and marketing (Torrisi, 1998, p. 136). However, the list of capabilities proposed by Torrisi is limited to and does not exhaust the capabilities associated with software production neither in a latecomer context nor in advanced context (for critical review see [27]).

A systematic framework for analysing technological capabilities in software companies has been developed in [27], which argues that to build technological

capabilities in software development the latecomer companies need to build an array of technical and organisational capabilities.

Applying this framework to the case of the Bulgarian software industry, all of the capabilities are investigated in a qualitative way, and that has been coupled with a quantitative assessment for those of them, for which a quantitative assessment could have been produced meaningfully. It is through the quantitative assessment that this paper investigates the accumulation of technological capabilities and the occurring level of coherence. The capabilities for software development investigated in the study are summarised in the following table.

Capabilities for software design
Capabilities for software programming
Capabilities for high quality assurance
Capabilities for prompt delivery
Capabilities to develop specialised expertise in a particular domain
Capabilities to diversify the products and services offered

Table 1. Capabilities for software development investigated in this paper

The study is based on a survey conducted among 40 leading software companies, and the respondents are technical and executive managers. The companies were asked to assess their capabilities at the domestic and international markets. The above listed capabilities are explored on a five-point scale, where 1 stands for poor, 2 for modest, 3 for good, 4 for very good, and 5 for excellent.

The analysis begins by looking at the accumulation of individual capabilities and comparing the capabilities of domestic-oriented vs. export-driven companies, to outline similarities and differences between them. The analysis is undertaken in a comparative manner, but the percentages reported refer to the share in the sample as a whole, not

within the sub-groups. All companies included in the sample are companies considering themselves to offer new products or services[2], and thus the database is a fruitful base for comparing 'domestic' vs. 'export' technological capabilities.

The second part of the analysis focuses on the level of coherence of the technological capabilities. This part of the analysis does not discriminate between the technological capabilities of the domestic-oriented vs. the export-driven companies, although the exporters are responsible for the capabilities performed on the international markets, whereas the capabilities on the domestic market are entertained both by domestic-oriented and export-driven companies. Instead of distinguishing between the capabilities of the domestic-oriented and the export-driven companies, the analysis investigates the difference between the technological capabilities, which the Bulgarian companies perform on the domestic vs. the international markets, to explore the coherence among the 'domestic' and 'export' technological capabilities.

The analysis investigates the correlation between all capabilities, and compares the fit amongst them with respect to the market on which they are deployed. For example, the study looks at the fit between the capabilities for software programming and the capabilities for software design, which companies produce to compete on the domestic market, and compares them with the fit between the capabilities for software programming and the capabilities for software design, which companies produce to compete on the international markets.

[2] To be able to analyse technological capabilities of latecomer software companies operating only on domestic market, it is important to distinguish between companies offering innovative solutions for the domestic market and to separate them from 'garage'-type software services, which may be flourishing in latecomers.

Taking into account the fit among the pairs of the individual capabilities, the analysis draws conclusions about the level of coherence among the capabilities performed on the domestic and international markets. Based on that, conclusions are derived about the level of coherence of the technological capabilities, which the companies perform on the domestic market (to which the analysis refers as 'domestic' technological capabilities) vs. the level of coherence of the technological capabilities, which the companies perform on the international markets (to which the analysis refers as 'export' technological capabilities).

The analysis below explores pair wise the fit between the capabilities, performed on the domestic market and then compares with fit between the same types of capabilities but performed on the international markets, and subsequently draws conclusions about the level of coherence among the 'domestic' vs. the 'export' technological capabilities. The results are based on Spearman correlation analysis, provided in table 4 in the Appendix. The higher the correlation among the capabilities, the higher the fit amongst them, and respectively the higher the coherence in the aggregated technological capabilities performed on the domestic and the export markets. The correlation coefficients have been corroborated with the results of partial correlation controlling for size, export intensity, etc. and the latter show that the correlation coefficients remain largely unaltered, i.e. different levels of coherence emerge indeed.

5. *Overview of the development of the Bulgarian software industry*

Bulgarian software industry offers a fruitful base for analysis of the identified issues. The Bulgarian software industry is predominantly domestic-owned (although in

the last few years the industry sees an increase in foreign-owned companies, the share of indigenous companies prevails and is around 85% [28][3] and Bulgaria has been developing ICT industries in the past.

Bulgaria was among the former command countries selected (appointed) to develop an ICT industry within the COMECON, along with Russia, Hungary and former East Germany, and in this sense it had channelled resources and developed technological infrastructure for priority development of the sector. The enrolment ratio in science and engineering is above the EU and CEE average[4] and Bulgaria ranked significantly higher than the international average in the International Mathematics and Science Study. Bulgaria's secondary education is among the best in the world: 5th in the world in sciences, 11th in mathematics (World Bank and The Economist rankings). Further, Bulgarian pupils regularly win Olympiads in Mathematics and Bulgarians are among the top university students worldwide (2nd in the world in SAT scores). These education potentials have been channelled into IT professional certificates. The Global IT IQ Report in 2002 by Brainbench Inc. ranks Bulgaria (with 8,844 Certified Professionals) eighth in a ranking of the top 10 countries based on number of certified IT professionals. Bulgaria ranks third worldwide for the number of certified professionals as a percentage of the population.

Despite the availability of human resources the country has not been able to develop big and internationally renowned IT industry. The Bulgarian software industry remains predominantly domestically oriented and only a small percentage of the companies operate in international markets. The industry reveals a clear 'bifurcation'

[3] Author's estimations based on data from Bulgarian National Statistical Institute
[4] Eurostat, European Science and Technology Observatory and UNESCO Yearbooks

pattern with respect to its export intensity: around 80% operates only in the domestic market, while the rest of the companies work predominantly in the international markets, and very few companies position in the middle of the scale. Furthermore, most of the companies that are involved actively in exporting had entered the international markets straight from the very beginning, without serving the domestic market beforehand, as previous studies based on a survey and interviews revealed [29].

In the domestic market the indigenous software companies provide the whole range of software activities, like system integration, computer system software, networking software and web-design, CAD/CAM/CAE software, intermediate telecommunications and wireless development software, application software, firmware. The high segment of domestic-oriented software activities involves creation of ERP systems, B2B and B2C solutions, document flow and project management solutions, CAD/CAM/CAE software, intermediate telecommunications and wireless development software, customised services, etc. The low segment of domestic-oriented activities entails customisation and localisation, data migration, system integration, etc.

In the international markets the Bulgarian companies undertake significantly narrower range of software activities: some companies are outsourcing and few companies succeeded to enter the international arena by offering their own products and customised services. The inception of software outsourcing activities in Bulgaria begun in late 1990es and although the years of 2000 and 2001 saw some upsurge, their presence drastically dropped after 2002. The recent years see significant revival of the outsourcing activities in the Bulgarian market. Bulgaria has been ranked 14th in the ATKearney Outsourcing Report and 22th in the Global Outsourcing Report. Very few Bulgarian

software companies have managed to enter successfully the international markets on their own by offering customised services. They are individual cases and represent a marginal share in the industry.

The revenue of the software industry in Bulgaria[5] reveals a stable increase throughout the 1990es and 2000 with 10-30% annual growth[6] but nevertheless remains modest. According to IDG Bulgaria in 2004 the industry had yield nearly 34 million EURO, which is less than the peak year of 2002 generating 36.3 million but nevertheless a recovery after the drop in 2003. Industry officials concur with these figures and outline that the official figures provided by the National Statistic Office are overestimated due to statistical inaccuracy in data compiling.

The issues, which emerges out of this general overview, what capabilities the domestic-oriented and export-driven companies have been able to muster, do these differ from one another and how?

Studies exploring the development of the ICT industry in the Bulgaria have been predominantly focussing on the restructuring of the industry and the emergence of new private enterprises [30]. Very few studies have been exploring the issues of technological development of the industry [31]. It is exactly technological development and capabilities building that need to become the focal point, if the analyses are to tackle the problems of competitiveness and sustainable growth of the indigenous industry.

6. Analysis of the individual capabilities accumulated in domestic-oriented vs. export-driven companies

[5] The data include indigenous and multinational enterprises
[6] According to analyses of National Statistical Institute and IDG Bulgaria

The analysis of the individual technological capabilities reveals that Bulgarian software companies consider their abilities to serve the domestic market as excellent (table 1 in the Appendix). The companies appear confident in all of the outlined abilities, when deployed on the domestic market, as the modes of 5 and the means reveal. Nevertheless, not all companies reveal the same levels of accumulation of capabilities, as the standard deviation reveals (table 1 in the Appendix). For some capabilities the companies reveal similar levels of accumulation, like the capabilities for software design and software programming. However, in the rest of the capabilities in the set companies' performance deviates significantly. Standard deviation of (.520) emerges in the capabilities for producing high quality products and services, followed by high levels of deviation of (.971) and (.956) in the capabilities for prompt delivery and building expertise in a specialised domain respectively, and the highest deviation appears in the capabilities to diversify products and services (standard deviation of (1.173).

Even greater deviation occurs with respect to companies' abilities to perform on the international markets, as the mode and mean and standard deviation reveal (table 1 in the Appendix). All means drop down to the middle point of the scale and below. Further, companies appear to deviate significantly in their capabilities to perform on international markets and this hold for all capabilities (all standard deviation coefficients range from (1.257) to (1.532) see table 1 in the Appendix).

The analysis reveals that a clear distinction emerges between companies' abilities to perform on the domestic and the international markets. Both the domestic-oriented companies and the exporters have managed to build capabilities for the domestic market, and they appear confident in the whole array of skills and capabilities, including the skills

for software engineering, project management and expertise about the local market. Nevertheless, despite the strong performance of both groups on the domestic market, a slight distinction between the capabilities of the domestic-oriented companies and the exporters emerges, as the domestic-oriented companies reveal slightly lower coefficients for all capabilities than the exporters.

This difference becomes far more noticeable when we compare the capabilities of the domestic-oriented companies vs. the exporters to compete on the international markets. While all exporters reveal strong capabilities and expertise to perform on the international markets, the domestic-oriented companies appear far less successful in developing the necessary skills, expertise and capabilities to execute international projects. Thus, for example, when comparing the capabilities of the Bulgarian companies for software engineering and specialised expertise on the international markets, the exporters come up with coefficients, which are nearly twice higher the coefficients, which the domestic-oriented companies get. Further, for these capabilities the domestic-oriented companies position below the middle point of the evaluation scale, i.e. by obtaining means below 3.

Overall, the results of the analysis of the development of the individual technological capabilities of the domestic-oriented vs. the exporter-driven companies reveal sharp inter-group differences in the level of accumulated capabilities and the abilities to compete on the domestic and the international markets.

These results have been also supported by the results of the ANOVA test, comparing the accumulation of capabilities in domestic-oriented companies vs. exporters (table 2 in the Appendix). The ANOVA analysis confirms that significant differences

exist between the exporters and the domestic-oriented companies with respect to their capabilities for software programming for the international markets (coefficient (.000), capabilities for software design for the international markets (coefficient (.000), abilities to offer high quality products and services on the international markets (coefficient (.001), and also with respect to the capability to develop specialised expertise in a particular domain in the international markets (coefficient (.000).

Significant differences between the capabilities of domestic-oriented vs. exporters appear in the whole array of skills and abilities necessary to compete on the international markets and higher level of accumulation appears in all technological capabilities in the group of the exporters. In this sense, the bifurcation pattern, which the industry performs in its export intensity, is underpinned by a bifurcation pattern in its technological capabilities. On the grounds of this evidence, it appears that a dualistic pattern of capabilities emerges. Most of the companies operating on the domestic market seem to have managed to build technological capabilities for the domestic market, but not for the international markets. On the other hand, all exporters seem to possess technological capabilities enabling them to compete on the international markets and also on the domestic market. Thus, two separate sets of technological capabilities emerge: domestic technological capabilities and export technological capabilities.

The domestic technological capabilities represent the capabilities necessary for a company to compete and innovate on the domestic market. As the domestic market requires products and services with lower technological sophistication, the innovations, which the domestic-oriented companies introduce can be considered as new only to the domestic market, not necessarily to the world markets. Therefore, the domestic

technological capabilities can be seen as half-way built technological capabilities, when compared to the technological capabilities, which the latecomer companies need to perform in order to compete on the international markets. Apparently, the domestic-oriented companies are still half-way through 'climbing up' the technological ladder.

As very few studies have been exploring the differences between the technological capabilities of companies, which have managed to build technological capabilities enabling them to compete on the international markets and the technological capabilities of companies, which are half-way through that process, it is appealing to explore whether any other differences emerge between the domestic technological capabilities and the export technological capabilities, apart from the differences in the level of accumulated constituent capabilities enabling the companies to compete on the international markets. The investigation about the differences between the domestic technological capabilities and the export technological capabilities continues in the following section, looking at the level of coherence of the capabilities.

7. Coherence of technological capabilities: 'domestic' vs. 'export' technological capabilities

The analysis of the level of coherence among capabilities is divided in two parts. The first section presents the capabilities, which reveal high level of coherence pair wise, while the second section looks at the capabilities with lower degree of coherence pair wise. The results are presented in table 3 in the Appendix.

7.1. Technological capabilities with high degree of coherence

The highest degree of coherence within the set of capabilities pair wise appears between the capabilities to maintain specialised knowledge in a particular domain and the capabilities to produce high quality products and services. Companies that have been able to develop specialised expertise in a particular domain in the international markets appear to have been able to produce high quality products and services in the international markets, and the fit between the two appear to be extremely high (coefficient (.909). A comparable strong fit, although slightly lower, occurs between the capabilities to maintain specialised expertise in a particular domain in the domestic market and the ability to produce high quality products and services in the domestic market (coefficient (.740). Companies' ability to produce high quality products and services is coupled in a tight fit with their capabilities for software programming and the capabilities for prompt delivery, but it's extremely tight fit with the capabilities to maintain specialised expertise in a particular domain confirms that learning and accumulating expertise pays off utmost.

Strong alignment occurs between companies' abilities to maintain specialised expertise in a particular domain and the skills to deliver on time. Prompt delivery is a capability, which has been less deployed on the domestic market, as the analysis above revealed. It appears, however, that companies that have developed specialised expertise in a particular domain on the domestic market possess also strong skills for prompt delivery on the domestic market (coefficient (.679). Moreover, the fit between these capabilities when performed on the domestic market is comparable to the fit between them, when deployed on the international markets (coefficient (.756). In other words, companies having specialised expertise in a particular domain appear to have developed strong skills for prompt delivery, and this hold equally for the domestic and international

markets. This case represents the smallest distance between the fit of the 'export' vs. the 'domestic' technological capabilities.

Exploring the coherence between the capabilities for software programming and software design, it appears that the fit between them when performed on the international markets is extremely strong (correlation coefficient .842). Although the fit between the capabilities for software programming and software design performed on the domestic market is also significant at .01 level, with the correlation coefficient (.604), the coefficient, or the fit between these two capabilities, when deployed on the international markets is 1.4 times higher than the fit on the domestic market.

Similar parallelism emerges with respect to the fit between the capabilities for software programming and capabilities for producing high-quality products and services, which companies perform on the domestic and the international markets. Despite the high significance of the coefficients, the fit for the international markets (coefficient (.843) is 1.6 times higher the fit for the domestic market (coefficient (.528).

Comparable correspondence emerges between the fit among the capabilities for software programming and the skills for prompt delivery, which companies execute on the domestic and international markets. Notwithstanding the high significance of both coefficients, the fit between the capabilities, which companies achieve so to compete on the international markets (correlation coefficient (.844) is 1.7 times higher the fit, which companies achieve, when competing on the domestic market (coefficient (.493).

Similarly, capabilities for prompt delivery appear to be strongly coupled with the capabilities for producing high quality products and services. A strong fit between them occurs, when performed on the domestic and the international markets, and yet the fit on

the international markets (coefficient (.817) is 1.7 times higher than the fit on the domestic market (coefficient (.468).

7.2. Technological capabilities with low level of coherence

The differences in the fit of the domestic vs. the export technological capabilities begin to emerge, when comparing the following pair of capabilities. The fit between the capabilities for software design and the capabilities to master specialised expertise in a particular domain, which companies perform on the domestic market, is with a correlation coefficient (.394). Despite being significant at .05 level, this fit is 2 times lower than the fit, which companies perform between the capabilities for software design and the capabilities to master specialised expertise in a particular domain, when competing on the international markets (correlation coefficient (.796). Apparently, when operating on the international markets, the companies find it mandatory to develop excellence in both capabilities and to align them to a great extent, while for companies operating on the domestic market this is less the case.

Overall, in all cases above a clear fit occurs among the capabilities, which companies achieve on the international and the domestic market, although the fit of the capabilities on the domestic market appears to be lower although significant.

However, this tendency is not sustained throughout all capabilities. In the rest of the cases the disparity between the fit of the domestic vs. the export technological capabilities emerges clearly.

Notwithstanding the different levels, the fit among the capabilities for software design and the capabilities to maintain expertise in a particular domain exists, as shown

above. Whereas in the case of capabilities for software programming and the capabilities to master expertise in a particular domain a wider disparity in the fit emerges. When performing on the international markets, companies find it compulsory to develop excellence in both capabilities and to align them to a great extent (correlation coefficient (.779), whereas this appears not to be the case for companies operating on the domestic market (coefficient (.246). Apparently, developing excellent capabilities for software programming is not necessarily coupled with specialised expertise in a particular domain, when companies are to perform on the domestic market.

Similar disparity appears with respect to the fit among the 'export' vs. the 'domestic' capabilities for software design and the capabilities to offer high quality products and services. While the fit amongst them is highly significant when companies perform on the international markets (correlation coefficient (.800), the fit among these is rather low when companies operate on the domestic market (correlation coefficient (.325). It is striking that companies may operate without having aligned their basic technical capabilities, like capabilities for software design, with their capabilities to offer high quality products and services. This discrepancy appears to hold only on the domestic market and it serves to indirectly indicate that the domestic market maintains lower technological sophistication in comparison to the international markets.

Even greater divergence appears in the fit among the 'export' vs. the 'domestic' capabilities for software design and the capabilities for prompt delivery. The capabilities for software design and the capabilities for prompt delivery, which companies execute on the international markets, appear to reveal a strong fit (with correlation coefficient (.848), whereas a fit amongst these capabilities, when deployed on the domestic market, is non-

existent (correlation coefficient (.189). The analysis of the individual capabilities revealed that prompt delivery does not appear to be a strong capability on the domestic market. At this point the analysis reveals that companies do not find it necessary to align their capabilities for software design with their abilities to deliver on time, when performing on domestic market, while for the export markets the strong fit between the two appears to be a must.

The strongest disparity between the 'domestic' and the 'export' technological capabilities emerges in the fit between companies' capabilities to diversify their products and services and the rest of the capabilities in the set. The ability to diversify appears to be unrelated to companies' export intensity (this is the only capability in the set, which is not positively correlated to the export intensity). But interestingly enough, a strong positive correlation appears between the capability to diversify and all the rest capabilities in the set, when these are deployed on the international markets. In other words, companies appear to diversify their products and services both on the domestic and the international markets, but it is only the exporters who appear to make a deliberate effort to develop a strong fit between the excellence in diversification and the rest of the capabilities. The exporters reveal a strong fit among the capabilities to diversify and the rest of the capabilities in the set, and this holds for all capabilities in the set. Whereas no such fit occurs when diversification skills are deployed with the rest of the capabilities on the domestic market.

In order to compete on the international markets companies find it necessary to develop a strong fit between their capabilities for software design and the capabilities to

diversify products and services (coefficient (.691), while this is not the case, when deploying the same capabilities on the domestic market (coefficient (.122).

Similarly, when competing on the international markets companies perform a strong fit between their capabilities for software programming and the capabilities to diversify products and services (coefficient (.736), while this is not at all the case, when deploying the same capabilities on the domestic market (coefficient (020).

The same pattern persists with the rest of the capabilities in the set. Executing international projects companies perform equally strongly their diversification skills and their capabilities for producing high quality software (coefficient (.742), while no such alignment occurs in companies' performance on the domestic market (coefficient (.267).

Similarly, offering diversified products and services on the international markets is coupled with their prompt delivery (coefficient (.702), while similar coupling does not occur at all on the domestic market (coefficient (.026).

Producing diversified products and services on the international markets is strongly coupled with having specialised expertise in a particular area (coefficient (.685), whereas this does not hold for the domestic market (coefficient (.258).

7.3. Conclusions about the degree of coherence of export vs. domestic technological capabilities

Perhaps the most important and striking point, which emerges out of the analysis, is that very high level of coherence occurs among all capabilities, when they are deployed on the international markets. Not even a single exception of low or medium high level of coherence exists in the case of the export technological capabilities. It is striking that

although capabilities for diversification do not appear to be correlated with the export intensity, i.e. exporters do not necessarily have greater diversified range of products and services they offer, the skills for diversification do appear to be highly correlated with the rest of the capabilities, when they are deployed on the international markets. This by itself is revealing of how tight must be the fit among all capabilities to enable latecomer software companies to compete internationally.

While operating on the domestic market, the companies appear to perform a high degree of coherence among some capabilities, representing a half of the whole set of capabilities, and yet the level of coherence appears to be lower than the level of coherence of the same capabilities deployed on the international markets. But in the other half of the cases, the companies perform a low level of coherence among the capabilities in the set. Apparently, when deploying their technological capabilities on the domestic market, the software companies do not find it necessary to develop a strong level of coherence among all capabilities. Respectively, this suggests that the demand in the domestic market is relatively unsophisticated and allows companies to serve customers without performing a tight fit among all capabilities.

Unlike the case of the export technological capabilities, where a high level of coherence emerges between the capabilities to diversify and the rest of the capabilities, the same tendency does not occur in the case of domestic technological capabilities. Despite the fact that most of the companies, operating on the domestic market reveal high degree of diversification of the products and services they offer, the level of coherence between the capabilities to diversify and the rest of the capabilities is very low in absolutely all cases. This perhaps is coming to suggest that a strategy of diversification

on the domestic market is more likely to be an ad hoc strategy of utilising all available opportunities rather than a deliberate attempt to broaden companies' knowledge base and align it with the rest of companies' technological capabilities. This comes as another piece of evidence about the relatively unsophisticated demand on the domestic market, which allows companies to provide a range of software services without necessarily ensuring a strong fit between these and the rest of the technological capabilities.

8. Conclusions

The paper makes contributions in two directions. First, it introduces the notion of coherence of technological capabilities. It emphasises that if we are to make a comprehensive account, in analysing the accumulation of technological capabilities we need to investigate not only the accumulation of individual capabilities but more importantly the degree of coherence among the constituent capabilities. The degree of coherence depicts the deeper structures in the process of the technological capabilities building. Successful technological building requires not only accumulation of individual capabilities but it also necessitates development of a high degree of coherence among the capabilities.

The second contribution of the paper is bringing back the debate about development of indigenous software industries by the latecomers. The accumulation of individual capabilities to perform on international markets appears to be a difficult task, as the case of the Bulgarian software industry reveals. The demand on the domestic market is technologically less sophisticated and the companies find the shift to international markets difficult.

The results of this study clearly suggest that building technological capabilities to compete on the international markets involves greater technological efforts in all aspects and all levels of technological capabilities, while the domestic market requires less-sophisticated technological efforts to compete, and thus offers very limited opportunities for the domestic-oriented companies to accumulate capabilities, which subsequently they will be able to deploy on the international markets. Even when they had already developed good capabilities to perform on the domestic market, the latecomer companies do not find it necessary to develop high degree of coherence among the capabilities in the set when performing on the local market, due to the low performance requirements. This appears detrimental to their attempts to develop capabilities to compete on the international markets.

These results contest the 'walking on two legs' proposition, suggesting that the latecomer software companies need to pay more attention to the domestic opportunities because of their high returns in terms of gaining experience and innovation in software production and providing training opportunities that allow a broadening of software exports [32]. The case of Bulgaria, and most of the latecomer countries, shows that technological development in the domestic market does offer learning opportunities for software production and yet they remain far away from the frontier developments and do not enable the latecomer software companies to enter the international arena.

The results of this study present a revealing case that building technological capabilities in the latecomer software industry is indeed a cumbersome task. The latecomer companies need not only to accumulate a set of separate individual capabilities, but more importantly to build a strong level of coherence among them. This

seems to be the major distinction between the technological capabilities, which are deployed on the domestic vs. the international markets.

This point bring us back to the argument of Steinmueller [33] about the possibilities for leapfrogging by the developing countries, where the discussion is centred on an optimistic perspective about the possibilities for production and use of information and communication technologies (ICTs) by the developing countries. The software and information services in particular are outlined as one of the prospective areas for technological leapfrogging. The author emphasises that to be able to embark on a leapfrogging trajectory the latecomer companies need to develop absorptive capacities to acquire expertise to produce and use the ICTs, and that the modern ICTs and access to information facilitate the development of absorptive capacities (Steinmueller, 2001, p. 197-9).

The results of this analysis reveal that a modest number of Bulgarian software companies have been able to build technological capabilities to compete on the international markets, while the predominant part are failing to develop the required coherent capabilities. Although these should be coupled with additional analysis about the underlying learning processes, these suggest that developing absorptive capacities remains a challenge for the latecomer companies and the optimistic forecasts about the possibilities for leapfrogging by the latecomer countries by developing indigenous software industries have been overestimated. This is not to contest the optimism about the potential of the latecomer companies to develop mastery over new technologies and eventually to generate new technologies, but rather to suggest that it is most likely that a limited number of latecomer companies will be able to develop leading-edge capabilities.

Perhaps latecomer countries like India, China and Brazil, which have been able to mobilise their potential in harnessing the benefits from the ICTs, present optimistic examples (despite the fact that the software industries in China and Brazil remain predominantly domestic-market oriented, the domestic demand is sophisticated, as it is represented by MNEs). Whether other cases would provide grounds for optimism or rather the experience of the rest of the latecomers would provide evidence for a counter argument, is still to be seen. The case of the Bulgarian software industry itself presents a case for moderate optimism. It is optimistic that a group of companies, although representing a relatively small share in the industry, has managed to enter and compete on the international markets. Nevertheless, the questions remain whether any of the domestic-oriented companies will be able to make a shift to the international markets and how sustainable the development of the domestic-oriented companies will be in the future.

This paper needs to be complemented by further research in four directions. The first direction of research is to expand the analysis of capabilities. In order to take a comprehensive account of the capabilities, which the latecomer software companies need to muster, the analysis of the constituent capabilities should be elaborated further to develop a framework for analysing technological capabilities in latecomer software companies distinguishing between technical and organisational capabilities, which is done in [34]. Second, further analysis should be done to investigate the occurring high or low level of coherence among software capabilities and relate this to the market on which they are deployed and further relate this to the specifics of technological capabilities building in latecomer software companies. This point is beyond the scope of this paper,

which aims to introduce and identify different levels of coherence of technological capabilities but avoids making the analysis too much industry- and context-specific. Third, the analysis of the capabilities in this paper had been based predominantly on quantitative data. This has been done deliberately to emphasise the significant inter-group difference in the level of accumulation of technological capabilities and to reveal the different degree of coherence in capabilities. The analysis will be complemented by qualitative research to depict further details. Fourth, further research needs to be directed at investigating the learning process underlying the accumulation of different levels of technological capabilities, to disentangle the complexity of technological capabilities building in the latecomer context. In this part of the analysis it would be appealing to explore the impact of organisational capabilities in the process of technological capabilities building and whether organisational congruence foster development of technological capabilities with high level of coherence.

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Appendix

Capabilities	Mean	Mode	Std. Deviation	Std. Error Mean
Design capabilities for local market	4,86	5	0,351	0,058
Design capabilities for international markets	2,84	3	1,305	0,212
Programming capabilities for local market	4,92	5	0,273	0,044
Programming capabilities for international markets	3,08	3	1,381	0,23
High quality on local market	4,7	5	0,52	0,085
High quality on international markets	3,42	5	1,519	0,253
Prompt delivery on local market	4,53	5	0,971	0,162
Prompt delivery on international markets	3,56	5	1,517	0,256
Specialised expertise in domain in local market	4,41	5	0,956	0,157
Specialised expertise in domain in international markets	3,24	5	1,532	0,249
Diversified products & services in local market	4,11	5	1,173	0,193
Diversified products & services in international markets	2,59	3	1,257	0,207

Table 1. Accumulation of individual capabilities in the Bulgarian software companies

Capabilities	Mean square	F	Sig.
Design capabilities for local market	0.040 0.137	0.290	0.915
Design capabilities for international markets	26.389 1.073	24.587	0.000
Programming capabilities for local market	0.036 0.058	0.627	0.434
Programming capabilities for international markets	28.889 1.183	24.427	0.000
High quality on local market	0.002 0.207	0.011	0.917
High quality on international markets	23.308 1.710	13.630	0.001
Prompt delivery on local market	0.654 0.995	0.657	0.424
Prompt delivery on international markets	10.928 2.104	5.193	0.029
Specialised expertise in domain in local market	0.005 0.992	0.005	0.943
Specialised expertise in domain in international markets	29.403 1.689	17.411	0.000

Table 2. ANOVA analysis of differences between technological capabilities of domestic-oriented vs. export-driven companies

	Programming capabilities for local market	Programming capabilities for international markets	High Quality for local market	High quality for international markets	Prompt delivery in local market	Prompt delivery in international markets	Specialised domain expertise in local market	Specialised domain expertise in international markets	Diversified products &services in local market	Diversified products &services in international markets
Design capabilities for local market	.604(**)		0.325		0.189		.394(*)		0.122	
Design capabilities for international markets		.842(**)		.800(**)		.848(**)		.796(**)		.691(**)
Programming capabilities for local market			.528(**)		.493(**)		0.246		-0.02	
Programming capabilities for international markets				.843(**)		.844(**)		.779(**)		.736(**)
High Quality for local market					.468(**)		.740(**)		0.267	
High quality for international markets						.817(**)		.909(**)		.742(**)
Prompt delivery in local market							.679(**)		0.026	
Prompt delivery in international markets								.756(**)		.702(**)

Specialised expertise in domain in local market									0.258	
Specialised expertise in domain international markets										.685(**)

Table 3. Spearman's correlation coefficients for the degree of coherence among domestic vs. export technological capabilities