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Science, technology and innovation for competitiveness: The challenges of smart specialization for Bulgaria

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ABSTRACT:

In the wake of the crisis, science, technology and innovation (STI) policies have become frontrunners in countries' perpetual race for competitiveness. Among them, the smart specialization (SS) concept has gained significant attention in the European context. In this paper I propose a systemic framework to analyze STI systems and their links with economic competitiveness of a country, as depicted by its export performance. I apply this framework in the case of laggard EU-economy (Bulgaria) employing a mix of quantitative and qualitative analyses to analyze its STI and competitive profile. This type of investigation may serve as a diagnostic tool for other economies to identify their own SS trajectories. Finally, corroborating the results of the analysis with Bulgarian particularities I provide tailored policy advice following the guidelines of the SS strategy.

Keywords: Bulgaria; Smart specialization; Exports; Patents; Scientific publications;

> *"It is not the strongest of the species that survive, nor the most intelligent, but the ones most responsive to change."* — Charles Darwin

1. INTRODUCTION

It is already a cliché to invoke innovation and technology as drivers of economic growth and competitiveness, given the impressive amount of attention devoted to this topic (Cameron, 1996; Hall and Jones, 1999; Freeman, 2002; Rosenberg, 2004; Wang et al., 2007; Gibson and Naquin, 2011). Furthermore, the current crisis has exposed significant weaknesses of growth strategies that were relying heavily on artificial "bubbles" from non-tradables (e.g. financial sector, real estate, and construction) which are prone to burst eventually (Blanchard et al. 2012). As a result, science, technology and innovation (STI) are increasingly perceived as sources of economic growth (Adams and Clemons, 2008; Aghion et al., 2009) encouraging major policy efforts to develop strong STI systems (Filippetti and Archibugi 2011).

Among these initiatives, smart specialization (SS) has recently gained significant political support as solution for a more efficient European STI system (Foray et al., 2011; Giannitis and Kager, 2009). Employing arguments from trade theory, such as comparative advantage and factor endowments, the SS framework stresses the need for regions and countries to focus only on certain STI areas in which they are competitive. Moreover, it advocates minimal governmental involvement, opting instead for the use of entrepreneurial discoveries and stakeholders' actions, except when it comes to identifying areas of interest and deploying complementary assets (e.g. specialized education, incentive schemes) to support these areas.

However, despite the appeal of these arguments, the SS agenda remains just as difficult to implement in practice as any other innovation policy alternative, given the variety of idiosyncratic factors involved (Mowery and Oxley, 1995; Hadjimanolisa and Dickson, 2001; Wang et al., 2007). While in developed economies, national systems of innovation (NIS) are working well due to significant private investments in R&D, superior institutional settings and highly skilled human resources, choosing a SS strategy in latecomer countries may be more of a top-down decision given their heavy reliance on public and foreign sources of innovation (Furman et al., 2002; Hu and Matthews, 2005; Krammer, 2009). Thus, the supporting public infrastructure and policies (Lundvall, 1992; Nelson, 1993) become critical for long-term competitiveness and economic success (Radosevic, 1999). Moreover, different goals (global leadership, catching-up, prevention of competitiveness losses) require different SS strategies that are not exempt from risks, such as “picking up a looser” or stalling technological lock-ins (Giannitis and Kager, 2009).

This study adopts a systemic approach and examines in-depth the links between different STI components and economic competitiveness providing avenues for future smart specialization paths. To this end it utilizes an eclectic mix of quantitative and qualitative analyses that target the national STI system. Its assessment of international competitiveness is anchored in the recent literature on industrial organization, exports and economic growth (Imbs and Wacziarg 2003; Klinger and Lederman, 2004). The empirical setting has three parts and focuses on Bulgaria, a laggard both in economic and innovative terms within the European Union that faces multiple challenges in rekindling its growth to pre-crisis levels. The first part assesses the Bulgarian international competitiveness using detailed (2 and 4 digits) export flows to identify possible niches for future export-led development (Hausmann and Klinger, 2008). The second part provides a comprehensive analysis of both "new-to-the-market" and "new-to-the-world" innovation using international and domestic patent data (Acs et al., 2002; Grupp and Mogee, 2004). This analysis is complemented with insights on firm innovation from the Business Environment and Enterprise Performance Survey (BEEPS) run by the World Bank[1]. Finally, the third part provides an analysis of the scientific system in Bulgaria using bibliometric indicators (Weingart, 2005) and identifies opportunities for future scientific developments (D’Este and Patel, 2007) as well as potential synergies with industrial and technological systems. Drawing upon these results, I develop several policy recommendations for Bulgaria to improve its competitiveness through a more efficient utilization of its existing STI assets and development of new core-competencies following a SS strategy that fits best its economic and STI strengths. The objective is to provide policymakers an analytic tool for developing national SS strategies. This tool will have two main functions: first, to identify competitive STI areas of a country given its innovative and scientific performance and second, to explore systemic dysfunctions that prevent efficient flows of knowledge between the STI and economic systems. Both of these functions become critical issues for SS policy design in the case of STI laggards, considering their low levels of competencies and resources devoted for this process.

[1] The Bulgarian BEEPS used here was conducted in 2008 and includes 288 firms from manufacturing and services.

Hence, I contribute to the literature in several ways. First, I provide a detailed analysis of STI systems building on recent scholarly (systemic innovation literature) and policy (SS concept) advancements and linking them with downstream economic effects following the export-led growth literature. Secondly, I focus on Bulgaria, a laggard in terms of STI but a relative success story in terms of net exports (about 60% of its GDP), to make the case for heterogeneous SS strategies even within the EU. Here I depart from the postulated minimal public intervention, and advocate for strong involvement of governments in the case of catching-up countries and regions, as a mean to create a critical mass for successful STI systems. Finally, I provide several policy suggestions based on SS principles and Bulgarian particularities.

My findings suggest that Bulgaria needs to respond to multiple and diverse challenges ahead. First, in the spirit of SS, it is imperative to support innovation in areas with great export performance ("champions" category) by increasing their level of sophistication (so far they are resource based products with low degree of processing) and harnessing new technologies to diversify into related product niches with higher value-added. Secondly, it must develop new areas of comparative advantage based on export potential (“achievers”) through targeted funding instruments and entrepreneurial incentives. The analysis of exports and STI proposes two strategic sectors (IT and pharmaceuticals) that fit well in this category. Better legislative support for these activities will be crucial for stimulating initial knowledge creation and subsequently strengthen competitive advantage. In terms of STI, international collaboration remains the main channel for production and absorption of frontier knowledge, and one that needs support in line with the sector focus of the chosen SS strategy. Transparency about the latter and involvement of multiple stakeholders (private business, universities, etc.) should be prioritized in order to maximize the success of these policies. Strengthening links between academia and business as well as new policies for education and research (i.e. restructuring of the Bulgarian Academy of Science) should be implemented as soon as possible. Finally, as a newcomer in the EU, Bulgaria needs to be much more efficient in accessing and absorbing European structural funds, and redesign instruments for commercialization of public-sector research, that lingers as a daunting legacy from previous decades of communism.

The rest of the paper is structured as follows. The second section surveys the literature on competitiveness, smart specialization, and the link between STI systems and growth. Section 3 provides a detailed assessment of Bulgaria's performance in terms of exports and STI, discussing future growth avenues in these areas. Section 4 puts forward a list of targeted innovation policies and instruments tailored for the Bulgarian STI and industrial context. Finally, Section 5 discusses more general implications of this type of analysis and applicability to other countries.

2. COMPETITIVENESS, GROWTH AND SMART SPECIALIZATION IN STI

2.1 Measuring competitiveness

Competitiveness remains a concept that is often misunderstood and difficult to quantify despite its apparent simplicity. Most definitions capture it in a multidimensional setting, as the success of an entity (a firm, sector, country, or group of countries) in competing with peers. However this complexity induces problems in identifying what exactly it means to *be competitive* and at which level this should be measured. Thus, major criticism refers to issues such as the arbitrary nature of measures employed (Reichel, 2002), aggregation issues (Jenkins, 1998) and strong conceptual overlap with productivity (Krugman, 1994). Regardless, competitive advantage is viewed as a way to improve the performance of firms, sectors and economies (Porter, 1990) and competitiveness indexes remain extremely popular in policy and media circles (Acs et al., 2002).

From an economic perspective, competitiveness of a country is synonymous with superior productivity. Moreover, both concepts are rooted in the country’s microeconomic successes (Porter, 1990) driven by national systems of innovation (R&D investments, product quality and innovation, human capital), and quality of institutions[2]. Moreover, the strong link between competitiveness and trade is acknowledged both in theory and empirics (Alcala and Ciccone, 2004). Thus, a straightforward way to analyze competitiveness is to employ conventional trade indicators (i.e. Balassa, Michaely and Lafay) or more recent constructs (i.e. export sophistication, unit value distance, open forest) stemming from the export-led growth

[2] In Porter’s model all four main determinants of competitiveness (firm strategy, structure and rivalry; demand conditions; supporting industries; factor conditions) are subject to policy stimuli from the government.

literature (Hausmann and Klinger, 2008; Imbs and Warcziag, 2003; Klinger and Lederman, 2004).

Identifying systemic capabilities that drive competitiveness and their interactions is an important target for economic policy in terms of future growth perspectives. As a result, many studies attempt to capture various facets of competitiveness. These metrics encompass a large variety of aspects such as economic factors (e.g. the ability to attract investment, employment rate, cost of living), business factors (management efficiency, corporate governance, finance), infrastructure (basic infrastructure, scientific and technological one, education, research and development) and governmental efficiency (fiscal policy, institutional quality, public spending, business environment), all of which shape a country's ability to compete internationally[3]. In this paper I employ both types of measures (composite country indicators and detailed export related indicators) to obtain a good overview on the relative position of a country in the global landscape of competitiveness. Trade (export) competitiveness indicators are employed to assess a country's position and niches for success (growth). The latter are much more detailed than the commonly employed "generic" indicators (e.g. IMD and WEF), allowing me to link countries' scientific and technological profiles.

2.2 STI systems, knowledge and competitiveness: an intricate relationship

Regardless of the theoretical lenses employed, researchers agree regarding the effects of innovation on economic competitiveness (Mulder et al., 2001). On one hand, mainstream economics adopted a Schumpeterian view that highlights the role of technology and innovation in the international performance of firms, sectors or countries (Hall and Jones, 1999). The new-growth theory (Romer 1991; Grossman and Helpman 1991) finds increasing returns and positive spillovers from R&D efforts across multiple levels: firm, industry or country (Coe and Helpman 1995; Keller 2004). In parallel, the evolutionary branch of economics provides similar answers by focusing on the sector-specific nature of innovation, and investigates its impact on competitiveness of these systems (Nelson and Winter 1977; Dosi 1988). While extremely different in their approaches (theoretical foundations, empirical implementation and policy

[3] The two most popular measures are the ones prepared by the International Institute for Management Development (IMD) and the World Economic Forum (WEF). However, all these constructs lack a theoretical backbone.

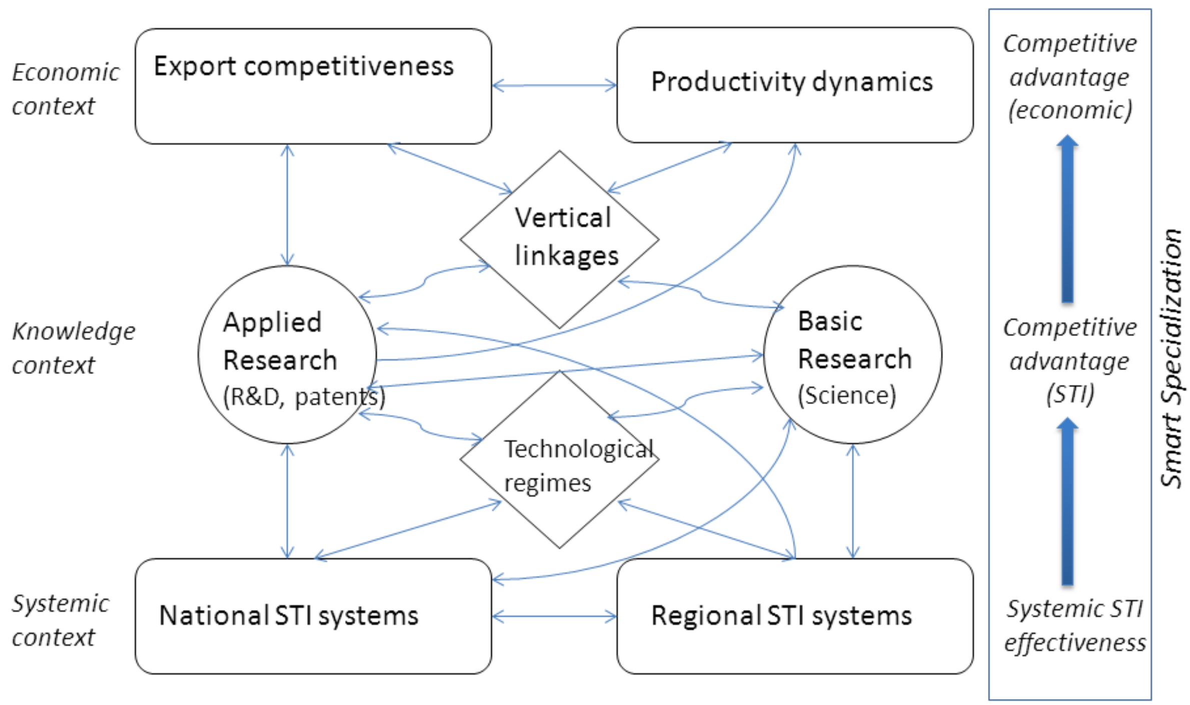
prescriptions), these two strains of literature strongly agree on the robust links between innovation and economic success.

Furthermore, the link between economic growth or competitiveness and trade performance is well documented both in theory and empirics (Lankhuizen, 2000). Export performance and competitiveness share a common selection mechanism: countries that become competitive in a certain sector manage to secure also a higher export share in that domain, and vice versa. Moreover, the recent export-growth literature suggests an U-shaped relationship between export specialization and income per capita, and moreover, that growth performance of countries depends on the degree of export "sophistication" (Imbs and Wacziarg 2003; Klinger and Lederman 2004). Overall, developing economies specialize in narrow niches of production and exports, usually low-tech industries as a result of modest technological capabilities. In time, a rise in income triggers diversification and introduction of new and more sophisticated products (Cadot and Strauss-Kahn, 2007). Finally, at high levels of income, certain export lines are closed and the export base concentrates around upper value-added products. Through this process countries advance their production and export patterns and secure a more competitive position in the global system.

Secondly, both trade and growth theories predict a strong relationship between exporting and innovation performance. Product life-cycle theory models innovation as emerging from a well technologically-endowed North, just to be imitated and eventually adopted in the production of Southern goods (Vernon 1966; Krugman 1979; Dollar 1986). More recent work endogenizes this process and distinguishes exporters and multinational firms as those at the top of productivity distributions as a result of superior technologies and know-how (Melitz 2003). Moreover, empirical findings associate economic success with innovation (Cassiman and Golovko 2007; Lachenmaier and Wößmann 2006) and learning-by-exporting effects (Clerides et al. 1998; Damijan and Kostevc 2010) although causality remains a subject of debate (Bernard and Jensen 1999; Damijan et al. 2008).

Finally, numerous studies emphasize the systemic nature of S, T and I through concepts such as *triple helix* (Leydesdorff and Etzkowitz, 1998), *innovation ecosystems* (Aulet, 2008) or *knowledge triangle* (Soriano and Mulatero, 2010). All these frameworks draw attention on the integrative nature of innovation with an emphasis on its drivers and multiple non-linear interactions (Castelacci, 2008). Thus, the efficiency and quality of innovation systems (national and regional) are strongly related to creation of comparative advantage in STI, and subsequently in production and export markets. Such systemic links present strong arguments for creation and development of strong STI systems, which envision subsequent STI and industrial production paths (see **Figure 1**).

Figure 1. STI systems and the competitiveness: the role of smart specialization



Note: Figure adapted from Castelacci (2008). STI refers to science, technology and innovation.

However, STIs' structures are extremely complex including different actors (e.g. firms, governments, NGOs, research institutes, etc.), institutional settings (both formal-laws, regulations- and informal –routines, norms, traditions- ones) and infrastructure (of knowledge, financial or physical nature) that interact and evolve within these systems (Lundvall, 1992). Therefore, any policy design initiatives require a balanced mix of measures with a certain degree of central planning as well as harnessing the best of such heterogeneous forces like profit maximization motives versus basic knowledge creation. A recent concept that builds upon all these elements and has become extremely popular in the European policy circles is the "smart specialization" strategy.

2.3 Smart specialization as a national policy tool

Smart specialization (SS) is a relatively recent yet successful policy concept (Foray et al., 2011) that envisions an innovation-driven development strategy focusing on regional (country) relative strengths, as observed from its industrial production or export patterns. Through SS in STI, efficient exploitation of knowledge resources is insured. Each country would be able to identify areas of relative strength in specific R&D fields that would complement its competitive advantage and match the existing political discourse. This will entail them to reach a critical mass of expertise as well as increasing knowledge transfers in these fields. In essence, SS should be a bottom-up discovery process that focuses on entrepreneurial values and mobilizes all stakeholders in identifying the best alternatives for specialization. Moreover, the role of public policy is important both in identifying and fostering these alternatives, thus calling for a bi-directional policy mix beyond the simplistic dichotomy ("top down" vs. "bottom-up") utilized by many policies. The rapid assimilation of this salient concept by European policy circles and practitioners is a perfect example of "policy running ahead theory" despite lacking strong theoretical foundations or concrete implementation strategies[4].

Building on these recent efforts, this study proposes a potential blueprint for an SS analysis. Such a complex strategy requires careful consideration and involves various stakeholders (e.g. governments, entrepreneurs, universities, private firms) that need to agree upon a vision for the future, identify strengths and strategies, as well as networks and communities through which knowledge utilization can be maximized and risks successfully mitigated. While sectoral composition of the economy is important both as an input and also as a desired outcome of these strategies, SS is not so much about choosing winners in terms of industrial policy but about spurring R&D and innovation efforts in areas of existing industrial strengths. Therefore, identifying the latter becomes very important for SS strategy. Furthermore, SS provides alternatives for each region/country, regardless of its technological endowments: those with higher capabilities should indeed specialize in invention of GPTs (General Purpose

[4] SS is a key element of the EU 2020 plan and will be the focus of future OECD data collection and efforts.

Technologies, such as IT or nanotech) while the rest should invest in co-invention of applications relevant to sector champions of their economies (Foray et al., 2009). Thus, the development of GPT contingent areas should arise both from policy and entrepreneurial circles.

However, this process requires significant amount of data in order to assess industrial and STI strengths and identify future avenues in terms of collaborations or synergies between different actors both within and between systems. A large battery of indicators can improve our understanding and selection of STI fields of interest vis-à-vis the rest of the world, especially in laggard countries that suffer from STI system fragmentation, shrunken R&D budgets and lack of world class STI resources. SS does not endorse only innovation, but underpins structural changes that bring additional economic value associated with it. Therefore, besides STI systems, these indicators should pay attention to the correlations between investments in R&D and science and gains in competitiveness of core industries.

3. DATA AND METHODOLOGY

Building on the aforementioned theoretical arguments, I seek to provide a policy tool that accounts for both systemic STI issues and concrete SS objectives to achieve economic success. The empirical analysis focuses on Bulgaria, but it can be easily replicated for other economies. It employs a series of quantitative and qualitative analyses that follow the systemic structure described in **Figure 1** and exposes recent developments in terms of competitiveness, exports, innovation, R&D, patents and scientific output. This framework links the potential competitive advantage in STI and economic domains through quantitative analyses, complemented with qualitative assessments of STI systemic issues that Bulgaria faces. Throughout these analyses I use a reference group of six countries in order to benchmark Bulgarian performance in an international context.

3.1 Economic context

3.1.1 General competitiveness

After 1990, Bulgarian competitiveness has improved slowly, but not nearly enough to catch-up with EU peers or to keep up with other emerging markets: Bulgaria ranks 71st out of 133 countries in the Global Competitiveness Report 2010-2011, and 51st out of 183 economies in the Doing Business Report 2011. These aggregated numbers provide a consistent bleak picture of its performance, suggesting that severe institutional problems (financial barriers, corruption and bureaucracy) need to be tackled immediately. In these turbulent times, there is strong consensus even in Bulgaria that "business as usual" is unlikely to generate sufficient growth to dent unemployment and strive for convergence with the EU economic levels, calling for different strategic approaches.

3.1.2 Export competitiveness

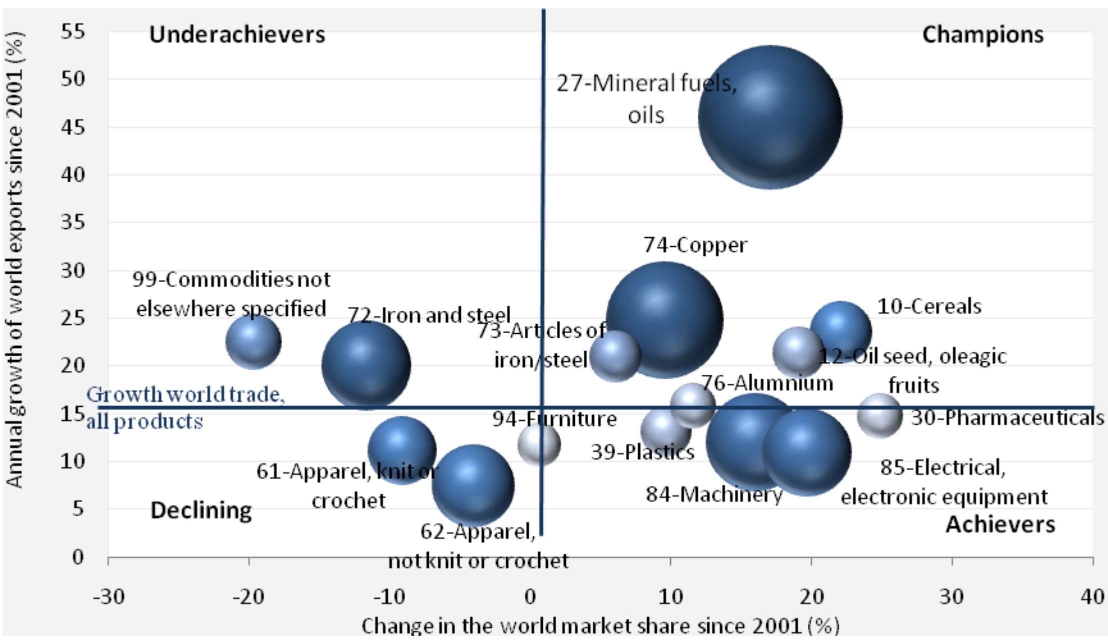
As a lesson of the current crisis, Bulgarian policymakers have realized that exports need to play a more central role in the country's growth in order to stimulate recovery and insulate from future boom-bust cycles. Prior to the crisis, Bulgaria benefited from large inflows of FDI (30% of GDP in 2008), which have returned now to pre-boom levels (4% in 2010). In the context of weak domestic demand, exports represent a viable alternative for sustaining growth. Moreover, in the case of Bulgaria, exports are already an important component of the economy representing nearly 60% of its current GDP, with significant increase even in the aftermath of the crisis (26% in 2011). However, despite its recent performance, Bulgaria positions itself in the middle of the Eastern European pack, behind regional export champions (like Hungary)[5], and its trade balance remains negative for most of its top exports. To assess further its export performance I will examine its main exports at 2 and 4-digit granulation.

Figure 2 presents the recent performance of Bulgaria's 15 leading export products at 2-digit level. The two axes (change in the world market share=0, and annual growth between 2001 and 2008 of all exports = 18%) give four quadrants that characterize the evolution of Bulgarian exports vis-à-vis to the world. The upper-right quadrant (***Champions***) includes Bulgarian top products that enjoy fast growth in world markets. These are mineral fuels and oils, copper, cereals and agricultural by-products as well as articles from iron and steel. Products in the

[5] In 2008, Bulgaria had US$3,958 exports per capita, higher than Romania (US$2,781) and Turkey (US$2,378), but below Croatia (US$6,553), Hungary (US$12,549), Italy (US$11,100) or Finland (US$22,664).

Underachievers quadrant exhibit high demand worldwide but Bulgaria underperforms here vis-à-vis the rest of the world and steadily losing market share. The iron and steel industry stand out here. Products with dim perspectives for future exports are clustered in the ***Declining*** quadrant and include garments and furniture. These products face fierce competition from countries like China and India, and labor costs adjustments damage their competitiveness. Finally, products in the lower-right quadrant (***Achievers)*** are gaining world market share but have not yet seen stellar export growth. Several industries with higher technological content, that have a good chance of becoming champions of Bulgarian exports, are in this group: pharmaceuticals, machinery, electrical equipment and chemical intermediates (aluminum, plastics).

Figure 2. Dynamic exports profile of Bulgaria: 2001-2008



Note: the area of the circles corresponds to the export size in $US mil.; the top 15 exports are represented
Source: own calculations, based on UN COMTRADE, 2010

Next I examine their performance in terms of prices and quality by computing aggregated *unit values* for exports at 4 digits level:

$$UVD_{o,t} = \sum_{i} \log\left(Pmax_{i,t} - P_{i,t}\right)\frac{xval_{i,o,t}}{X_{o,t}}$$

where *c* refers to country, *t* is the time period, P_i is the price of product *i*, $Pmax_{i,t}$ is the highest priced export for good *i* worldwide, *xval* and *X* are the total exports of *i*, and respectively of country *c*[6]. The *unit value distance* reveals that Bulgaria's export basket has made virtually no progress between 1990 and 2008 (i.e. its rank is 71th in 1990; 86th in 2000; 67th in 2008) in contrast to countries like Hungary and Turkey. Furthermore, I construct a sophistication measure for the whole export basket of the country (EXPY) that equals the weighted average of the sophistication of each of its exported goods (PRODY):

$$PRODY_{i,t} = \sum_{c} \frac{(xval_{i,c,t}/X_{c,t})}{\Sigma_j (xval_{i,c,t}/X_{c,t})} * Y_{c,t}$$

$$EXPY_{c,t} = \sum_{i} \left(\frac{xval_{i,c,t}}{X_{c,t}}\right) PRODY_{i,t}$$

where $Y_{c,t}$ is the GDP per capita, $xval_{i,c,t}/X_{c,t}$ is the value-added share of the commodity in the country's overall export basket of a country *c*. Superior or sophisticated products (higher PRODY) are the home turf of developed nations, while countries' EXPY is a good predictor for their future economic performance (Hausmann and Klinger, 2008). Overall, Bulgaria holds an average position in EXPY, with moderate improvements over time that are in line with Turkey, Romania or Serbia, but below Central European nations and global top-exporters. In fact, only six of its top 15 exports have sophistication levels above the global average (see **Table A.1** in the Appendix) supporting trade reorientation and high-sophistication "niche targeting" (i.e. electric current, copper and derivatives, etc.). A plausible cause for this export un-sophistication is the low share (3%) of high-tech exports, substantially below the EU-27 average (16%) suggesting the absence of strong STI systems. Even among their top ten exported goods, only electrical equipment and boilers and machinery possess a high-tech component[7]. Bulgarian sophisticated products (glassware, optical apparatus, pharmaceuticals, chemicals and plastics) are found in a second tier of performance (ranked 10-20) and have very small global market shares.

[6] The main weakness of these measures lies in the data quality and availability and harmonization across countries and time.

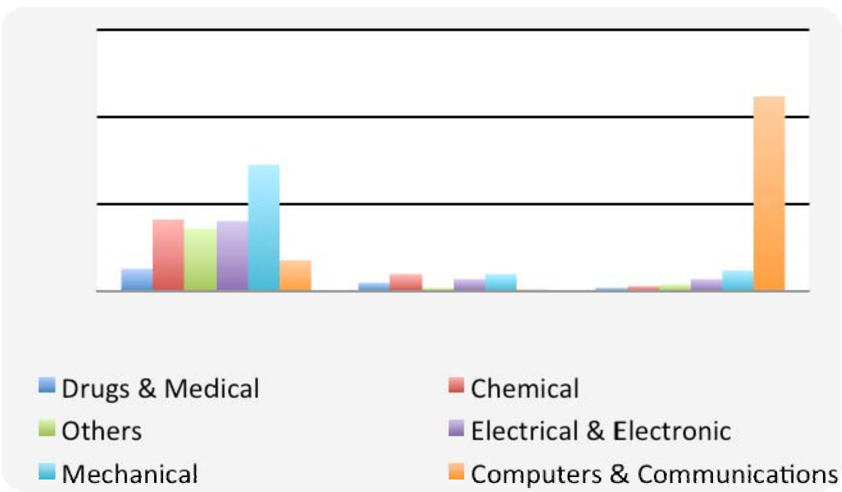
[7] Aerospace, computers, office machinery, electronics, instruments, pharmaceuticals, electrical machinery and armament are considered high-technology sectors.

3.2 Knowledge context

3.2.1 Specialization of applied research

To measure innovative capacity of a country I employ *international patents statistics*, a standard indicator for innovative performance in both policy and academia, despite their well-known caveats (Acs et al., 2002). Bearing in mind these limitations, I focus on patents granted in US (USPTO) and Europe (EPO) and check the robustness of my conclusions also against data from the Bulgarian patent office (BPO)[8]. Regardless of the measure, Bulgaria exhibits a weak track record in terms of patenting (averaging 0.85 US patents per million inhabitants), surpassing Romania (0.24) and Turkey (0.19), but below advanced transition countries such as Hungary (5.16) and Croatia (3.08) and Western nations (Italy, 27.81; Finland, 137.11).

Figure 3. Bulgarian international patents granted at USPTO (1981-2010)



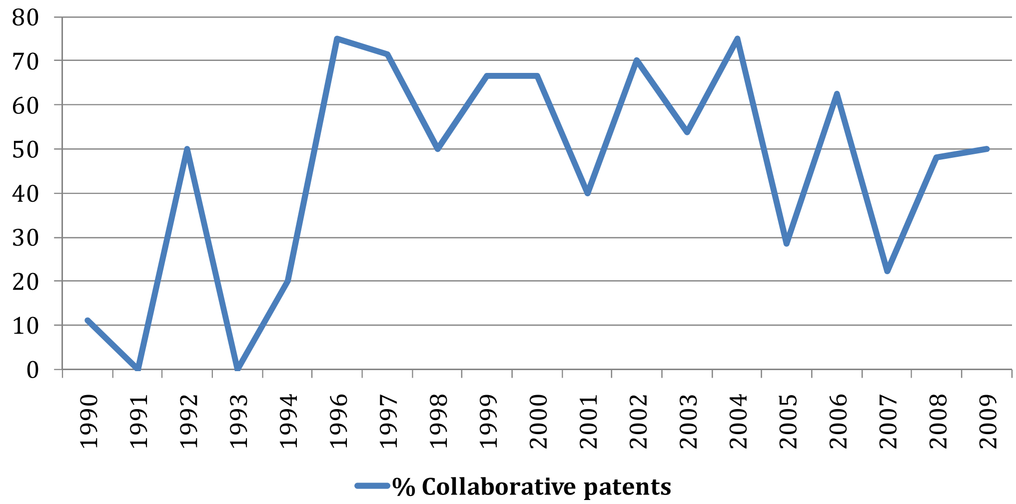
Source: own calculations using the NBER patent dataset and USPTO online search patent database
Note: these numbers refer exclusively to the inventions with a Bulgarian first-inventor

Compared to the pre-transition period (before 1990), there are significantly fewer Bulgarian international patents today. **Figure 3** presents a historical breakdown of Bulgarian patents granted in the USPTO using the technological classes of (Hall, Jaffe, and Trajtenberg 2001). It shows a massive drop in the traditional patenting fields (mechanical, electrical and electronics, chemical) driven both by a reduction in investments and a lack of technology

[8] The latter provides a broader picture of the technologies that are developed in the Bulgarian economy, however, national patenting rates tend to be noisier measures and not suitable for cross-country comparisons.

upgrades (Krammer, 2009). Bulgaria's top-performing patenting classes were connected to traditional industries with mature technologies, such as metallurgy, chemicals, industrial heating and medicaments. However, in the last years a positive trend has emerged with new patents coming from high-tech industries, driven by significant R&D efforts of multinationals (**Figure 3**). While this portfolio is small in absolute terms, it is focusing on emerging technological fields: communication and navigation technology, data processing, computers, software and memory and miscellaneous others (defense, engines)[9]. Such diversification into new technological areas that are more relevant in the current global economic environment is an important development, in sync with SS strategy, and should be nurtured in the future through careful policy support.

Figure 4. The percentage of Bulgarian patents with international co-inventors (1990-2009)



Source: own computations based on utility patents granted at USPTO

Another interesting trend in Bulgarian patenting is its rapid internationalization. Prior to 1990 almost all patents were the results of "all Bulgarian" teams of inventors coming from large public R&D institutes (Radosevic, 1999). Collaboration with foreign researchers and firms rose in the late 1990s and kept increasing ever since, and today these co-inventions account for more than half of the country's patents at USPTO (**Figure 4**) mirroring similar findings in the region (Goldberg et al., 2008). Most of these collaborations take place with partners from Western Europe (Germany, Sweden, Belgium), the USA and Japan. The emergence of new players in the

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[9] Patents granted to Bulgarian inventors declined substantially post-1990, but have seen an uptick thanks to SAP labs, a German IT company.

region, some of them important multinationals with a global presence (GE, Samsung, Sun, Nokia), as assignees of Eastern European patents is not surprising (Krammer, 2009). However, there is almost no collaboration with other Eastern Europeans, except for a few patents co-authored with Russian inventors.

Finally, when analyzing the concordance between technological and industrial Bulgarian strengths, I find a significant mismatch (**Table A.3**). Employing the concordance tables developed by Schmoch et al. (2003), I identify main technological contributors (Column 4) to top exports categories (Column 1) and compare the former with the actual Bulgarian most innovative fields (Column 5) identified from detailed patent data. Overall, I find that there is significant mismatch between the two, with many of the export "Champions" (minerals, oils, food, chemicals) lacking a strong technological background. Partly this is due to the fact that these products (industries) are represented by rather narrow intakes of technologies due to their industrial maturity; however, there is a clear mismatch between remaining technological competences of Bulgaria at the world frontier and its current export platform. From the opposite direction, fields like communications, computer components, firearms, medical products (Column 5) show strengths on the innovative side that have not been (yet?) translated into major commercial benefits (i.e. becoming some of the top exports of Bulgaria). Some of these fall under the category "Achievers" in **Figure 2**, while most remain outside the top 20 exports of Bulgaria (low sales), given increased competition it faces in these niches and existing quality (sophistication) levels of these products. It is clear that all these technologies represent important candidates for future export "achievers" and "champions". The UN COMTRADE data does not record service exports therefore a lot of software products (market with * in **Table A.3**) does not have a direct match in the export data. However, given that the share of IT products in the Bulgarian GDP is about 10% (of which 1.5% is represented by software products) I am confident that these technological fields are well represented among the top exports of the country.

3.2.2 Specialization of basic research

The catalytic role of scientific research in nurturing innovation is widely acknowledged (Rosenberg, 1990; Pavitt, 1991). Moreover, the availability and quality of scientific education determines the absorptive capacity potential through availability of skilled human capital (Cohen and Levinthal, 1990). Thus, strengthening the scientific base becomes a critical aspect for maintaining steady flows of new knowledge and skilled personnel in the economy. Finally, scientific activities have important connotations for economic specialization and subsequently competitiveness of nations, as shown by Laursen and Salter (2005).

To capture the Bulgarian position in the global scientific landscape, I focus on bibliometric indicators based from several specialized databases, namely *Web of Science*, *Essential Science Indicators* and *Scopus* from Elsevier[10]. Overall, scientific production has proved more resilient than patenting of new technologies, but still insufficient for Bulgaria to retain its pre-transition position relative to its peers. Measured on a per capita basis, Bulgaria's scientific production is on a par with Romania, Turkey and Croatia but behind European leaders (Finland and Italy) and Central Eastern countries (Croatia and Hungary)[11]. In fact, growth of Bulgarian publications lags behind the world's average, and consequently Bulgaria's contribution to the world pool of publications decreased from 0.19 percent in 1996 to 0.14 in 2008. Another major challenge that Bulgaria faces is improving the quality of its output, namely achieving greater impact in core specialties. Analyzing the H-index[12] statistic, Bulgaria scores 97 between 1996 and 2008 (i.e. it has 97 papers with at least 97 citations in this interval), similar to Romania and Croatia, but again below Turkey, Hungary or Poland (**Table A.2**).

The Bulgarian strengths reside in physics (optics, applied, condensed matter and multidisciplinary), chemistry and engineering (materials science, electrical and electronics). Overall, Bulgaria's pure science and engineering remains the main source of international publications (see **Figure 5)**. However, its scientific specialization does not seem to support its export profile (**Table A.3**). Thus, when analyzing the concordance between scientific and industrial Bulgarian strengths, I find a mismatch between its scientific (Column 3) and export excellence domains (Column 1) that rely heaviest on the fields detailed in Column 2. Similar to patenting, current Bulgarian scientific scene does not focus on supporting technologies

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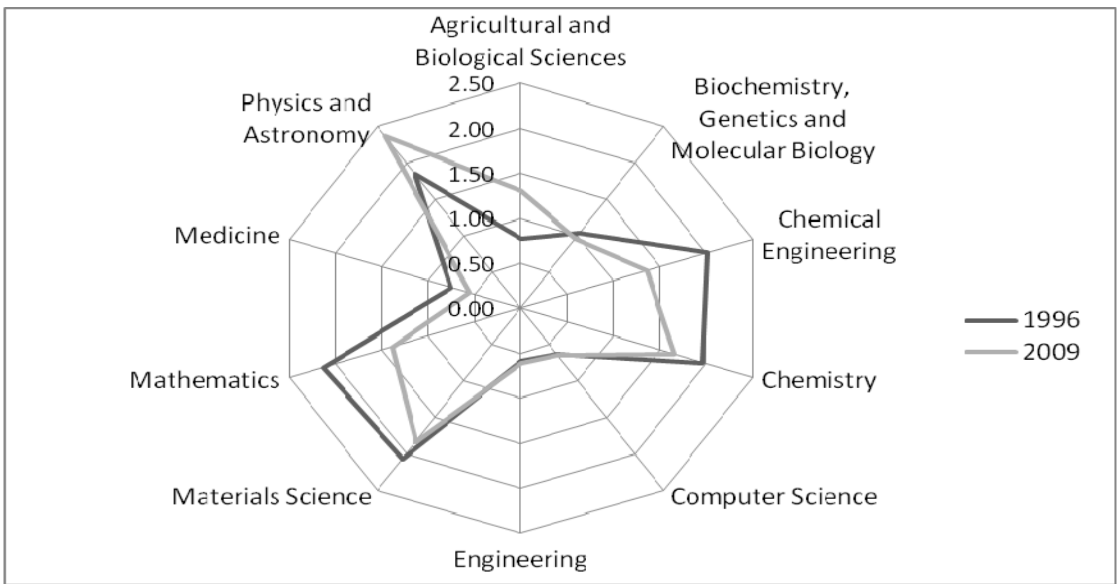
[10]As a limitation, both Web of Science and Essential Science Indicators focus on journals in English; however, Scopus covers also several Bulgarian language publications.

[11] Its global share of scientific publications is 0.14%, similar to Romania (0.22%) and Croatia (0.18%), but behind bigger countries (Turkey- 1.17%, Italy - 3.27%) or more prolific ones (Hungary -0.38%, Finland -0.65%).

[12] This measure was developed by Jorge Hirsch, and equals *h* if a country publishes *h* papers each of which has been cited by others at least *h* times in the considered time frame.

(applications) for its resource-heavy export "Champions" (minerals, oils), glass and even food industries, in which the country seems to excel from an industrial point of view but possess less multidisciplinary backgrounds (Laursen and Salter, 2005). However, the "achievers" category remains well represented with significant interest in the fields of pharmacology, medical equipment, telecommunications, electronics, etc. that might represent the next wave of Bulgarian success stories and some good candidates for concerted SS strategies at the regional level. This systemic mismatch should be considered in any innovation policy to be implemented.

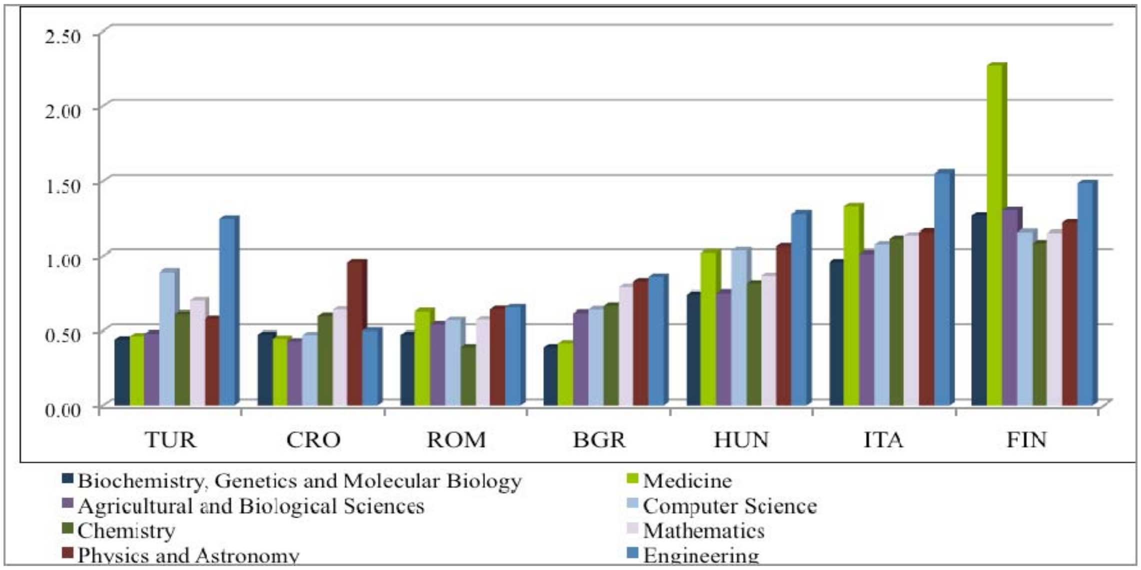
Figure 5. Specialization Index for Bulgaria: 2009 versus 1996



Source: Own calculations based on SCOPUS data (2010).
Note: This index measures the ratio of the country's world share of publications in a discipline to the world share in all disciplines

Similar to patenting, three quarters of Bulgaria's scientific production originates from the Sofia (Academy of Science; University of Sofia; University of Chemistry, Technology and Manufacturing) while other regions (Varna, Plovdiv, Pavlikeni) are far less prolific. Furthermore, when allowing for heterogeneity in terms of quality of publications, the impact of Bulgarian science remains far below European comparators (see **Figure 6**). The literature (Partha and David, 1994; Stephan 1996) underlines the importance of incentives for high-impact and peer-reviewed publications. New funding policies could address this issue by allocating resources to institutions that demonstrate increases in their research's impact. This will create a more competitive environment in which management of research institutes is encouraged to increase the quality of research, and not just the headcount or tenure of full-time researchers.

Figure 6. Relative impact index in selected disciplines for Bulgaria and comparators: 1996-2008



Source: own calculations based on SCOPUS database (accessed March, 2010)
Note: the relative scientific impact index is computed as the ratio of the world share of citations for a country A between 1996 and 2008 to the world share of A's publications in a certain year. A value above 1 indicates that country A received more citations per paper (thus is more visible) than the global average.

Finally, an analysis of most influential articles with a Bulgarian author reveals that these stem from, more or less the same fields of relative strength, namely physics, clinical medicine, chemistry and engineering[13] (ISI Thomson's "New Hot Papers" section). Similar to patenting, most of these articles are co-authored with researchers from abroad. This suggests that Bulgaria needs to strive for more external collaborations as an avenue to enrich its domestic expertise and nurture a homegrown competitive advantage in science. The overall share of co-authored publications with foreign scientists has increased tremendously, from 16% in the communist era (1981-1990) to 35% in the 1990s, and over 50% in the present. Most foreign collaborators are

[13] This list is based on the number of citations received, corrected by field propensities. The top-five "hot" Bulgarian papers come from medicine, physics, chemistry and geo-sciences (March, 2010) and most of them are coauthored and international.

from Germany, France Italy and the USA, although recent trends record an increase in partnerships with scientists from other EU countries (Belgium, Spain and Poland) and Russia. These are very positive developments, as bibliometric studies find that papers with international co-authors have significantly more visibility and impact (measured by citations) than otherwise (Figg et al. 2006; Inzelt et al. 2009).

3.3 Systemic context

The innovation literature refers to issues that hinder the evolution of STI systems as systemic problems or failures (Klein-Woolthuis et al., 2005; Hekkert et al., 2007; Chaminade and Edquist, 2010). Commonly these are conceptualized as relating to the four structural dimensions of STI systems (actors, institutions, infrastructure and interactions) and can be quantified in terms of capacity, quality or intensity (Wieczorek and Hekkert, 2012). The following paragraphs provide an assessment of these failures in the Bulgarian case using data from BEEPS surveys ran by the World Bank and other secondary sources.

Actors' problems concern the presence and involvement of various actors (i.e. governments, firms, etc.) in STI systems. In this respect, the most salient factor for Bulgaria is the lack of substantial business R&D efforts, which are commonly perceived as the main engine of innovation in a country (Furman et al., 2002). BEEPS data suggests that while domestic firms are actively upgrading their product lines (55%), only a small percentage diversifies via new products (40%), and even fewer perform R&D (28%). The latter appear to reap the fruits of innovation, as described in the literature (Melitz, 2003): they are larger, more productive and exporting firms, clustered around the capital, Sofia (see **Table 1**).

Table 1: Characteristics of different Bulgarian types of firms

	Non-innovating firms	**Innovating firms**	**Non-exporting innovating firms**	**Exporting innovating firms**
Average age of companies in years	12.7	12.7	12.8	12.5
Share of new companies (less than 4 years old)	5.2%	2.4%	2.9%	0.8%
Average number of employees	25	35	28	61
Share of SMEs (up to 250 employees)	94%	93%	96%	83%
Percent of companies located in Sofia	11.2%	44.4%	37.5%	67%

Percent of companies which have a line of credit or a loan from a financial	39.6%	41%	40.5%	42.7%
Percent of companies with at least 25% of foreign ownership	8.2%	11.8%	6.8%	27.6%
Average annual sales growth rate over 2005-2007	16.4%	25.8%	27.8%	20%
Average growth rate of employees over 2005-2007	0.25%	8.1%	8.7%	6.1%
NUMBER OF FIRMS	165	121	91	30

Source: World Bank estimates (BEEPS 2008)
Note: Shaded cells show statistically significant differences, dark grey at 1% level, grey at 5% level, light grey at 10% of significance.

This finding is consistent with the low level of private R&D for the country (0.15% of GDP) that is below the European average. Secondly, this is complemented by low entrepreneurial rates (World Bank, 2012), which pose further challenges in terms of policy (Foray et al., 2009). Finally, transition problems (Chaminade and Edquist, 2010) that arise from changes in technological paradigms cannot be met solely by private sector. The decades of communism Bulgaria since 1990s still have a negative impact on its current STI performance, calling even more for comprehensive and "smart" policy solutions.

Institutional problems remain a significant challenge for Bulgaria. The survey results emphasize also the importance of competition and access to finance, with clear policy implications. In Bulgaria, most managers identify domestic competition as an important factor that affects the firms' decision to develop new products, services and markets (**Table 2**). Foreign competition affects a smaller share of firms, but is a significant factor for innovating companies and especially those that are export-oriented. Moreover, financing is an important barrier: about one in five companies face constraints in their access to finance, and the governmental support remains rather scarce. The significance of such financial aspects has increased since the recent crisis (Correa and Iootty, 2011)[14]. Finally, innovative and exporting firms share concerns regarding the overall quality of the institutional environment where political volatility, informal competition and corruption are hindering competitive advantage.

The *interaction problems* in the case of Bulgaria are pertaining to existence of weak networks or connections between main actors. We have already seen that one of the major issues

[14] The main obstacles to the enterprise operations reported by the CIS in Bulgaria are the high cost of innovations (4.8% of firms), the lack of funds (4%), the lack of sources outside of the company (3.1%), market power of the established companies (2.4%) and lack of qualified workforce (2.2%).

from a systemic point of view the apparent disconnect between comparative advantage in STI and that in terms of exports (economic activities). Such complementarity problems (Chaminade and Edquist, 2010) occur, as different competences within a system cannot complement each other as originally intended. Moreover, these are clear examples that advocate government's involvement in STI policies by bringing them together and maximizing the potential synergies between these components through establishment of new links (e.g. incubators, joint research and commercialization agendas, etc.).

Table 2: Enablers and barriers of innovation

	Non-innovating firms	**Innovating firms**	**Non-exporting innovating companies**	**Exporting innovating companies**
Percent of companies for which pressure from domestic competitors affects innovation decision	52.6%	61.2%	63.8%	53.1%
Percent of companies for which pressure from foreign competitors affects innovation decisions	21.8%	41.9%	35.6%	61%
Percent of companies which export their production	11.4%	23.5%		
Percent of companies for which pressure from customers affects innovation decisions	58.9%	62.8%	65.4%	54.6%
Percent of companies for which access to finance is an obstacle to its operations	15.8%	19%	18.6%	20.5%
Top 3 elements of the business environment, which represent the biggest obstacle faced by the firm	-Access to finance -Practices of informal competitors -Tax rates	-Political instability -Inadequately educated workforce -Corruption	-Corruption -Political instability -Inadequately educated workforce	-Political instability -Practices of informal competitors -Crime, theft, disorder
Percent of companies that received subsidies from the government or EU over the last 3 years?	4.2%	3.7%	1.8%	9.7%
NUMBER OF FIRMS	165	121	91	30

Source: World Bank estimates (BEEPS 2008)

Note: Shaded cells show statistically significant differences, dark grey at 1% level, grey at 5% level, light grey at 10% of significance.

Infrastructure problems can refer to physical, knowledge and financial infrastructure. Bulgaria remains in deficit in all three areas. With respect to transport infrastructure (e.g. ports, railroads, roads, information technology), on a rating ranging from 1 (very low) to 5 (very high) Bulgaria scores around 2.5 every year (World Bank statistics). Another component of infrastructure that relates to STI systems is connectivity with the rest of world. Here, Bulgaria has an average status, with 48.8% internet users (as of 01-01-2012), below the European average of 71% (Source: http://www.internetworldstats.com/stats9.htm). Finally, previous analyses show also that the quality of the STI infrastructure (scientific publication, patents) is low both in terms of absolute numbers per researcher but more importantly, in terms of quality (world impact). Thus, there is significant room for improvements across the board in terms of infrastructure.

4. POLICY IMPLICATIONS AND RECOMMENDATIONS

In the context of Europe 2020, SS strategy has emerged as a key element for innovation policies seeking to increase the overall STI performance in Europe and subsequently harness it for economic growth and development. Prior sections have presented a detailed analysis of Bulgarian STI systems and economic competitiveness. This section utilizes these findings and provides policy rationales that are clustered around the four main concepts (4Cs) of a SS strategy (RIS 3 Guide):

1. *Competitive advantage*: build upon existing economic strengths and match them with business needs, STI capabilities and available human capital.

Bulgaria needs to stimulate exports in products with increased sophistication and technological intensity in coherence with its scientific capabilities and existing specialization ("Achievers" category in section 3.2). Moreover, related diversification into higher value-added goods and services through co-invention (adaptation of GPTs to improve quality or efficiency levels) in the mid-term to long-term is an indispensable ingredient to sustain export growth and international competitiveness. Firms in these sectors should be stimulated to undertake strategic actions that will develop a clear strategy for future development. There is also a great need to support these high-potential areas via innovation and FDI targeted policies, as well as establishing links with correspondent scientific bodies in forms of technical parks and business incubators. Finally, the government must identify and eliminate any bottlenecks faced by high-potential industries (skills, infrastructure and other factors).

2. *Choices*: SS is all about investment in few selected areas of interest based on a process of entrepreneurial discovery and governmental assistance.

Given the status quo of Bulgarian STI system, there is an urgent need for innovation policies that target priority sectors. This analysis suggests that there are several viable options (pharmaceuticals and IT, among others) for future export champions that can be fuelled by FDI inflows and a strong domestic scientific base. However, both of these industries face specific challenges and require tailored policy interventions to sustain them. Some of the most common obstacles for the development of the pharmaceuticals industry include administrative hurdles that delay entry by generic drug producers, informal market competition from countries outside the EU, and limited uptake of funding instruments for innovation. Similarly, the development of the IT industry could be facilitated by a strategic orientation in funding and resource availability for firms, broadband infrastructure development, and leaner legislative burden, development of education curricula in schools and universities and stronger IPR laws.

3. *Critical mass*: SS should spur world class excellence in selected domains (specialization) and through them achieve technological diversification at the European level.

Enterprise surveys suggest that, besides lacking the necessary skills, firms are not encouraged to undertake own R&D projects. In fact, financing of innovation projects is extremely problematic (20%) and the number of available grants is insufficient. This yields significant losses for the Bulgarian economy, given the clear differences in terms of value and job creation between exporters and non-exporters, especially those that also innovate. In order to meet its proposed target (1.5% of GDP for R&D), the Government needs to increase the absorption of EU funds, public STI support, and efficiency of its funding instruments. Estimates point out that this will require absorption of €539.2 million from the Operational Program "Development of the Competitiveness of the Bulgarian Economy" 2007–2013 funds by 2015 (World Bank, 2012). So far, the absorption of European funds has been very slow due to a variety of factors such as low administrative capacity, excessive red tape and restrictive eligibility criteria, poor awareness of the programs, lack of pre-finance activities. National instruments need to play a crucial role as project pipelines for EU support, as they are the only source available for funding early stage R&D. While after 2005 these instruments grew substantially, in 2009 and 2010 they suffered significant cuts due to greater fiscal discipline and budget constraints. In addition, Bulgaria could benefit from fostering participation in other European initiatives such as EUROSTARS, JEREMIE and CIP.

4. *Collaboration*: through SS regions and countries aim for leadership positions in their respective domains of expertise complemented, however, by collaborative endeavors in STI and business alike.

In terms of innovation, after a severe plunge in the 1990s, Bulgarian supply of new technologies is picking up, mostly driven by foreign sources of technologies. Most of these new patents granted to Bulgarians by USPTO are related to high-tech industries, especially computers and communications, driven by multinationals' domestic R&D activities. These developments emphasize the crucial aspect of supporting and encouraging inward "high-tech" FDI into the country providing Bulgarian companies to connect with lead inventors and corporate R&D. The present performance of Bulgarian science calls for similar measures to support international collaboration and flows of knowledge via people and projects. Moreover, scientific productivity should be incentivized through funding increases to research institutions conditional on improvements in impact metrics. This would create a more competitive environment in which management of research institutes is encouraged to increase the quality of undertaken research.

5. CONCLUSIONS, LIMITATIONS AND FUTURE AGENDA

Today, STI policies are perceived as important tools to enhance national competitiveness and welfare. Such actions should optimize the relations between actors and components of these systems and account for a multitude of factors. Competitiveness involves high STI dynamism, being able to change and adapt fast to a new environment, and taking advantage of the existing knowledge and technologies. This dynamism is improved through multiple measures targeting components of STI systems (e.g. industrial cluster policies, R&D and science support, taxation and education policies) with a clear objective of improving the long-term competitiveness at the national (regional) level.

This work provides a synthetic framework to develop national SS strategies that link the competitive and STI profile of a country. The study employs a variety of quantitative and qualitative data and focuses on Bulgaria, a representative case for transition and developing economies that aim to improve their competitive position. This analysis can be replicated for other countries (regions) as a diagnostic tool for potential SS paths to follow. The results of this exercise supplemented with qualitative information from enterprise surveys provide a rich basis for SS recommendations that focus on the short- and medium-term options. Moreover, these issues account for both Bulgarian (National Reform Program 2011-2015) and European realities (Europe 2020 agenda) calling for a harmonized response across national STI systems to support these areas of relative strength.

Naturally there are some inherent limitations associated with this work. First, following the export-led growth literature I consider only exports to be a valid representation of international competitiveness of country, while in reality the picture can be much more complex. Secondly, due to the nature of the export data from UN Comtrade database, the analysis does not include also service sectors. Given their increasing importance in the world economy, this might bias the results. However, complemented with a qualitative assessment of export activities this bias is reduced drastically. Finally, Bulgaria and other developing and transition economies still face major institutional challenges. While some aspects pertaining to STI systems have been dealt with in the systemic analysis subsection, a deeper assessment of these mechanisms should be implemented for those sectors identified as primary targets for the SS strategy.

Bulgaria has achieved significant improvements over the last decade in terms of living standards. However, the recent crisis has revealed as for many other countries that this growth was built on unsustainable grounds rooted in financial and real estate bubbles. Its competitive position in terms of trade is based on low-tech and low-value added products that lack in terms of sophistication and diversification opportunities. This is a direct result of poor technological performance that still relies heavily on mature sectors from its communist past and lacks a coherent strategy for the future. The socialist legacy still weights down on the scientific Bulgarian profile. There is a vast disconnect between its STI and production systems, except in the case of IT which benefited from large and R&D intensive influxes of FDI. Most researchers are employed in the higher education and the public research institutes around the country, which constricts severely the absorptive capacity of domestic firms. Businesses lack incentives and financial resources to undertake innovation, which in turn dictates their chances of success, either domestic or international. The scientific and technological competences accumulated are quite narrow and rapidly moving towards obsolescence, while the shift towards current relevant and rewarding areas of research battles systemic inertia, lack of skilled human capital and financial restraints.

So what are the opportunities for Bulgaria to harness its STI systems for competitiveness and growth? A possible solution is given by smart specialization. First, Bulgaria needs to *make STI a priority for its regions and industries*. STI systems need to be restructured in a way that meets today's requirements for success. Channels for communication among actors within these systems (firms, universities, Academy of Science) need to be established and reinforced so the exchange of knowledge, alignment of interests and cross-incentives occur effortlessly. Enterprises themselves need to change as well: adopt R&D as a vehicle for future success and pursue it internally as well as externally through alliances and collaborations with universities or institutes. Second, *specialize in areas of relative strengths and create synergies*. The SS strategy requires involvement in areas of comparative advantage in economic or STI terms. Today's Bulgarian champion exports are mostly low-tech and resource driven sectors that need to be complemented by strong STI bases and co-development of GPTs to boost value-added and productivity. Alternatively, the emphasis should be placed on "rising stars" (such as IT, pharmaceuticals) that exhibit the greatest STI and export potential for the future. These strategic sectors would benefit tremendously in terms of streamlined legislation, foreign investment facilitation and increased academic resource provisions (collaborations with universities and trained graduates). Such an approach should foster engagement of different stakeholders (private sector, public institutions, non-profit) in building the creative and social capital required for the success of these industries. Finally, despite significant institutional change since 1990, major challenges remain ahead in terms of *supporting innovation*. To meet its targets, Bulgaria will need to increase greatly its absorption of EU funds for competitiveness and human resource development, lift public spending, target priority sectors, streamline the institutional STI framework and raise the efficiency of its national instruments. The latter play a crucial role in creating a project pipeline for EU support programs, as the only funding source for early stage R&D. Streamlining the institutional framework that spans innovation and R&D would help

Bulgaria to fully exploit the opportunities provided by EU funds that support competitiveness and human resource development. Finally, the need for *policy harmonization* stems from the systemic nature of STI and lessons of current failures, such as achievement of "knowledge-based" status for the EU as a whole. Following blindly an increase in certain innovative inputs (e.g. targeting R&D expenditures of *x* percent, giving out tax breaks) does not guarantee success in the absence of others (qualified work force, inefficient patent system etc.). Thus, continuous adjustments and a "smart" and "systemic" approach towards tailoring Bulgarian STI systems will be required to achieve technology-induced competitiveness.

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APPENDIX:

Table A. 1. Top 15 contributors to Bulgaria's EXPY (2008)

Code	Short product description	PRODY (PPP)	Contribution to EXPY	Exports, $US mil.	RCA	UVD
6821	Copper and copper alloys refined	12,822	6.12%	1,920	20.69	0.45
5417	Medicaments (including veterinary)	28,535	2.20%	530	0.67	0.08
0412	Other wheat and meslin, unmilled	18,566	2.05%	311	7.31	0.05
6744	Sheet, plates, rolled of thick iron	18,933	1.66%	446	5.83	0.02
7492	Cocks, valves and similar appliances	26,543	1.42%	355	2.04	0.05
6732	Bars, rods (not wire rod)	15,586	1.37%	216	3.97	0.12
6842	Aluminium and aluminium alloys	19,884	1.30%	355	2.82	0.03
6822	Copper and copper alloys, worked	13,582	1.27%	265	4.37	0.05
2820	Waste and scrap metal of iron	13,049	1.00%	211	4.06	0.02
8439	Women, girls, infants outerwear	17,819	0.97%	198	3.34	0.05
7781	Batteries and electric accumulators	20,364	0.84%	565	2.92	0.04
8745	Measuring, controlling instruments	24,670	0.79%	310	10.47	0.04
8451	Outerwear knitted or crocheted	20,962	0.76%	220	2.29	0.02
0484	Bakery products	17,913	0.72%	166	4.82	0.01
7752	Domestic refrigerators	17,138	0.72%	129	6.15	0.06

Source: own calculations based on UN COMTRADE, 2010. Product codes are SITC Rev. 2 at 4 digits.

Note: UVD (unit value distance) is computed for each product as the log difference between unit values in the highest-price country for an exported product and Bulgaria's exports at SITC-4 digit level

Table A. 2. Scientific publications and citation totals (1996-2008)

Country	Citable documents	Citations	Citations per Document	Scientific impact (H index)
Italy	581,455	6,809,577	12.29	432
Finland	121,358	1,714,200	15.10	273
Hungary	70,330	633,534	9.37	183
Turkey	162,296	821,820	6.03	139
Bulgaria	29,342	165,992	5.92	97
Romania	41,408	175,079	5.00	96
Croatia	30,886	136,669	4.90	92

Source: SCImago based on SCOPUS data (accessed March, 2011).