Empirically Led Internationalisation of S3

An Investigation Based on Micro-Data for the Country of Slovenia

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Table of Contents

Figures

Tables

Executive Summary

Introduction of Study

Slovenia can be considered one of the better functioning Research and Innovation Strategies for Smart Specialisation (RIS3)[1] examples among European countries considering that the nation-state has set up consistent priorities with an adjusted policy mix and an especially well functioning governance structure already.[2]

RIS3 has served as an agent of change whereby triple-helix actors organized themselves around the RIS3 targeted Strategic Research and Innovation Partnerships.[3] This process should now be taken to the next level, by introducing evidence based on micro-data that might inform strategies for internationalization based on place-specific competencies and resulting in targeted policy initiatives that should guide the mid-term revision of the Slovenian S3 strategy, which is foreseen for 2019. In this process Slovenia could serve as a pilot example of demonstrate how frontier research methodologies and innovative micro-data sources paired with advancements in theories that pertain to knowledge-based and innovation-driven economic development approaches could lead to more effective and efficient RIS3 implementation.

The present study is an attempt in this direction. It is led by three international experts[4] with the following global objective:

> The study's objective is to perform a full knowledge, product and skill space analysis for Slovenia and subsequently identify key local and international entities (firms, institutions) in order support S3 development for future growth potential in science, technology and industrial activities.

In particular, the study addresses several relevant topics in this context, including:

- Technological Knowledge Production and Evolution;
- Foreign Direct Investment (FDI) and tax effects; and
- Global Investment Flows (GIF) and Global Value Chains (GVC).

The aim is to take a first attempt on how one of the biggest challenges in RIS3 could be addressed, i.e. to provide basis for targeted internationalisation, not just on the sectoral or product-level but also on the firm and cluster-level, which has not been done before. Furthermore, the aim is also to produce measures and indicators that will allow for comparison and preparation of a dedicated policy mix taking into account micro-level data as well as future trends. Results of this study are intended to serve as a possible benchmark for the preparation of RIS3 strategies for the post 2020 period.

Generating and providing expert and research-led insights to economic development activities and public policy making is a complex task that requires collaboration between researchers, policy makers and practitioners. In a first step, and this is where the present project is situated, it demands experts working on different lines of inquiries that pertain to innovation studies and economic growth to work together as a team.

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1 European Commission (2012) *Guide to Research and Innovation Strategies for Smart Specialisations (RIS 3)*; available at http://s3platform.jrc.ec.europa.eu/s3-guide. [accessed, May 10th, 2019].

2 Slovenian Smart Specialisation Strategy (S4): Republic of Slovenia, Government Office for Development and European Cohesion Policy – http://www.svrk.gov.si/en/areas_of_work/slovenian_smart_specialisation_strategy_s4/. [accessed, May 10th, 2019].

3 Etzkowitz H. and Leydesdorff L. (1995) The Triple Helix – University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development, *EASST Review* 14(1): 14-19.

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Only once insights on specific aspects are combined in a holistic economic development framework, we can expect to comprehend the socio-economic processes that lead to technological change, economic growth and prosperity. As such the present project is much more than the sum of the individual sections that follow in the main part of this report.

The Smart Specialisation Strategy Concept

Smart Specialization Strategies (S3) are place-based economic development approaches that have become a key component of the European Union's innovation policy efforts to enhance regional economic competitiveness.[5] One aspect of the smart specialization concept put forward by its architects is the significance of science and technology domains and their properties in terms of size and connectedness.[6] Thus, the presence of local technological capabilities and their relative level of relatedness, e.g. as measured by co-occurrence, offer insights into regional patterns of technological and skill specialization as well as the synergies that exist between them.[7] Despite the many signals and persistent calls by several creative minds behind the S3 thesis that it would require a number of alternative indicators that provide a more nuanced understanding of the presence and connectedness of knowledge-intensive and high-tech sectors in a regional setting to convert on this policy-vision, empirical advancements certainly have significantly lagged behind the flood of S3 theorizing.[8]

The present investigation constitutes a considerable step forward in this regard, and as such provides a range of progressive and meaningful empirical insights that will enable policy-makers to observe the development of regional capabilities through an evolutionary lens in light of S3. Furthermore, the present study moves the analysis from a static interpretation to a dynamic understanding of regional diversification and technological change, i.e. it enables researchers as well as practitioners to observe the drivers of change rather than just the change itself.[9]

And finally, the analytical insights presented here provide a theoretically sound and empirically feasible framework for the actual implementation of knowledge-based regional policy actions, something that is currently still missing in most S3 actions despite the popularity of the concept amongst economic developers and policy makers.[10]

In an attempt to convert on this vision of providing the most advanced S3 investigation among EU countries so far, the present investigation focuses on three main aspects along with associated sub-topics:

1) **Technological Knowledge Production and Evolution**
   a) The Slovenian Knowledge Space and its evolution
   b) Changing patterns of technological knowledge production
   c) Inventor collaboration networks
   d) Knowledge diversity and relatedness
   e) Recombinant knowledge production
   f) Technological industry and occupation profiles

2) **Foreign Direct Investment (FDI) and tax effects**

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5 ibid., #1 on p. 8.

6 Foray, D., David, P. and Hall, B. (2011) 'Smart specialization. From academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation' Working Paper (170252) Available at: https://infoscience.epfl.ch/record/170252/.

Foray, D., David, P. and Hall B. (2009) Smart Specialization - The Concept. Knowledge Economists Policy Brief Number 9, June, European Commission, DG Research, Brussels.

7 David, P., Foray, D., Hall, B. H. (2009) 'Measuring Smart Specialisation: The Concept and the Need for Indicators'. Knowledge for Growth Expert Group.

8 ibid.

9 Kogler, D.F. (ed.) (2016), *Evolutionary Economic Geography – Theoretical and Empirical Progress*, New York, Routledge. Further, Kogler et al. (2017) offers an example of such an advanced empirical approach.

10 See McCann and Ortega-Argilés (2013; 2015) for an in-depth discussion of these and related topics.

a) Tax policy and the location of foreign direct investments
b) Slovenian Exports and FDI measures
c) The technological content of Slovenian trade

3) Global Investment Flows (GIF) and Global Value Chains (GVC)
a) GVCs and opportunities for upgrading
b) Building, Embedding and Reshaping GVCs
c) The position of Slovenia in GVCs and GIFs: greenfield investment and M&As

What follows is a brief overview of the main results from this analysis.

The Slovenian Knowledge Space and its Evolution

- The Knowledge Space methodology was applied to the case of Slovenia, which in turn provides novel insights into the changing patterns of knowledge production in the country.
- The Slovenian Knowledge Space has evolved significantly over the 2001-2015 time period, and it is clearly evident that the nation has developed areas of expertise that differentiates it from other European nations.
- The position in patent output when ranked among EU28+2 countries is in the middle and has only slightly changed over the observed 15-year time period, although an upward trend is clearly observable.
- Given the relatively small size of the economy and adjusted for population and manufacturing employment, Slovenia is ranked well above other Eastern and Southern European countries.
- In Slovenia we find fewer international collaborations in the development of patents compared to other European economies, notably Czech Republic, Poland and Estonia.
- The share of top 10 assignees in the overall output of patents has declined significantly, which indicates a more even distribution of actors engaged in technological knowledge production processes.
- The share of pharmaceutical firms in the overall output of patents has continuously declined, while the share of public entities that are involved in producing technical knowledge has increased.
- Patent classes A61K (PREPARATIONS FOR MEDICAL, DENTAL, OR TOILET PURPOSES) and class C07D (HETEROCYCLIC COMPOUNDS) are technological knowledge domains that are very prominent in the Slovenian Knowledge Space.

Technology Structure and Trends in the pan-European and Slovenian Knowledge Space

- The most "influential" and "bridging" technology patent classes were highlighted and indicate Slovenia's areas of knowledge specialization.
- A variety of technological knowledge indices outline Slovenia's position among the EU28+2 countries.

Technological Relatedness Density Scores

- Technological relatedness density scores indicate growth potential in particular technology domains.

- A list of patent classes that have the highest potential to become new areas of knowledge specialization have been highlighted.

Technological Industry Sector Profile

- A full technological skills and occupation profile highlights changing patterns and the type of occupations that are most involved in the production of technological knowledge in the country.
- Science and engineering professionals, followed by assemblers, medal, machinery and related trades workers are among the most prominent occupation groups represented.

Taxes and FDI Location

- Taxes, including the treatment of R&D, are a significant determinant of multinational location.
- Compared to other European countries, FDI into Slovenia is estimated to be particularly sensitive to its corporate tax.
- A small reduction in the Slovenian corporate tax would serve to increase its chances of attracting foreign firms. To achieve the same result would require a fairly large reduction in the personal income tax rate.
- A switch from the current regime of accelerated depreciation for R&D expenses to a tax credit may serve to increase Slovenia's attractiveness to FDI.

Slovenian Exports and FDI Measures in the Context of Global Value Chains

- Relative to the global average, Slovenia is more integrated into global value chains, both feeding into them and in terms of where it secures its inputs.
- Slovenia's largest export industry, chemicals, is somewhat less reliant on global value chains than others. Therefore it may be advantageous to encourage more self-reliance for target industries while remaining aware of the overall benefits of international integration.

Technological Content of Trade

- Vehicle and Medical/Veterinary technologies dominate Slovenian trade (with petrol technologies also important in inputs).
- There is considerable overlap in the technological content of Slovenian imports and exports. This again suggests integration with global value chains.

GVCs and Opportunities for Upgrading

- Upgrading can only take place following an integrated approach of alignment between local resources, and global capabilities and expertise.
- Upgrading must be based on two targets: 1. The quality and nature of inbound and outbound connectivity to/from the region, and 2. its interdependence with neighbouring territories as well as those at distance.
- Investment flows matter in their quality, not their quantity. For Slovenia, in dictating S4 this will mean utilising information on who is investing and where they are investing to ensure the best GVC links are built through GIFs.

Building, Embedding and Reshaping GVCs

- The proactive search of new knowledge from firms internationalising can positively stimulate R&D in Slovenia
- There is precedence for success in bridging the divide between Slovenia and GVCs, actively championing upgrading from a public policy perspective.
- Strategies should target both global MNEs and local firms. The aim is to find appropriate links between the two and build capacity. The focus should be on a combination of product, process and functional upgrading.

The Position of Slovenia in GVCs and GIFs: Greenfield Investments and M&As

- Both inward and outward FDI (greenfield and M&A) have failed to recover at pre-crisis levels.
- Not quantity and but quality that matters. Important to look at GVC stage and nature of new investment
- Focus should be on the type of activities Slovenia aims to chase, these should be explicitly linked with S4 priority areas.
- If Slovenia is to internationalise fully and de-risk its economy from a few select GVCs, investment from emerging economies would be beneficial.
- For upgrading in the framework of a S4 strategy, efforts are necessary to increase Slovenia's centrality in FDI flows. A two-sided strategy approach will achieve this: 1) establish and intensify the connections with the most central nodes in the global and EU FDI network; 2) reinforce Slovenian connections with its peers' economies.
- Embedding GVCs remains critical to de-risk the internationalised economy.

Concluding Remarks

The study set out with the objectives to analyse the "Empirically Led Internationalisation of S3: Based on Micro-Data for the Country of Slovenia". The main objective was to describe, analyse and then to present the Slovenian government with a comprehensive study based on theoretical insights and driven my advanced data sources and methodologies. The present report provides a detailed overview and analysis to all these objectives, but then also aimed to offer some preliminary recommendations in regard to the development of a future Slovenian smart specialization strategy that considers: A) local knowledge production patterns and the opportunities that might derive from those; B) investment, foreign direct investment and tax effect models; and C) an analysis of the Public policy space of Slovenia, all geared towards the design of a S4 Strategy leveraging technological knowledge, global value chains and investment flows. The present report should provide the Slovenian government with valuable insights that will ensure that it can pursue the vision of an empirically led internationalization of S3 based on micro data.

1. The Slovenian Knowledge, Product & Occupation Space

The main focus in this chapter of the report is on the evolution of Slovenian knowledge production patterns and the opportunities that might derive from those. Following the Knowledge Space methodology, specifics regarding the technology structure at the pan-European and Slovenian context will be presented and subsequently investigated. Technological relatedness density scores will point to particular technology domains with growth potential, while the technological products, skills and occupation profiles will offer even further insights that should be considered when drafting relevant policies that aim to pursue the vision of an empirically led internationalization of S3 based on micro data for Slovenia.

1.1. Invention and Innovation

The production of novel products and processes (inventions) and its appropriation to earn returns on the marketplace (innovation) is key to every modern knowledge-based economy.

Competitive advantages of one jurisdiction over others is usually founded in utilizing and exploiting place-based capabilities and specializations. At the lowest end of the spectrum of economic development places compete on costs measures, e.g. cheaper labour, or natural resources that are needed for production processes, but not available elsewhere. While latter might yield significant returns as in the case with some resource-rich economies, a competition on cheaper inputs to production usually equals a race to the bottom. Real advanced economies, and this would be true for several decades now, mainly compete on competitive advantages that are based on knowledge and innovation. Out of this rationale, the concept of “Smart Specialisation” has developed.

1.2. Smart Specialisation – Domain & Connectedness

Smart specialisation and societal innovation can only work if choices are based on real knowledge of local potential and if the right actors are involved.[11]

The productivity gap between the USA and the EU is widening since the mid-1990.[12] One of the main explanations in this context is that the persistent lack of specialization in Europe limits the potential benefits of technological linkages and spillovers between both sectors and regions.[13] In a response to this “Smart Specialization” has been proposed as a policy programme that might offer a solution in this regard.[14]

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11 Quote by former President of the European Committee of the Regions, Markku Markkula, in the Parliament Magazine, October 2015, p.50.

12 Van Ark B., O’Mahony M. and Timmer M. P. (2008) The Productivity Gap between Europe and the United States: Trends and Causes, Journal of Economic Perspectives 22(1), 25-44. See also here for more recent evidence: Castellani D., Piva M., Schubert T. and Vivarelli M. (2018) The sources of the US/EU Productivity Gap: Less and less effective R&D. LEM Working Paper Series, Institute of Economics, Scuola Superiore Sant’Anna, Pisa. ISSN (Online) 2284-0400.

13 Kogler D. F., Essletzbichler J. and Rigby D. L. (2017) The evolution of specialization in the EU15 knowledge space, Journal of Economic Geography 17(2), 345-373.

14 Key references in this regard are: 1) Foray, D., Van Ark, B. (2007) Smart specialisation in a truly integrated research area is the key to attracting more R&D to Europe. Knowledge Economists Policy, Brief No. 1, October, p. 4. European Commission, DG Research, Brussels. 2) Thissen, M., Van Oort, F., Diodato, D., Ruijs, A. (eds) (2013) Regional Competitiveness and Smart Specialization in Europe: Place-based Development in International Economic Networks. Cheltenham, UK: Edward Elgar Publishing Ltd. 3) McCann, P., Ortega-Argile´ s, R. (2015) Smart specialization, regional growth and applications to European Union cohesion policy. Regional Studies, 49: 1291–1302.

In its most basic definition this programme is concerned with science and technology domains and their properties in terms of size and connectedness.[15] This suggests that: "In order to develop a competitive innovation strategy [..] regions need to identify their core competencies, as well as the potential for complementarities within their respective knowledge bases."[16] In order to convert on the vision of effective Smart Specialisation Strategies (S3) for regional economies a first step is to develop indicators that offer "a better understanding of high-technology and knowledge intensive sectors and the synergies that exist between them."[17]

1.3. The Knowledge Space Methodology

The Knowledge Space methodology (Kogler et al., 2013; 2017) offers the opportunity to identify place-based potential leading to informed and place-specific growth strategies.

If knowledge is the essential fuel that powers advanced economies, then it should become of focal interest when the objective is to analyse the economic state of regions and nations. While in general this is an accepted stylized fact[18], the particular properties of knowledge produced in specific places, especially in terms of their quantity, quality and embeddedness in the wider local economic system, are rarely considered in relevant socio-economic studies.

To address this shortcoming, the concept of the Knowledge Space was developed with the aim to provide a methodology capable to capture economic realities, translate them into a networked representation of existing capabilities and skills that also allows to test their inter-connectedness, and also to offer an advanced tool for progressive economic development evaluation and planning purposes.

Figure 1 illustrates the basic understanding that defines a local Knowledge Space. Essentially, the initial aim is quantifying the various types of knowledge that feed into development processes of a specific industry (sub-)sector. In the present example, the local economy consists of 3 top-level sectors, each of which is comprised of sub-sectors. At the intersections between those 3, in this case knowledge-intensive sectors, further advanced divisions of innovative economic activities that draw inputs from sub-sectors located within various top-level sectors are illustrated. For example, biosystems engineering or biological systems engineering situated at the top-middle of the illustration is a field of engineering that draws knowledge inputs from both, biotechnology and information technologies. An example of one practical application in this context would be biosensors.
Needless to say, only places that have the capabilities and capacity of producing both core technologies, or at least found a way to access that specialized knowledge, which is difficult due to the stickiness and the tacitness of economic valuable knowledge[19], will

15 For detailed information on the initial ideas of a potential Smart Specialisation policy programme see Foray, D., David, P., Hall, B. H. (2009) Smart specialisation—the concept. Knowledge Economists Policy Brief Number 9, European Commission, DG Research, Brussels; and Foray, D., David, P., Hall, B. H. (2011) Smart specialization: from academic idea to political instrument, the surprising career of a concept and the difficulties involved in its implementation. MTEI Working paper, École Polytechnique Fédérale de Lausanne.

16 Kogler et al. 2017, p. 347. Full reference: Kogler D. F., Essletzbichler J. and Rigby D. L. (2017) The evolution of specialization in the EU15 knowledge space, Journal of Economic Geography 17(2), 345-373.

17 Ibid p. 347. See also, David, P., Foray, D., Hall, B. H. (2009) Measuring Smart Specialisation: The Concept and the Need for Indicators. Knowledge for Growth Expert Group. Available online at: https://www.scribd.com/document/80115599/Measuring-Smart-Specialisation-The-concept-and-the-need-for-indicators [accessed, May 24th, 2019].

18 Feldman M. P. and Kogler, D. F. (2010) Stylized facts in the geography of innovation. In B. Hall and N. Rosenberg (eds) Handbook of the Economics of Innovation, pp. 381–410. Oxford: Elsevier.

19 Gertler M.S. (2003) Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there), Journal of Economic Geography 3,75-99.

have the advantage to enter into this area of the knowledge space that is driven by recombinant knowledge inputs deriving from two or more sectors. The right-hand side of **Figure 1** displays a networked representation of a hypothetical Knowledge Space that a) identifies each sector in terms of its quantity (size of nodes) as well as its relative position to other sectors (the distribution among and distance between individual nodes).

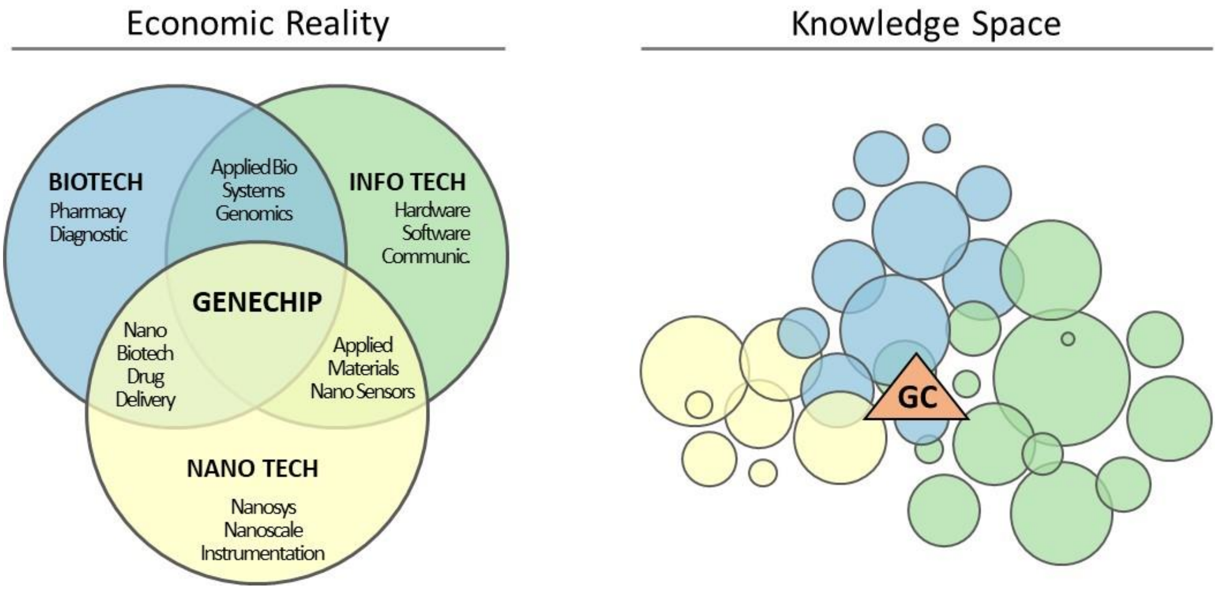

Figure 1. The Knowledge Space Methodology
Source: Kogler 2016[20]

Initially applied to cities in the United States[21], and later also to regional economies in the EU15 nation-states[22] this novel framework provides the opportunity to fully investigate the composition, i.e. domain and connectedness, of knowledge produced at various spatial scales. It provides insights into the patterns of local specialization while also offering the opportunity to investigate evolution of knowledge production processes. In this context it challenges the notion that localized knowledge production is purely driven by serendipitous regional trajectories, but rather aims to establish a framework that ensures a transition to planned and organized development pathways guided by evolutionary insights.[23] Following an overview of technological knowledge production in Slovenia over the time period 2001-2015 in the following sections, the focus will then shift towards the analysis of the evolution of Slovenian Knowledge Space.

1.4. Measuring Knowledge Production and Diffusion – Patent Data

Patent data provides a wealth of information about novel products and processes of economic value and thus offers an opportunity to quantify the Knowledge Space.

20 The illustration was developed by Dieter F. Kogler for the purpose of illustrating the "Knowledge Space" methodology at academic and policy-oriented conferences and meetings. It is the core methodology behind the European Research Council (ERC) funded project "Technology Evolution in Regional Technologies" (TechEvo); Principal Investigator: D. F. Kogler; 2017-2022; see: https://cordis.europa.eu/project/rcn/206490/factsheet/en [accessed, May 24th, 2019].

21 Kogler D. F., Rigby, D. L. and Tucker, I. (2013) Mapping knowledge space and technological relatedness in US cities. European Planning Studies, 21: 1374–1391.

22 Kogler D. F., Essletzbichler J. and Rigby D. L. (2017) The evolution of specialization in the EU15 knowledge space, Journal of Economic Geography 17(2), 345-373

23 Kogler D. F. (ed) (2016) Evolutionary Economic Geography: Theoretical and Empirical Progress. London: Routledge.

Knowledge unlike any other economic good possesses some unique properties, which in turn makes it difficult to measure and quantify. One quality of knowledge is its public-good character.[24] On the one hand this refers to the non-rivalry character of knowledge, i.e. it doesn't diminish with use even if it is exploited by many users simultaneously. On the other hand, knowledge is also considered non-excludable, i.e. it is accessible to those who invest in the search for it. All of this promotes the notion that knowledge is subject to increasing returns.[25] Furthermore, knowledge is cumulative insofar that new knowledge builds in prior insights and is added by re-combining elements deriving from the existing stock of knowledge. All of this might explain why knowledge production is considered to follow evolutionary trajectories that allow to delineate past and present patterns of specialization of economic activities in a given place.[26]

Patent data offers an ample opportunity to measure knowledge production and diffusion across economic sectors and their associated entities.[27] **Figure 2** illustrates a random European Patent Office (EPO) patent documents and highlights some of the relevant data elements in this context. These include: 1) information on the underlying technological knowledge inputs that served as the foundation in the development of a novel product and process of economic value, i.e. the patent classification system; 2) data on the associated inventors of the patented invention and there in particular their place of residence at the time of invention; 3) various date stamps that indicate the time of the invention; and 4) applicant information that designates the original owner and thus most likely initiator and funder of the development processes that has led to a particular invention.

In terms of identifying sectors and sub-sectors as illustrated in **Figure 1** as well as those sectors that are the intersection of more unrelated technologies, and that are built on recombinant knowledge, e.g. biosensors as described above, it is especially the patent classification system employed in patent documents that is of particular interest here. Each patented publication is assigned to at least one patent class, but most applications are assigned to more than one class. This in turn allows to identify the underlying technological knowledge that served as a foundation for the development of a novel product or process. In the present example (**Figure 2**) it is a combination of specific electrical and mechanical engineering knowledge that has been employed and has contributed to the patented invention.

Information about inventors, and especially their location at the time of invention, as well as about the applicants that have commissioned and engaged in research and development activities in order to generate a patented invention provides further insights in the overall knowledge production process taking place at a given locality. In summary, all the information found on patent documents provides an apple opportunity to analyse knowledge production processes, which will become the focal point of interest in subsequent sections of this report.

24 Arrow K. (1962) Economic welfare and the allocation of resources for inventions, in NELSON R. R. (Ed) The Rate and Direction of Innovative Activity, pp. 609-625. Princeton University Press, Princeton, NJ.

25 Lucas R. (1988) On the mechanics of economic development, Journal of Monetary Economics 22, 3-39. See also, Romer P. M. (1990) Endogenous technological change, Journal of Political Economy 98, S71-S102.

26 Kogler D. F. (ed) (2016) Evolutionary Economic Geography: Theoretical and Empirical Progress. London: Routledge.

27 Kogler D. F. (2015) Intellectual property and patents in manufacturing industries. In J. Bryson J. Clark and V. Vanchan (eds) The Handbook of Manufacturing Industries in the World Economy, pp. 163–188. Northampton: Edward Elgar.

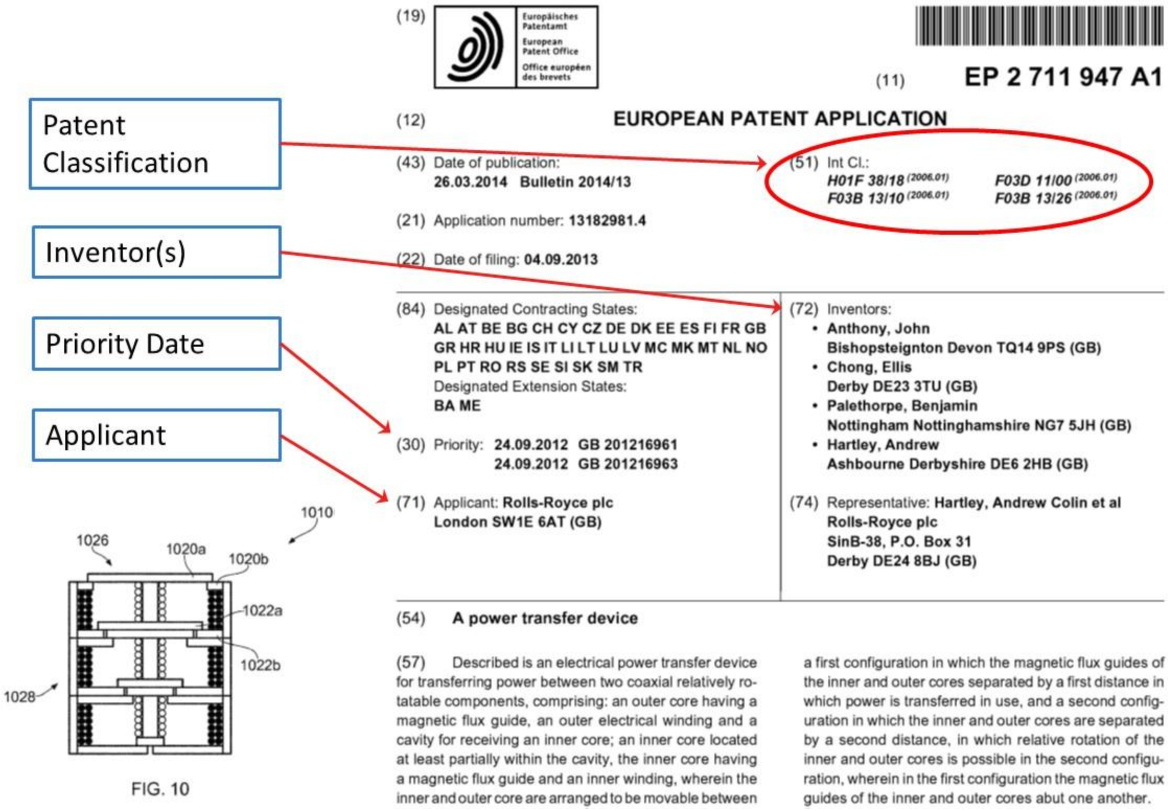

Figure 2. Example of a European Patent Office (EPO) patent document
Source: PATSTAT, EPO.

2. Knowledge Production in Slovenia

Over the past 2 decades Slovenia has managed to continuously increase its share of patented technological knowledge in the European Union.

The data to investigate invention in Slovenia over the past decades are derived from the EPO PATSTAT database.[28] The analysis presented in turn will focus on the years 2001 to 2015, grouped in three 5-year groups. Due to a lag between the time of a patent application and its subsequent publication most recent years are not considered here. Nevertheless, because technological change is guided by evolutionary principles this does not constitute a major problem in terms of indicating most recent trends. Also, the time lag between a patent application and the subsequent application of the novel product and process in the marketplace further justifies this approach. All years listed refer to priority dates of patents.

Patents are allocated to countries based on fractional inventor counting. Essentially, if a patent was developed by 3 inventors who at the time of invention resided in 3 different countries, only one-third of that patent is allocated to those respective jurisdictions. This is a common way of allocating patenting activity to spatial units.[29]

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28 For further details please refer to: https://www.epo.org/searching-for-patents/business/patstat.html#tab-1 [accessed, May 24th, 2019].

29 Kogler D. F., Rigby, D. L. and Tucker, I. (2013) Mapping knowledge space and technological relatedness in US cities. European Planning Studies, 21: 1374–1391.

Table 1 indicated the number of patents developed by inventors located in Slovenia at the time of invention. In the time period 2001-2005 there were 428 patents that can be allocated to Slovenia. This accounted for 0.15% of all patents developed across the current 28 European Union (EU) countries as well as the 2 European Free Trade Association (EFTA) countries of Norway and Switzerland; referred to as "EU28+2" subsequently. While this is a marginal share in the overall technological knowledge production process on the European continent, which is not surprising given the relatively small size of the Slovenian economy compared to some of the larger countries in the EU, it is especially the trend and the composition of knowledge production in Slovenia that is of interest here rather than sheer quantity. Looking at the trend over the 15-year period (2001-2015) Slovenia managed to increase its share of patenting in the EU28+2 space from 0.15% to 0.21%.

Table 1. Patents developed by Slovenian inventors

	2001-2005	2006-2010	2011-2015
No. Patents (SI)	428	590	492
No. Patents (EU28+2)	285,399	306,893	228,972
(%)	0.15%	0.19%	0.21%

Table 2 provides a full overview of patenting across EU28+2 countries over the same time period. Overall, Slovenia maintained its rank among these countries, slightly moving up from rank 19 at the beginning of the observed timeframe to rank 18 in the final 2 time periods.

Total output of patents might not always be the best measure of performance.[30] Frequently patent output is adjusted to per capita measures. **Table 3** provides the values of per capita patent production (i.e. per 10,000 residents) for all EU28+2 countries for the time period 2011 to 2015. Taking this adjustment on board, Slovenia's position slightly improves compared to the absolute measure of patenting, to rank 15 among 30 countries. Given that patenting is especially important in the manufacturing sector, and adjustment according to patent production per employees in the manufacturing sector might even provide further and more accurate insights on how productive a place is in terms of producing novel products and processes on a per capita measure. Once adjusted for the number of manufacturing sector employees (i.e. per 10k employees), Slovenia is ranked 16th across all EU28+2 counties.

Table 2. Patenting across the EU28+2 and Slovenia's position

	2001-2005		2006-2010		2011-2015	
Rank	Country	Patents	Country	Patents	Country	Patents
1	DE	113,298	DE	118,757	DE	84,737
2	FR	39,470	FR	43,085	FR	33,630
3	GB	28,318	GB	27,720	GB	20,148
4	IT	22,122	IT	23,714	IT	16,626
5	NL	18,183	NL	17,099	CH	12,414

30 Kogler D. F. (2015) Intellectual property and patents in manufacturing industries. In J. Bryson J. Clark and V. Vanchan (eds) The Handbook of Manufacturing Industries in the World Economy, pp. 163–188. Northampton: Edward Elgar.

6	CH	14,587	CH	16,237	NL	12,081
7	SE	10,975	SE	13,756	SE	10,225
8	BE	6,958	AT	8,593	AT	7,251
9	AT	6,866	BE	7,564	BE	5,905
10	FI	6,757	ES	7,237	ES	5,853
11	ES	5,360	FI	6,618	FI	5,651
12	DK	5,327	DK	6,262	DK	5,078
13	NO	2,003	NO	2,557	PL	1,906
14	IE	1,255	IE	1,621	NO	1,774
15	HU	643	PL	1,232	IE	1,376
16	PL	504	CZ	923	CZ	931
17	CZ	493	HU	918	HU	719
18	LU	434	SI	590	SI	492
19	SI	428	PT	536	PT	480
20	GR	410	GR	463	GR	355
21	PT	330	LU	430	RO	296
22	HR	164	SK	192	LU	270
23	SK	121	EE	169	SK	186
24	BG	93	RO	152	BG	125
25	RO	90	HR	148	LV	125
26	CY	49	BG	91	EE	117
27	LV	47	LV	89	LT	100
28	LT	43	LT	62	HR	72
29	EE	41	CY	51	CY	28
30	MT	31	MT	29	MT	22

Source: PATSTAT, EPO; author's calculations.

In addition to the overall count of patents produced in Slovenia, also the number of individuals involved in the production of novel products and processes is of interest. Employing advanced disambiguation algorithms, it is possible to assign a unique inventor ID number to each inventor in the patent database.[31] This in turn allows to analyse how many unique individuals, i.e. inventors, have been involved in producing patented innovations in Slovenia over the observed timeframe.

Table 3. Slovenia's position in patent output when adjusted for per capita and per employees in the manufacturing sector

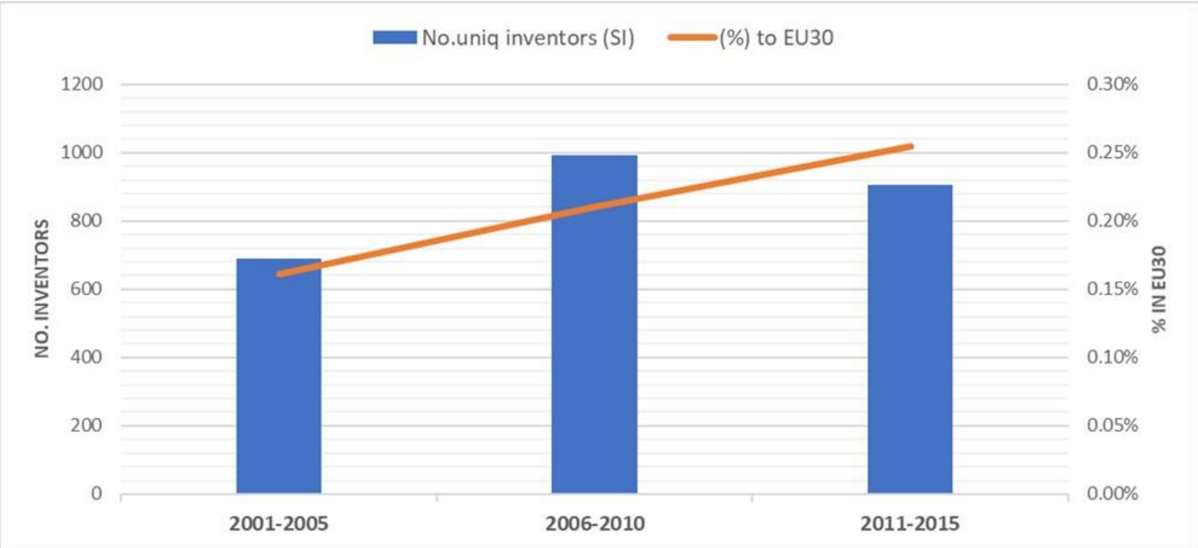
Rank	Country	Patents	Patents per 10k residents	Patents per 10k manufacturing sector employees
1	DE	84,737	10.51	105.63
2	FR	33,630	5.10	108.42
3	GB	20,148	3.14	69.28
4	IT	16,626	2.74	39.11
5	CH	12,414	15.44	96.52

31 Pezzoni, M., Lissoni F. and Tarasconi G. (2014) How to kill inventors: testing the Massacrator© algorithm for inventor disambiguation, Scientometrics 101(1), 477-504.

6	NL	12,081	7.19	144.77
7	SE	10,225	10.65	156.30
8	AT	7,251	8.55	107.18
9	BE	5,905	5.32	102.36
10	ES	5,853	1.26	26.57
11	FI	5,651	10.39	146.39
12	DK	5,078	9.05	167.07
13	PL	1,906	0.50	5.39
14	NO	1,774	3.49	51.12
15	IE	1,376	2.99	62.65
16	CZ	931	0.89	6.49
17	HU	719	0.73	8.61
18	SI	492 (#18)	2.39 (#15)	23.45 (#16)
19	PT	480	0.46	6.54
20	GR	355	0.50	14.72
21	RO	296	0.15	1.67
22	LU	270	4.94	74.30
23	SK	186	0.34	3.60
24	BG	125	0.17	1.84
25	LV	125	0.62	8.37
26	EE	117	0.89	9.12
27	LT	100	0.34	4.34
28	HR	72	0.17	2.29
29	CY	28	0.32	8.09
30	MT	22	0.51	8.48

Source: PATSTAT, EPO; author's calculations.

Figure 3 highlights the number of unique Slovenian inventors in each of the 3 time periods as well as puts these numbers in the context of the overall EU28+2 inventor population. Similar to the trends observed previously, also the share of unique Slovenian inventors increases over time. In the final 2 time periods about 1,000 and 900 inventors producing novel technical knowledge in Slovenia are identified.



	2001-2005	2006-2010	2011-2015
No. unique inventors (SI)	690	994	907
No. unique inventors (EU28+2)	427,633	472,626	356,054
%	0.16%	0.21%	0.25%

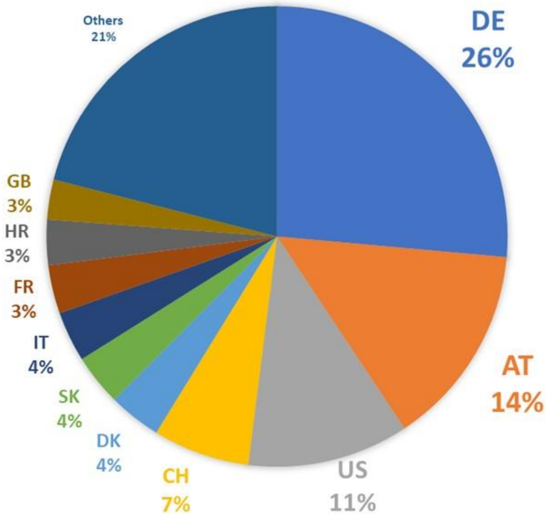
Figure 3. Number of unique Slovenian inventors by period; incl. EU28+2 share
Source: PATSTAT, EPO; author's calculations.

2.1. Slovenia – Inventor Collaborations

Most patented inventions are produced in collaboration. Inventor collaborations are usually highly localized, i.e. inventor teams are usually co-located in space while working on the development of a novel product or process. However, even if non-local collaborations are more infrequent, they do serve as an important conduit for accessing extra-local knowledge resulting in knowledge spillovers that might compensate for relevant expertise in the development of an invention that is not available locally.

Figure 4 illustrates this and shows that over the 2001-2015 timeframe Slovenian patents were developed by 90% of inventors who actually also resided in Slovenia at the time of invention with the involvement of 10% of inventors who resided elsewhere.

Figure 4. Share of Slovenian (local) and non-Slovenian (EU30/International) inventors listed on patents that contain at least one Slovenian inventor



In terms of the origin of international co-inventors, **Figure 5** provides a further breakdown. The vast majority of international collaborations of Slovenian inventors is with inventors located in Germany and Austria. US and Swiss co-inventors are also frequent whereas inventors from other countries only account for smaller shares.

Figure 5. Share of Slovenian (local) and non-Slovenian (EU30/Intern.) inventors listed on patents that contain at least one Slovenian inventor
Note: The category "Others" includes 26 countries: SE, ES, BE, NL, CA, IN, CN, CZ, RS, PL, RU, LU, IL, PT, BG, GR, IE, KZ, HU, TR, EE, SG, AE, AU, UA, JP.
Source: PATSTAT, EPO; author's calculations.

The share of international inventor collaborations over the observed timeframe is remarkable stable. In each of the 3 specific time periods collaboration with EU28+2 countries accounts for about 8%. The only noticeable change is the slight decline of national versus an increase in international (non-EU28+2) collaborations between the first and second investigated time period. **Figure 6** displays a breakdown of collaborative patterns including key metrics.

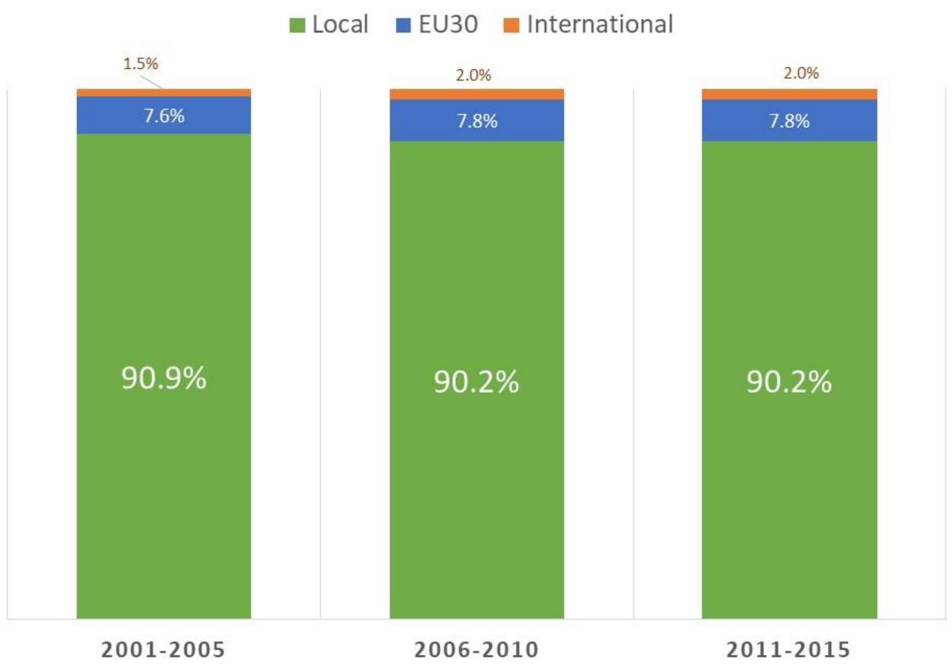


Figure 6. National, EU28+2 and International inventor collaborations
Source: PATSTAT, EPO; author's calculations.

Table 4 benchmarks the share of local, within EU28+2 and international collaborations taking place in Slovenia against a sample of other European countries for each of the 3 time periods. In Slovenia we observe higher shares of local, i.e. within country, inventor collaborations compared to the values in the Czech Republic, Poland, Estonia and Austria. Further, Slovenia has much fewer international, i.e. non EU28+2, inventor collaborations compared to the set of other countries.
In other words, knowledge production in Slovenia, once done in a team, which is more frequent than inventions by a single inventor, mainly happens at the national rather than international level. Given that non-local collaborations serve as a conduit of knowledge transfer, especially knowledge that is not available locally, this might put Slovenia in a disadvantaged position. The policy implications, also reflected in the title of the overall study, are clear in this regard.

Table 4. Counts and shares of local, EU28+2, and international inventor collaboration in Slovenia, Czech Republic, Poland, Estonia and Austria

Period	Country	Local	EU28 +2	Inter-nat.	Local (%)	EU28+2 (%)	Internat. (%)
2001-05	SI	369	36	7	89.5%	8.7%	1.8%
2006-10	SI	592	49	6	91.5%	7.6%	0.9%
2011-15	SI	548	57	18	87.9%	9.2%	2.9%
2001-05	CZ	452	105	34	76.5%	17.7%	5.7%
2006-10	CZ	836	168	64	78.2%	15.8%	6.0%
2011-15	CZ	1049	183	58	81.4%	14.2%	4.5%
2001-05	PL	419	78	47	77.0%	14.3%	8.7%
2006-10	PL	998	166	62	81.4%	13.5%	5.1%
2011-15	PL	2088	287	84	84.9%	11.7%	3.4%
2001-05	EE	39	12	3	72.9%	22.1%	5.0%

2006-10	EE	136	25	5	81.9%	15.1%	2.9%
2011-15	EE	146	28	9	79.5%	15.3%	5.2%
2001-05	AT	5299	287	389	88.7%	4.8%	6.5%
2006-10	AT	4985	318	448	86.7%	5.5%	7.8%
2011-15	AT	3611	282	324	85.6%	6.7%	7.7%

2.2. Entities producing technological knowledge in Slovenia

Taking the sample of Slovenian patents described and analysed in the previous section, attention now shifts to the entities that are associated with those patents. These are referred to patent applicants and/or assignees. Essentially any legal entity can be listed as a patent assignee on an invention. This can be an individual (natural person), corporation, university, research institute, etc.

Table 5 lists the top 10 patenting assignees listed on Slovenian patents in each of the time periods that have been already investigated previously. Just like the number of patents, also the number of patent applicants increases over time. Over the entire 15-year timeframe Novartis, a Swiss multinational pharmaceutical company, occupies the first rank in terms of the entity that is associated with most Slovenian patents. Independent inventors, i.e. patents that most likely list the inventor(s) of a patent also as the assignee, also occupy top 3 ranks in each of the time periods.

Complementing the top 3 ranks over the three 5-year periods is also the Slovenian headquartered international pharmaceutical company Krka. Although Krka's overall share of patents compared to Novartis has declined significantly over the most recent 5-year period analysed. In more recent times, the University of Maribor has emerged as the patenting assignee that follows the top 3, occupying rank 4 in the last two time periods observed.

Table 5. Top 10 patenting assignees listed on Slovenian patents in each time period

Rank	2001-2005 (N=77)			2006-2010 (N=115)			2011-2015 (N=168)		
	Assignee	Patents	(%)	Assignee	Patents	(%)	Assignee	Patents	(%)
1	NOVARTIS	77	22.8%	NOVARTIS	183	32.2%	NOVARTIS	65	15.8%
2	***Independent***	63	18.6%	KRKA	128	22.4%	***Independent***	58	14.0%
3	KRKA	61	18.1%	***Independent***	41	7.2%	KRKA	18	4.3%
4	KOLEKTOR GROUP	12	3.6%	UNIVERSITY OF LJUBLJANA	14	2.5%	UNIVERSITY OF MARIBOR	12	2.9%
5	ITW	7	2.1%	HIDRIA AET DRUZBA ZA PROIZVODNJO VZGNIH SISTEMOVIN ELEKTRONIKE	10	1.8%	TAJFUN PLANINA PROIZVODNJA STROJEV	10	2.4%
6	KOVINOPLASTIKA LOZ INDUSTRIJA KOVINSKIH IN PLASTICNIH IZDELKOV D. D.	6	1.8%	KEMIJSKI INSTITUT	9	1.5%	GORENJE GOSPODINJSKI APARATI	10	2.4%
7	ISKRAEMECO MERJENJE IN UPRAVLJANJE ENERGIJE	6	1.8%	ETI ELEKTROELEMENT	8	1.4%	UNIVERSITY OF LJUBLJANA	10	2.4%
8	ETI ELEKTROELEMENT	6	1.8%	HELLAKGHUECK	8	1.4%	GORENJE	10	2.3%
9	TERMO, D.D., INDUSTRIJA TERMICNIH IZOLACIJ, SKOFJA LOKA	5	1.5%	ITW	8	1.4%	KEMIJSKI INSTITUT	8	2.0%
10	ISKRA MEHANIZMI, INDUSTRIJA MEHANIZMOV, APARATOV IN SISTEMOV	4	1.2%	GORENJE GOSPODINJSKI APARATI	7	1.2%	LAMA D.D. DEKANI	8	1.9%
Top 10 Concentration			73.0%			73.1%			50.4%

Source: PATSTAT, EPO; author's calculations.

In a top-level categorisation of patent assignees one can differentiate between inventions developed by private and public entities, as well as individuals. Latter category, i.e. where a natural person is listed as assignee, usually consists of a very small share, overall. In Slovenia this share is somewhat higher when compared to trends in other EU countries. In regard to the share of patents that are assigned to public entities, i.e. universities, national research institutes, etc., it continuously increases from about 5% in the first time period to around 14% of all assignees in the years 2011-2015.

Collaboration among patent assignees is a rather rare observation altogether. Collaborations between entities that are active in Slovenia with those that are not is even much more infrequent. **Figure 7** provides a quick snapshot in this regard and although international collaborations only account for a very small share among all collaborations they are increasing in frequency over time.

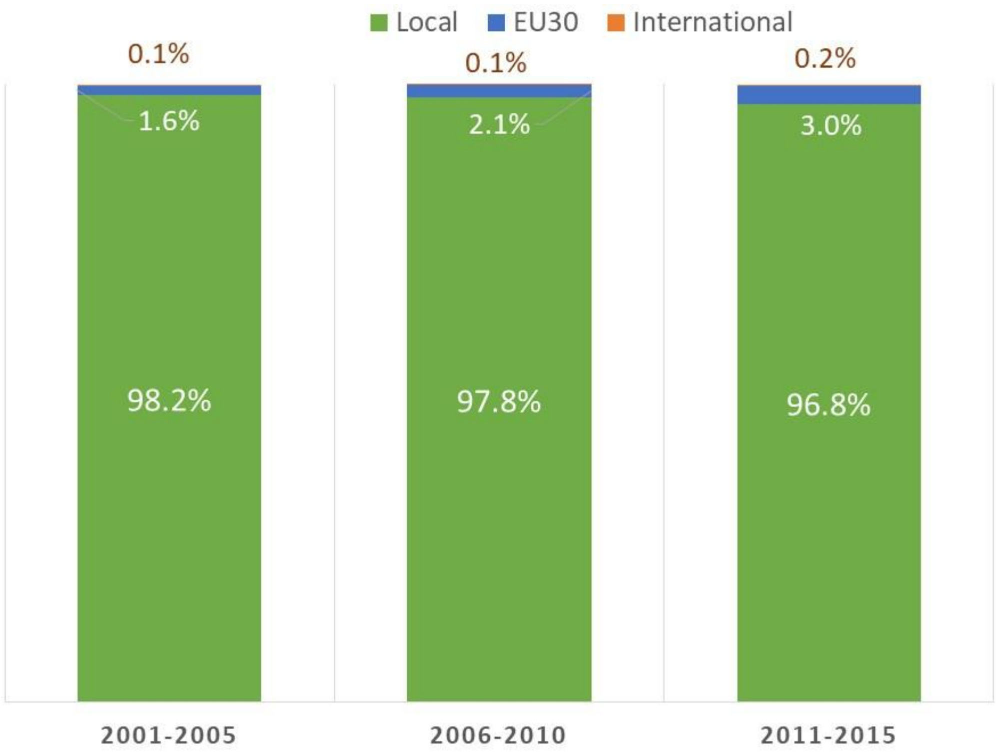


Figure 7. National, EU28+2 and International collaborations among patent assignees
Source: PATSTAT, EPO; author's calculations.

Although international assignee collaborations are a rather rare event, they might be of interest due to their importance for knowledge transfer and spillover processes that have the potential to compensate for the lack of local capabilities and thus elevating inventive output beyond of what would be possible if purely based on local expertise.

Table 6 provides an overview of the most important international co-assignees over the 2001-2015 time period. The first rank is occupied by a German individual inventor. The contribution, final column in **Table 6**, indicates the fractional share of co-assignee contribution to patents that have been assigned to Slovenia due to the involvement of at least one Slovenian inventor in the patented invention. In this example it means that this specific individual from Germany is the assignee on almost 8 patents if we sum up the shares s(he) is listed on across all Slovenian patents as co-assignee. At rank 2 we find the British engineering company Renishaw. Its contribution is 5 patents, which could indicate that Renishaw is listed on 10 Slovenian patent documents as the co-assignee together with one other Slovenian company or individual. In other words, it's a 0.5 share for each of two entities listed as co-assignees on a single patent, whereas it would be a third if there are 3 co-assignees, and so on. **Table 6** indicates that the contribution of non-local assignees' contribution declines rapidly following the top ranks. At rank 10 we already find entities that have most likely only served as non-local co-assignees for one single time over the entire time period.

Table 6. Rank of non-local assignees' contribution to Slovenian patents

Rank	Assignee	Country	Contribution
1	*Individual*	DE	7.8
2	RENISHAW	GB	5.0
3	*Individual*	AT	2.1

4	JEAN MUELLERELEKTROTECHNISCHE FABRIK	DE	2.0
5	RIJKSUNIVERSITEIT GRONINGEN	NL	1.3
6	GREENHILLS BIOTECHNOLOGY	AT	1.0
7	*Individual*	US	1.0
8	MESSGRIESHEIM	AT	0.8
9	UNIVERSITY OF GRAZ	AT	0.7
10	WM VERMIETUNGS UND VERWALTUNGS	DE	0.5
11	VIMEC	IT	0.5
12	UNIVERSIDAD DEL PAIS VASCO	ES	0.5
13	SCHUETZ - DENTAL	DE	0.5
14	PHOSPHOENIX	FR	0.5
15	MARES	IT	0.5
16	LPKF LASER & ELECTRONICS	DE	0.5
17	HORSTMANN TIMERS & CONTROLS	GB	0.5
18	HORSTMANN CONTROLS	GB	0.5
19	HELMHOLTZ ZENTRUM MUNCHEN, DEUTSCHES FORSCHUNGSZENTRUM	DE	0.5
20	FOUNDATION FOR RESEARCH AND TECHNOLOGY – HELLAS	GR	0.5

Source: PATSTAT, EPO; author's calculations.

3. The Evolution of the Slovenian Knowledge Space [2001-2015]

In this section of the analysis attention will be given to the evolution of the Slovenian Knowledge Space. The Knowledge Space methodology, introduced above, serves as the foundation to provide a more contextualized and place specific overview of technological knowledge production than what is possible with traditional innovation metrics such as the patent data indicators presented in the previous sections.

Taking the sample of Slovenian patents that have been already investigated so far, but now also taking advantage of the information that is contained in the patent classes listed on those documents, it will be not only possible to quantify the type of knowledge produced, but more importantly how one knowledge domain relates to another and how these patterns change over time. In this regard it will be necessary to highlight the organization and hierarchy of the utilized patent classification system.

Over time several different patent classification systems were employed across global patent offices. More recently it was the International Patent Classification (IPC) standards developed by the World Intellectual Property Organization (WIPO)that has emerged as an international standard.[32] Subsequently, it was a joint partnership

32 For an overview of the International Patent Classification (IPC) system, see: https://www.wipo.int/classifications/ipc/en/ [accessed, May 24th, 2019].

between the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO) that let to the development of the Cooperative Patent Classification (CPC) system, with is essentially substantially based on the IPC system.[33]

Each CPC classification term found in EPO patent documents consists of several hierarchical elements. The first digit is a letter and is labelled the "section symbol". For example, "C" stands for the "Chemistry and Metallurgy". The CPC scheme is organized in 9 sections, i.e. "A" to "H", including a "Y" section that indicates emerging cross-sectional technologies. The section is then followed by a two-digit number, which is referred to as the "class symbol". For example, "C01" represents "Inorganic Chemistry" in the "Chemistry and Metallurgy" section. The final letter then at the fourth digit of the code stands for the "subclass". Following on from the previous example, "C01B" represents "Non-Metallic Elements; Compounds Thereof". There are roughly 650 unique technology classes at the CPC 4-digit level.[34] The analysis presented below will utilize this level of CPC definition while the figures presented will use a colour scheme that corresponds to the section symbols. For a detailed description of the underlying Knowledge Space methodology as well as published examples please refer to Kogler et al., 2013; 2017 and Kogler and Whittle, 2018.[35]
Figure 8 displays the Knowledge Space (KS) for Europe (EU28+2) and for Slovenia for the time period 2001-2015. While the illustration of the pan-European KS doesn't allow to visually inspect specific nodes, i.e. CPC classes, it certainly provides some general insights. First, it shows that more or less all 650 possible CPC classes are present. Second, some nodes are more dominant in terms of their size than others. The size of a node indicates how frequent a specific class was utilized in the development of patented inventions in this time period. Third, it provides an idea of the relative position and clustering of technology classes. At the edges of the KS one can see not only smaller nodes, but also those who are relatively isolated from the rest of the space. These classes not only are used infrequently as knowledge inputs for the development of novel products and processes, but also are not well connected to the rest of the KS. In other words, they are rarely used, and when used then not much in combination with other nodes as indicated by co-classification on single patent documents.

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33 For an overview of the Cooperative patent Classification (CPC); see: https://www.cooperativepatentclassification.org/about.html [accessed, May 24th, 2019].

34 For a full list of the CPC scheme and CPC definitions, see: https://www.cooperativepatentclassification.org/cpcSchemeAndDefinitions/table.html [accessed, May 24th, 2019].

35 Kogler D. F., Rigby, D. L. and Tucker, I. (2013) Mapping knowledge space and technological relatedness in US cities. European Planning Studies, 21: 1374–1391;

Kogler D. F., Essletzbichler J. and Rigby D. L. (2017) The evolution of specialization in the EU15 knowledge space, Journal of Economic Geography 17(2), 345-373; and

Kogler D. F. and Whittle A. (2018) The Geography of Knowledge Creation: Technological Relatedness and Regional Smart Specialization Strategies. In: Paasi, A., Harrison, J. and Jones, M. (eds.), Handbook on the Geographies of Regions and Territories, Edward Elgar: London.

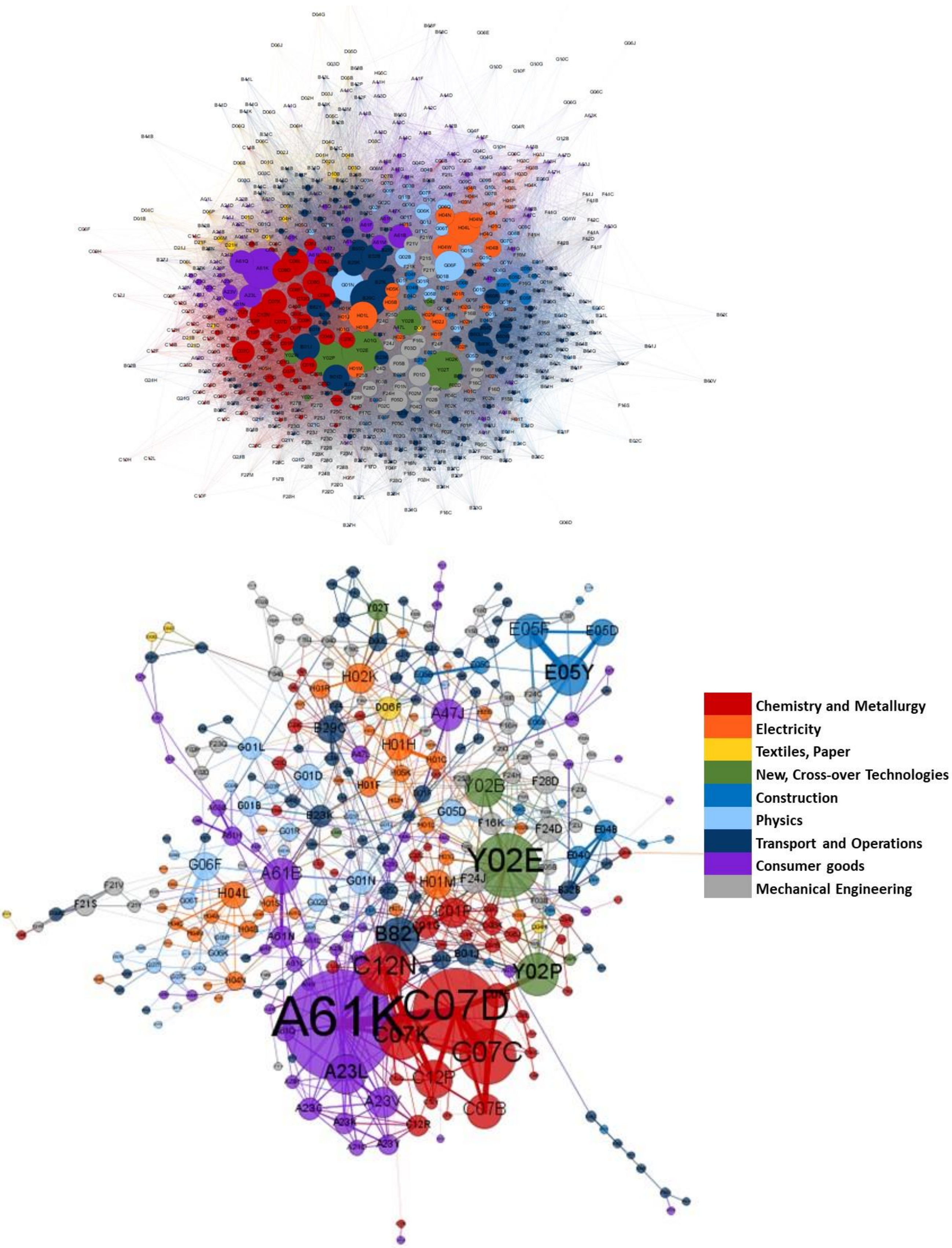


Figure 8. EU and Slovenian Knowledge Space, 2011-2015
Source: PATSTAT, EPO; author's calculations.

In terms of the clustering of sections, i.e. the applied colour scheme that corresponds to the hierarchical section organization of CPC classes as described above, it is clearly visible that these tend to cluster together within the section, but then also that certain sections seems to agglomerate with other specific sections. For example, the Chemistry and Metallurgy section is co-located with Consumer Goods classes while the Electricity section is in close locational proximity to Physics as well as Transport and Operations. **Dense areas of the Knowledge Space where nodes of different sections cluster together, or even overlap, are the areas of recombinant knowledge production that have high potential of generating more advanced, perhaps even breakthrough**; see **Figure 1**, above.

Shifting the attention to the Slovenian Knowledge Space displayed in **Figure 8**, it certainly shows significant differences compared to the pan-European one. For once only about one-third (~220) of all possible CPC nodes (~650) are present. Further, it is evident that classes A61K (PREPARATIONS FOR MEDICAL, DENTAL, OR TOILET PURPOSES) and class C07D (HETEROCYCLIC COMPOUNDS) are technological knowledge domains that are very prominent in the Slovenian KS. The relatively large size of these two nodes compared to other classes present indicates that these two CPC classes are frequently used in the development of local patents. In addition, the relative position of these two CPC classes within the KS also shows that these two technology classes are well connected to other local knowledge domains essentially bridging recombinant knowledge production that involves inputs from both the Chemistry and Metallurgy as well as Consumer Goods sections; something that has been already observed in the pan-European KS as well. Essentially, it is in the bottom-middle of the Slovenian KS where not only most technological knowledge production takes place, but it is also here where it is visually evident that most recombinant knowledge is generated. Looking further, it is also possible to detect some smaller, perhaps emerging, clusters of specialized local knowledge. At the top-right corner there is an agglomeration of sizeable Construction knowledge domains, i.e. classes E05D, E05F, E05Y. Given that **Figure 8** illustrates Knowledge Spaces that cover an extended time period, i.e. 2001-2015, it will be necessary to engage in a more dynamic and evolutionary analysis of knowledge spaces in order to determine if certain technology domains are on the rise or decline, to identify potential new opportunities, but perhaps also to determine which classes are marginal to the system of knowledge production, i.e. the classes that are disconnected and small in size at the fringes of the KS.

3.1. Changing Patterns of Technological Knowledge Production in Slovenia

Figure 9 displays the evolution of the Slovenian Knowledge Space over 15 years, divided into 3 networks each representing 5-year periods. Unlike in the previous figure, this allows to visually track the trajectory of technological knowledge production in the Slovenian economy. Compared to prior insights, it is clearly evident that CPC classes A61K and C07D played a significant role already in the first two time periods, i.e. 2001-05 and 2016-2010. However, looking at the final period (2011-15) the relevance of class C07D seems to have diminished over time. The cluster of Construction related knowledge domains identified previously, i.e. top-right corner in each sub-period, seems to have already existed back in the early 2000s. However, 5 years later this cluster of classes has diminished in relevance measured on the size of the respective notes, while yet another 5 years later it re-emerges as something more substantial, albeit rather isolated from the rest of the Slovenian KS. There are some other rather visible characteristics that can be easily detected when inspecting the Knowledge Spaces of the 3 time periods. **The number of nodes as well as the density of the space appears to increase.** Furthermore, some nodes either gain on centrality or lose their relative central position and get pushed to the margin.

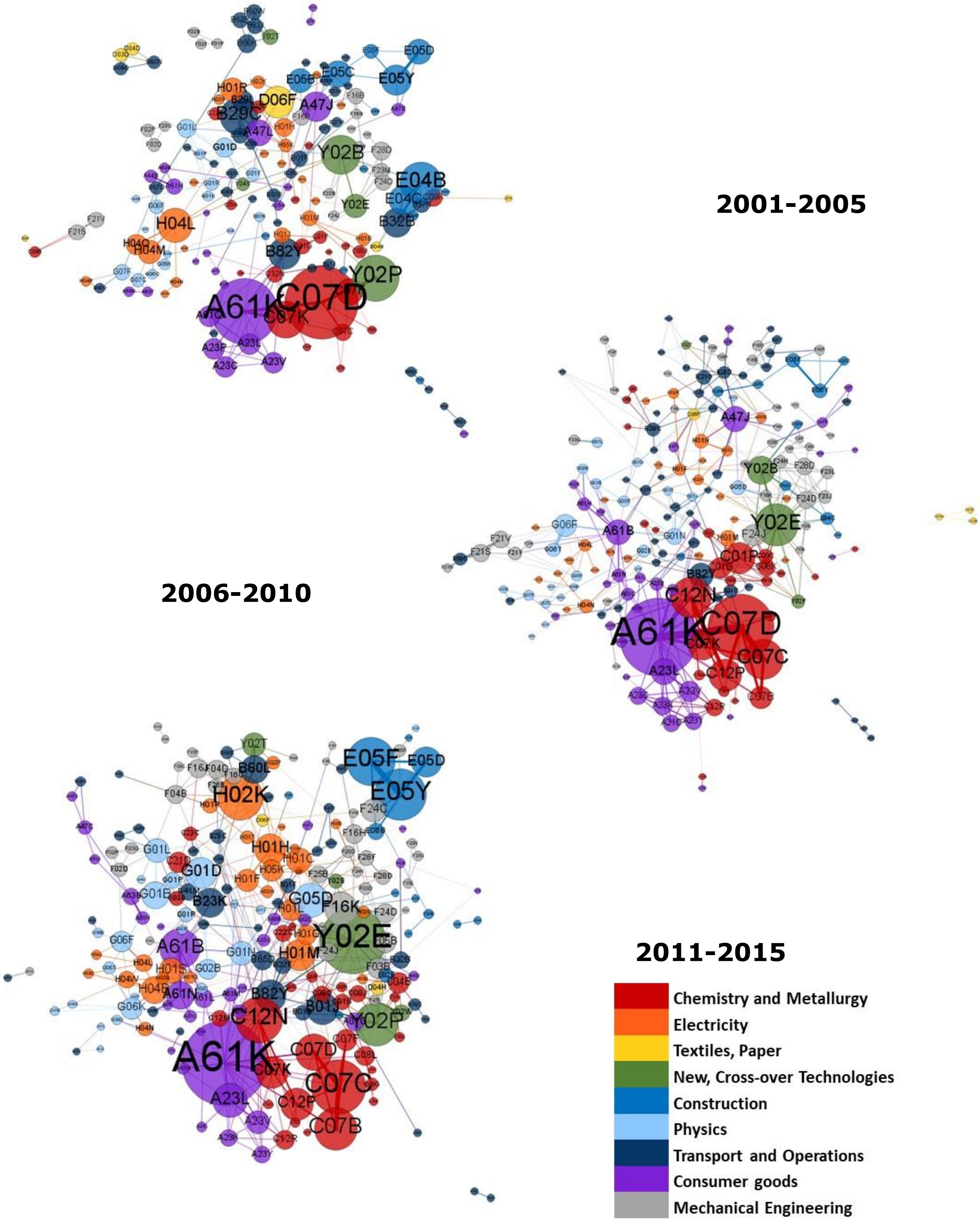


Figure 9. Evolution of the Slovenian Knowledge Space
Source: PATSTAT, EPO; author's calculations.

A visible inspection of Knowledge Spaces provides ample insights but is limiting in terms of a more serious investigation. The KS is essence is a networked representation of nodes (CPC classes) and edges (co-occurrence of CPC classes in individual patent documents). Thus, it is possible to analyse a KS via network analysis tools, provide network measures and then also engage in a more detailed network analysis exercise. **Table 7** offers standard network measures that correspond to the 3 Slovenian Knowledge Spaces displayed in **Figure 9**.

Table 7. Changing patterns of Slovenian KS network measures for 3 consecutive time periods

Period	No. Nodes	No. Edge	Density	Diameter	Avg. Path	Avg. CC
01-05	167	249	0.011	14.2	5.36	0.468
06-10	208	387	0.012	16.1	5.10	0.384
11-15	221	467	0.011	16.7	4.28	0.318

Source: Author's calculations.

From the first observed period (2001-05) to the last (2011-2015) the number of nodes increases from 167 to 221. **This means that Slovenian knowledge production is becoming more diverse, utilizing more and more domains as knowledge inputs for the generation of novel products and processes over time**. Similar, the number of edges also significantly increases over the 15-year time period, i.e. from around 250 to over 450. This indicates that more and more nodes are directly connected via co-occurrence links that are listed on individual patent documents assigned to Slovenia.[36] On the other hand, the density of the network more or less remains the same during the investigated timeframe, which signifies that the connectedness in the network, defined as the share of maximum possible ties, does not change. At the same time, the diameter of the network, defined as the shortest distance between the most distant nodes, increases, while the average path length, i.e. the steps along the shortest paths for all possible pairs of network nodes, decreases. Finally, the average clustering coefficient, which is based on triplets of nodes, decreases.

Figure 10 illustrates the 6 distinct Slovenian Knowledge Space network measures. In order to provide an overview and comparison of how these differ from the evolution of the pan-European KS, **Figure 11** displays the same measures for the same time period for the KS of the EU28+2 countries. There are a few significant differences. For once it is the number of nodes. The pan-European space occupies essentially all nodes and thus can't grow any further in this regard. National or regional economies, pending on the depth of technological knowledge that is produced and utilized there, usually do grow over time in terms of new nodes, i.e. CPC classes. The number of edges in the network significantly increases in both accounts; however, unlike in the example of Slovenia this growth of edges in the European KS occurs without adding more nodes, which in turn indicates that the connectedness in the network increases substantially. Network density and average path length measures further confirm this trend. Unlike in the case of the Slovenian KS, the average clustering coefficient indeed increases substantially in the pan-European space over the observed time period. It is especially here where there where one can find a significant difference between the evolution of the overall knowledge production network versus the one of a national economy, i.e. Slovenia. Essentially the potential to increase the degree to which nodes in the network cluster together is unlike higher at the national scale, which in turn indicated the opportunity to generate synergies in terms of recombinant knowledge production. This can be achieved either by intensifying the connectivity of triplets of existing nodes, or by adding technology classes that are known to serve as bridges between nodes that are currently missing as indicated in the pan-European Knowledge Space.

36 This follows the "Knowledge Space Methodology" outlined at the beginning of this report; see also Kogler et al., 2013; 2017.

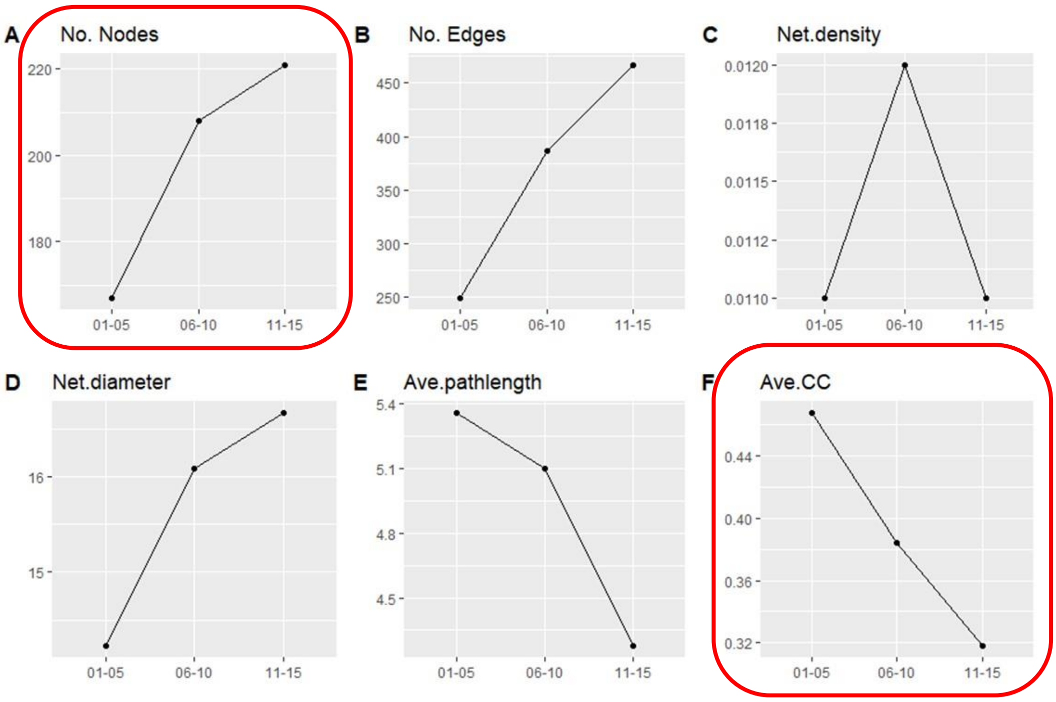


Figure 10. Evolutionary trajectory of Slovenia's Knowledge Space

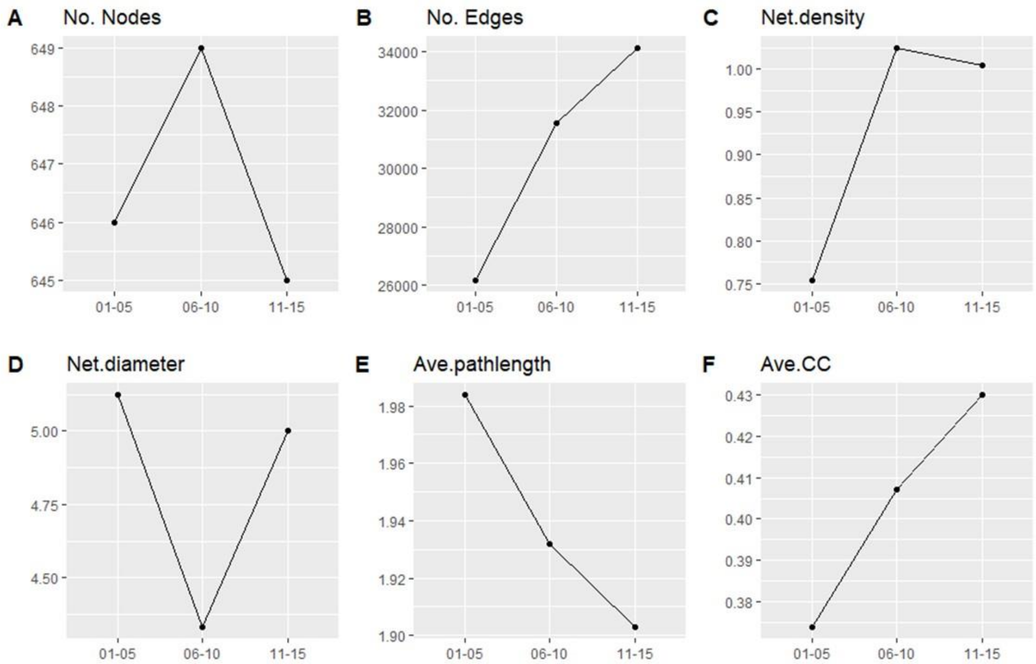


Figure 11. Evolutionary trajectory of EU28+2 Knowledge Space

Table 8 provides an overview of the most frequent converging technological knowledge domains, i.e. CPC classes, in each of the observed time periods in the Slovenian KS. **Novel products and processes that subsequently lead to an increase in the innovative capacity at places predominantly takes place via recombinant**

knowledge production.[37] The convergence of two knowledge domains signifies that these classes are increasingly used in combination in the development of inventions. There are global trends that can be observed in the pan-European KS, but each national or regional economy will display unique trajectories in this regard, which in turn defines local patterns of specialization.

Table 8. Most frequent converging technology classes in the Slovenian KS

Rank	Tech A		Tech B		Weight	Period
1	Heterocyclic Compounds	C07D	Y02P	Climate Change Mitigation Technologies	7.5	2001-2005
2	Preparations for Medical, Dental, or toilet	A61K	C07D	Heterocyclic Compounds	7	2001-2005
3	Preparations for Medical, Dental, or toilet	A61K	C07K	Peptides	6.314	2001-2005
4	Hinges or Other Suspension Devices	E05D	E05Y	Indexing Scheme Relating to Hinges or Other Suspension	5.8	2001-2005
5	Locks; Accessories therefor; Handcuffs	E05B	E05C	Bolts or Fastening Devices for Wings, Doors or Windows	4.167	2001-2005
1	Preparations for Medical, Dental, or toilet Purposes	A61K	C07D	Heterocyclic Compounds	15.501	2006-2010
2	Acyclic or Carbocyclic Compounds	C07C	C07D	Heterocyclic Compounds	12.433	2006-2010
3	Microorganisms or Enzymes	C12N	C12P	Fermentation or Enzyme-Using Processes to Synthesise	8	2006-2010
4	Electric Digital Data Processing	G06F	G06T	Image Data Processing or Generation, in General	7	2006-2010
5	Heterocyclic Compounds	C07D	C12P	Fermentation or Enzyme-Using Processes to Synthesise	6.715	2006-2010
1	Devices for Moving Wings into Open or Closed Position	E05F	E05Y	Indexing Scheme Relating to Hinges or Other Suspension Devices	10.332	2011-2015
2	General Methods of organic Chemistry	C07B	C07C	Acyclic or Carbocyclic Compounds	8.35	2011-2015
3	Valves; Taps; Cocks; Actuating-Floats; Devices for Venting	F16K	G05D	Systems for Controlling or Regulating Non-Electric Variables	7.166	2011-2015
4	Acyclic or Carbocyclic Compounds	C07C	C07D	Heterocyclic Compounds	6.35	2011-2015
5	Hinges or Other Suspension Devices	E05D	E05Y	Indexing Scheme Relating to Hinges or Other Suspension Devices	5.5	2011-2015

Source: Author's calculations.

The properties of individual technology classes already provide unique insights into the evolution of the knowledge production network. However, indicators of centrality that identify the most important nodes in terms of their influence and potential to bridge less connected areas of the network offer an even deeper understanding of how inventive output that relies on recombinant knowledge production progresses over time. This will now become the focus of the subsequent section of this report.

3.2. Technology Structure and Trends in the pan-European and Slovenian Knowledge Space

In order to analyse the technological knowledge structure of Slovenia a number of network centrality indices are investigated and then also compared to possible different trends in the overall pan-European Knowledge Space. The first and perhaps most obvious of these metrics is the degree centrality of sections within the patent classification system. This refers to the number of ties a node has, which in the present case is measured via the co-occurrence of technology classes listed together on single patent documents. **Figure 12** illustrates the trajectories of individual CPC sections in the EU28+2 and Slovenian Knowledge Space over 3 time periods.

37 Feldman, M., Kogler, D. and Rigby, D. (2015) rKnowledge: The Spatial Diffusion and Adoption of rDNA Methods', Regional Studies, 49 (5), pp. 798-817.

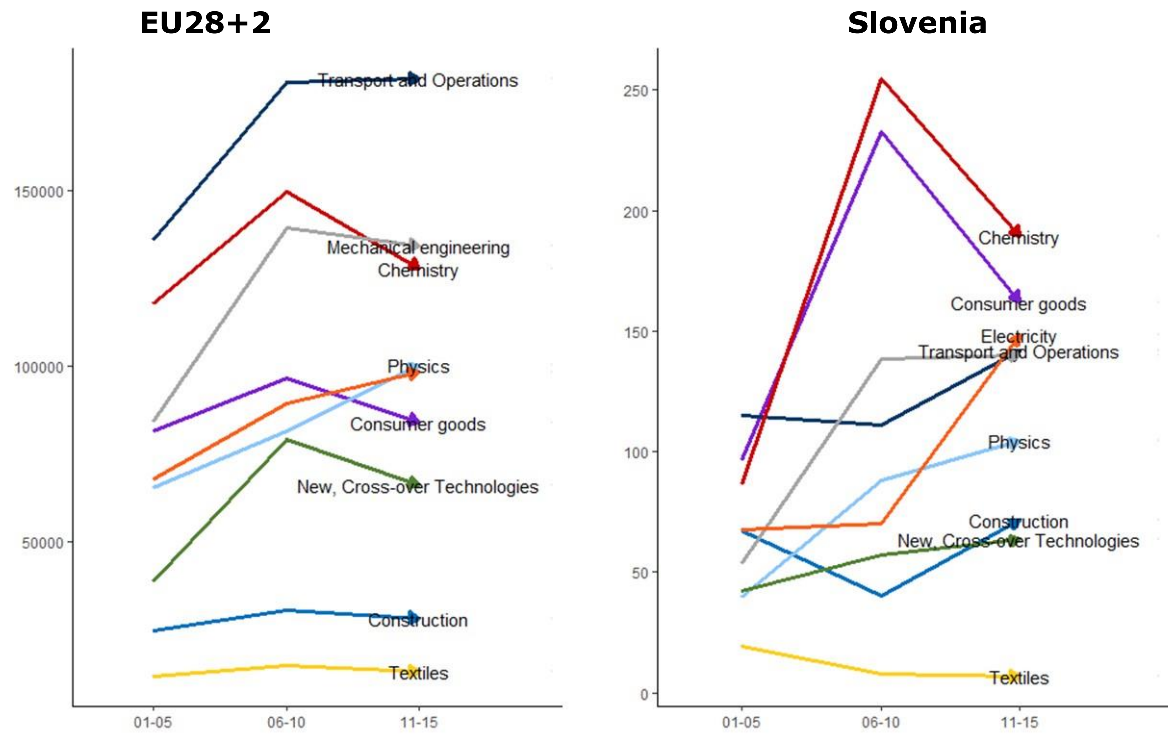


Figure 12. Degree centralities of CPC sections in the Slovenian and pan-European Knowledge Space
Source: PATSTAT, EPO; author's calculations.

Technological classes in Transport and Operations (CPC section B) are the most central nodes in the pan-European knowledge network. Classes in this section are thus the most connected ones serving as knowledge inputs in the production of novel products and processes along with a variety of other classes belonging to different CPC sections. Given that Transport and Operations technologies are applied on a wide range of innovations relying on recombinant knowledge deriving from more traditional sections such as Mechanical Engineering, but also inputs from more progressive sections, such as Electricity, this might not come as a surprise. In terms of most central nodes in the Slovenian KS, these are Chemistry and Consumer Goods. Based on the initial analysis of nodes and assignees above, again this might not be surprising at all. Driven by large-scale pharmaceutical production, an industry sector that exhibits a high propensity of knowledge production and patenting[38], this certainly seems to accurately reflect the technology structure of the Slovenian economy. Interestingly, degree centralities of wide variety of sections within the classification system seem to converge over time in Slovenia when compared to the pan-European trajectories. In the most recent time period (2011-15) the influence of Chemistry and Consumer Goods has diminished while the influence of Electricity and Transport and Operations has increased. **This might indicate a transitional phase in the technological knowledge production structure of the national economy. Perhaps it's less reliance on pharmaceuticals and a rise of other sectors leading to a diversification of the technology structure, which might be a welcome development in terms of avoiding risk due to overreliance on only one sector**. **Table 5** presented previously certainly hints at that given that the total share of inventive output generated

38 Kogler D. F. (2015) Intellectual property and patents in manufacturing industries. In J. Bryson J. Clark and V. Vanchan (eds) The Handbook of Manufacturing Industries in the World Economy, pp. 163–188. Northampton: Edward Elgar.

by the pharmaceutical entities listed there has considerably declined in the most recent time period.
Next, the influence of particular technologies becomes a focal interest in the investigation. For that purpose, eigenvector centrality measures are calculated and analysed in the same analytical setting as applied previously. Eigenvector centrality provides a measure of the influence of a node, i.e. a particular technology class, in the network, i.e. the knowledge space.

Figure 13 indicates the most influential technology domains in the EU versus those in Slovenia as well as their trends over the observed 15-year time period. There are significant differences between the overall EU ranking where Transport and Operations as well as Electricity are the most influential domains in the most recent time period vis-à-vis what we observe in the Slovenian KS where it is especially the Construction and Mechanical Engineering domains that have gained influence in the 2011-15 period. That significant differences exist is not surprising considering that each regional and national KS reflects place-specific technological knowledge and capabilities.

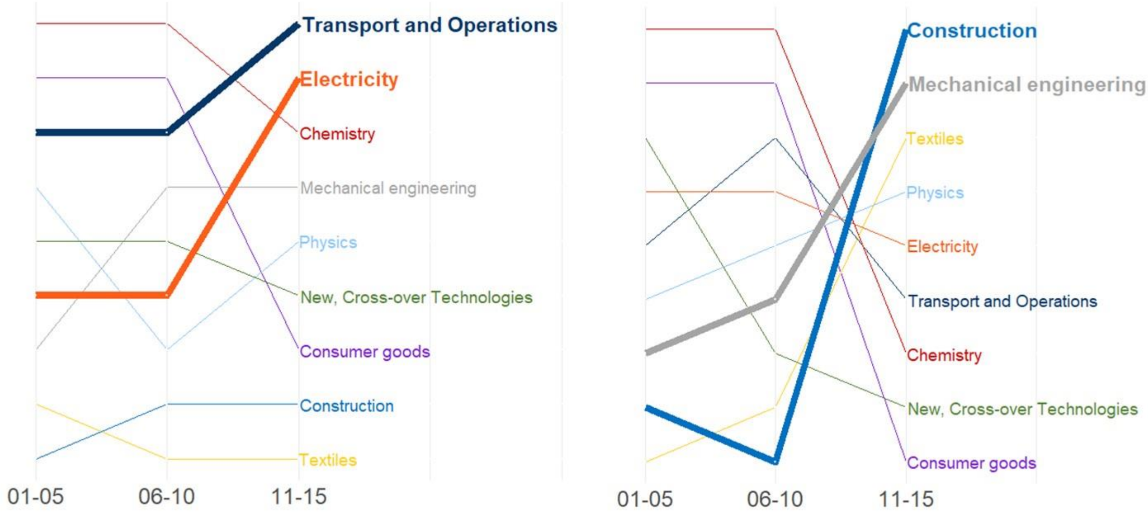


Figure 13. Eigenvector centralities of CPC sections in the Slovenian and pan-European Knowledge Space
Source: PATSTAT, EPO; author's calculations.

A closer look back at the Slovenian Knowledge Space over the 3 observed time periods (**Figure 9**, above) and especially at the time period 2011-2015 (**Figure 14**, below) indicates that it is probably especially the 3 Construction related classes E05D, E05F and E05Y that have propelled the Construction knowledge domain to the most influential one in the Slovenian KS.

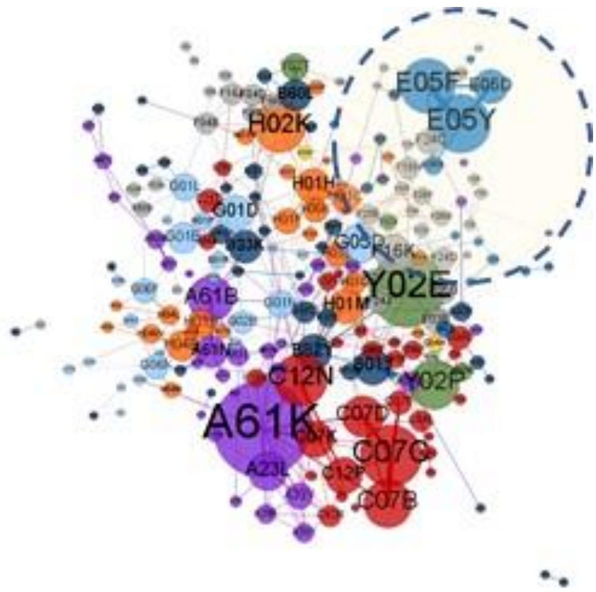


Figure 14. Slovenian Knowledge Space, 2011-15; 3 Construction related classes are highlighted
Source: PATSTAT, EPO; author's calculations.

In addition to influence, also the knowledge domains capable of bridging two domains in recombinant knowledge production processes are of interest. Betweenness centrality measures in a network indicate exactly that. Put simply, betweenness centrality is a metric that is based on the shortest paths between nodes in a connected network. In other words, the measure reflects the influence of a technology domain over the flow of information, i.e. recombination of knowledge in this case, based on the assumption that knowledge recombines over the shortest possible paths. Like with the previous measure of influential technologies, **Figure 15** indicates the most bridging technology domains in the EU versus those in Slovenia as well as their trends over the observed 15-year time period.

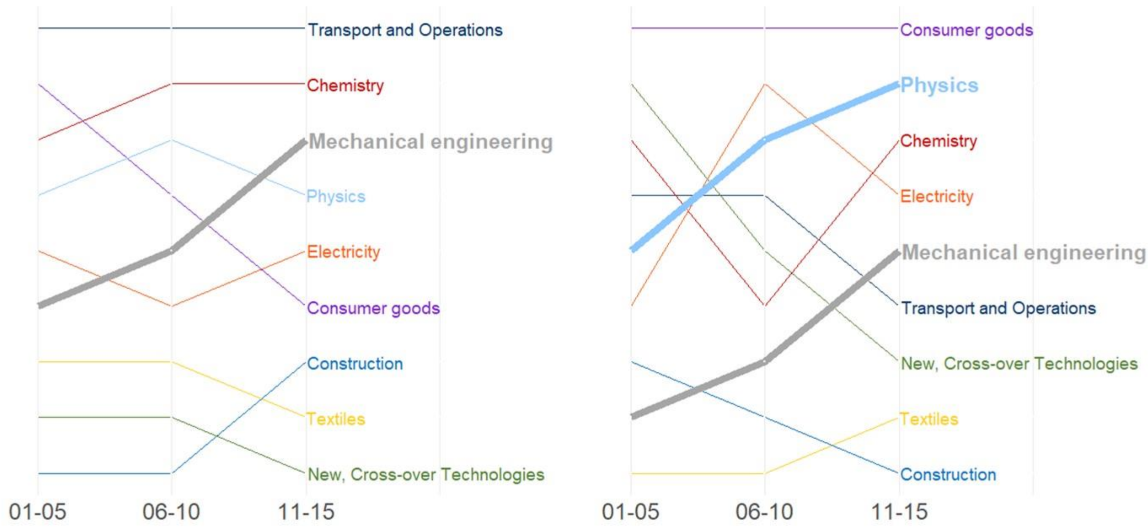


Figure 15. Betweenness centralities of CPC sections in the Slovenian and pan-European Knowledge Space
Source: PATSTAT, EPO; author's calculations.

In the pan-European KS, Transport and Operations as well as Chemistry have been constantly the top bridging knowledge domains over the past 10 years. Since 2001 Mechanical engineering has become a more important, while Consumer Goods have become a less important bridging technology. Compared to the Slovenian KS, Consumer Goods is the one dominant bridging domain over the entire observed 15 years. For all other technology fields, a number of changes are evident. **Figure 16** highlights the area where most bridging technology classes are located in the Slovenian 2011-15 KS.

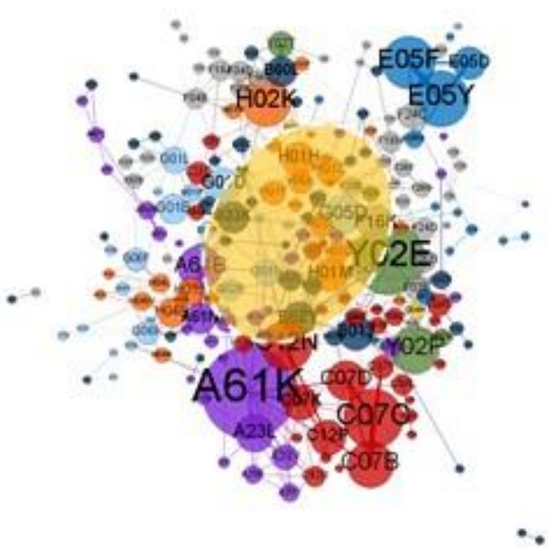


Figure 16. Slovenian Knowledge Space, 2011-15; area of the Knowledge Space where most "bridging" occurs is highlighted in yellow
Source: PATSTAT, EPO; author's calculations.

3.3. Technological Knowledge Indices and the Position of Slovenia in the EU28+2

Every invention that is patented is classified and allocated to at least one of the top-level CPC sections and then also to the more detailed class symbol and subclass that is associated with it. **Table 9** highlights the distribution in the number of classes that are associated with patents developed by Slovenian inventors versus those in the EU28+2 overall. Over 60% of Slovenian patents are only classified into one technology subclass compared to a ration of just over 50% in the EU. In terms of patent documents that contain at least two technology classes, i.e. 4-digit CPC codes, the ration between Slovenia and the EU28+2 is 23% and 29%, respectively. This indicates that Slovenian patents less frequently recombine knowledge inputs that derive from at least 2 or more CPC subclasses compared to Europe as a whole in the generation of novel products and processes of economic value.

Table 9. Distribution of number of classes associated with patents in Slovenia compared to the EU28+2 over the time period 2001-2015

No. CPC	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
No. patents (SI)	1,028	389	169	58	16	2	3	2	-	1,667
Ratio (SI)	61.7 %	23.3 %	10.1 %	3.5%	1.0 %	0.1 %	0.2 %	0.1 %	0.0 %	100.0 %
No. patents (EU30)	1,8 m	1 m	438k	170k	64k	24k	8,700	3,400	2,750	3,6 m
Ratio (EU30)	50.7 %	29.4 %	12.2 %	4.8%	1.8 %	0.7 %	0.2 %	0.1 %	0.1 %	100.0 %

Source: PATSTAT, EPO; author's calculations.

While the overall distribution of technology classes found in patent documents across national economies provides some interesting insights, it is really more advanced measures of variety and relatedness that offer further information about the state of available knowledge and its recombination potential at a particular place. The two most prominent technology indices in this regard are technological entropy and relatedness, both of which allow not only to evaluate the present state of technological advancement in a given locality, but also **offer an opportunity to project into the future in terms of the most likely technologies with the potential to add a regional competitive advantage to the local economy**. A number of studies have demonstrated that there are evolutionary forces that lead to 'natural' regional economic diversification patterns, while also pointing at the possibility to use such metrics for the development of directed investments and policy instruments in order to encourage specific technological pathways with the potential to increase a regions economic performance.[39]

39 For a general overview see: Kogler D. F. (ed) (2016) Evolutionary Economic Geography: Theoretical and Empirical Progress. London: Routledge. For a detailed overview of Relatedness measures as a driver of economic diversification, refer to the following two publications: Boschma R. (2017) Relatedness as driver of regional diversification: a research agenda, Regional Studies, 51 (3), pp. 351-364. & Kogler, D. (2017) Relatedness as driver of regional diversification: a research agenda - a commentary, Regional Studies, 51 (3), pp. 365-369.

3.3.1. Technological Entropy

The number of available building blocks, i.e. technological classes that are present in a local economy, largely determines knowledge recombination possibilities and subsequent patterns of specialization. Measured as entropy that is comprised of unrelated and related variety, it offers an avenue to investigate the composition of specialized local technological knowledge. **Figure 17** outlines the methodology of how technological entropy is calculated, and **Table 10** highlights Slovenia's position in terms of technological entropy vis-à-vis other European national economies.

Technological Entropy

$$Entropy = \underbrace{\sum_{g=1}^{G} P_g log_2\left(\frac{1}{P_g}\right)}_{\text{Unrelated Variety}} + \underbrace{\sum_{g=1}^{G} P_g H_g}_{\text{Related Variety}}$$

,where

- p_i is 3 digit share
- P_g is 1 digit share $P_g = \sum_{i \in S_g} p_i$
- $H_g = \sum_{i \in S_g} \frac{p_i}{P_g} log_2\left(\frac{1}{p_i/P_g}\right)$

Region #1 - Patents by CPC class

1 Digit	3 Digit	No. Patent	P_g	p_i
Chemistry and Metallurgy	C07 ORGANIC CHEMISTRY	6	14/55	6/55
	C12 BIOCHEMISTRY	8		8/55
Physics	G02 OPTICS	7	9/55	7/55
	G04 HOROLOGY	2		2/55
Consumer goods	A43 FOOTWEAR	5	15/55	5/55
	A45 EQUIPMENT	4		4/55
	A47 FURNITURE	6		6/55
Mechanical Engineering	F01 ENGINES IN GENERAL	3	13/55	3/55
	F21 LIGHTING	4		4/55
	F41 WEAPONS	6		6/55
Textiles, Paper	D04 KNITTING	1	1/55	1/55
Transport	B23 MACHINE TOOLS	3	3/55	3/55
Total		55	1	1

Region #1 Entropy (3.43) = UV (2.27) + RV (1.16)

Region #2 – Patents by CPC class

1 Digit	3 Digit	No. Patent	P_g	p_i
Electrocity	H01 BASIC ELECTRIC ELEMENTS	4	33/55	4/55
	H02 CONVERSION POWER	9		9/55
	H03 ELECTRONIC CIRCUITRY	15		15/55
	H04 COMMUNICATION	3		3/55
	H05 ELECTRIC TECHNIQUES	2		2/55
Physics	G01 MEASURING / TESTING	3	22/55	3/55
	G02 OPTICS	2		2/55
	G03 PHOTOGRAPHY	3		3/55
	G05 CONTROLLING	7		7/55
	G06 COMPUTING	2		2/55
	G07 CHECKING-DEVICES	2		2/55
	G09 DISPLAY	3		3/55
Total		55	1	1

Region #2 Entropy (3.20) = UV (0.97) + RV (2.23)

Figure 17. Methodology to calculate technological entropy
Source: PATSTAT, EPO; author's calculations.

As shown in **Table 10**, Slovenia's position in terms of technological entropy scores over the 3 observed 5-year time periods in the EU28+2 economic space changes significantly. From period 1 until period 3, Slovenia increases its rank from 21 to 16. In other words, in more recent times **Slovenia can be classified to have a much more diverse technological knowledge base than it did 10 years earlier**. However, one also sees that this has not been a linear improvement, but one that has gone first through a downswing, i.e. from rank 21 to 24, and only subsequently to an upswing, i.e. from rank 24 to 16. This might indicate a shift in the focus of specialization in terms of technological knowledge capabilities.

While variety alone is already a good indicator of existing and possible future possibilities of knowledge recombination activities, perhaps leading to those more advanced products and processes highlighted in the Knowledge Space methodology, it is especially the measure of related variety that provides an even better indicator in this regard. Theory and empirical evidence point to the necessity of having related knowledge domains in place in order to increase the possibility of recombination activities. **Table 11** again indicates the same ranking as previously shown in **Table 10**, but this time specific to the measure of related variety. In terms of Slovenia's position among European countries, the level of related variety in its knowledge base does not change much and remains around rank 20th over the entire observed time period.

Table 10. National technological entropy scores for Slovenia and other European countries

	2001-2005		2006-2010		2011-2015	
Rank	**Ctry**	**Entropy**	**Ctry**	**Entropy**	**Ctry**	**Entropy**
1	IT	8.13	IT	8.15	IT	8.18
2	AT	8.07	DE	8.13	DE	8.14
3	DE	8.07	AT	8.06	AT	8.08
4	CH	7.87	FR	7.88	FR	7.91
5	FR	7.81	CH	7.82	CH	7.88
6	ES	7.77	GB	7.75	PL	7.86
7	SE	7.69	CZ	7.70	CZ	7.86
8	GB	7.63	NL	7.70	GB	7.77
9	BE	7.55	ES	7.67	ES	7.72
10	NO	7.54	PL	7.65	BE	7.71
...	**Slovenia (21)**	**6.42**	**Slovenia (24)**	**6.33**	**Slovenia (16)**	**7.25**
26	HR	5.14	HR	6.06	EE	6.44
27	EE	5.10	CY	5.70	HR	6.39
28	LV	4.82	LT	5.69	LT	6.28
29	MT	4.73	LV	5.22	CY	5.25
30	LT	4.21	MT	5.11	MT	5.08

Source: PATSTAT, EPO; author's calculations.

Table 11. National technological entropy scores specific to the related variety measure for Slovenia and other European countries

	2001-2005		2006-2010		2011-2015	
Rank	**Ctry**	**RV**	**Ctry**	**RV**	**Ctry**	**RV**
1	IT	4.03	DE	4.05	DE	4.11
2	DE	4.02	IT	4.04	IT	4.05
3	AT	3.95	AT	3.97	AT	4.03
4	CH	3.89	FR	3.91	FR	4.00
5	FR	3.86	CH	3.83	CH	3.92
6	GB	3.77	GB	3.81	GB	3.89
7	SE	3.76	NL	3.76	PL	3.83
8	ES	3.69	SE	3.75	CZ	3.80
9	NL	3.64	CZ	3.68	NL	3.73
10	BE	3.55	PL	3.63	BE	3.73
...	**Slovenia (20)**	**2.67**	**Slovenia (23)**	**2.70**	**Slovenia (19)**	**3.32**
26	EE	1.85	HR	2.36	LV	2.79
27	HR	1.83	LT	2.11	HR	2.65
28	LV	1.53	CY	2.01	LT	2.62
29	LT	1.48	LV	1.91	CY	1.68
30	MT	1.46	MT	1.59	MT	1.22

Source: PATSTAT, EPO; author's calculations.

3.3.2. Technological Relatedness

In addition to the number of building blocks available (entropy) and their variety (related and unrelated), it is of course highly relevant to know average relatedness scores change in the Knowledge Space. As highlighted previously, Smart Specialization is mainly about domains, i.e. technology classes, and their connectedness (relatedness), which provides a much more accurate picture of the state and possible trajectories of a regional economy. Average relatedness measures have become a key element when analysing the current and future potential of knowledge recombination activities in a given locality.[40]

Figure 18 highlights the methodology that is used to calculate regional average technological relatedness scores. Based on co-occurrence matrix that defines the pan-European Knowledge Space it is possible o then calculate regional weights that depict the average relatedness of technologies present in a region or country.

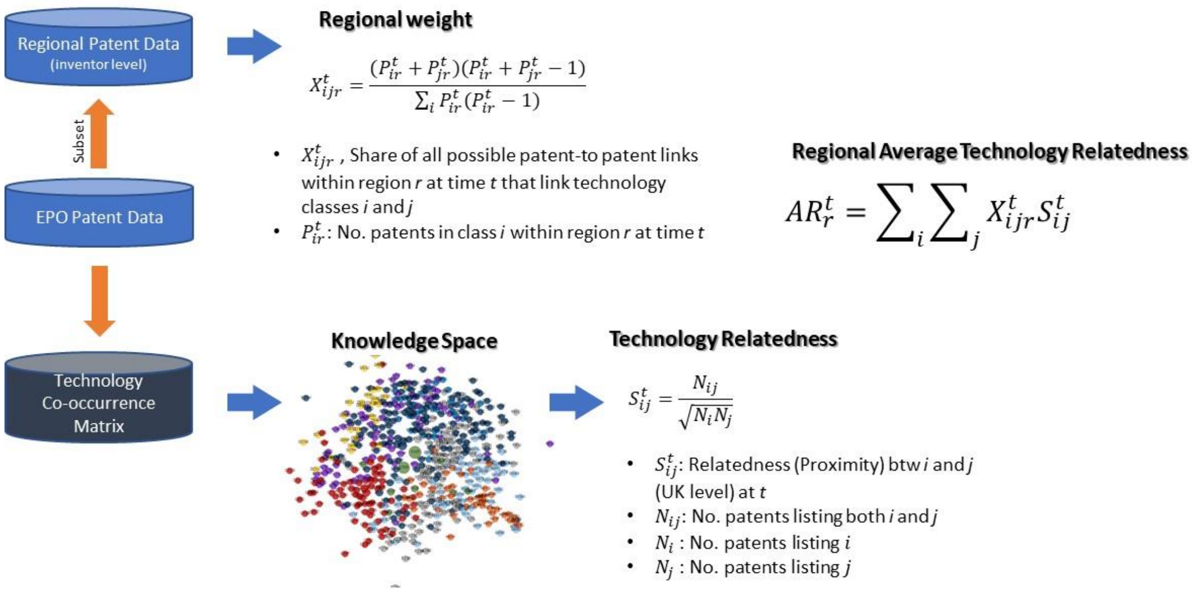


Figure 18. Methodology to calculate regional average technological relatedness
Source: PATSTAT, EPO; author's calculations.

Table 12 indicates Slovenia's position in terms of regional average technological relatedness among European national economies. The rank of Slovenia among the other 29 national economies remains stable at around 21 over the entire investigated time period. This indicates that although technological capabilities have changed over the 15-year time period, in particularly by adding further technological knowledge as shown by the rapid increase of technological classes in the Slovenian KS between 2001-15, the average connectedness of individual knowledge domains has remained stable. While a high average relatedness score doesn't necessarily directly translate into economic success, it has previously been demonstrated that higher relatedness scores also result in an increase of the rate of patenting.[41]

40 Ibid.

41 Kogler D. F., Rigby, D. L. and Tucker, I. (2013) Mapping knowledge space and technological relatedness in US cities. European Planning Studies, 21: 1374–1391.

Table 12. **National average technological relatedness scores for Slovenia and other European** countries

	2001-2005		2006-2010		2011-2015	
Rank	**Ctry**	**AR**	**Ctry**	**AR**	**Ctry**	**AR**
1	FR	2.45	DE	2.50	FR	2.49
2	DE	2.43	FR	2.49	DE	2.48
3	GB	2.42	ES	2.46	GB	2.45
4	BE	2.35	DK	2.42	ES	2.44
5	DK	2.34	GB	2.41	BE	2.37
6	CH	2.34	NL	2.39	CH	2.33
7	ES	2.32	BE	2.36	NL	2.29
8	IT	2.31	AT	2.36	AT	2.29
9	SE	2.30	CH	2.34	PL	2.25
10	AT	2.27	IT	2.33	DK	2.24
...						
20	SK	1.62	NO	1.81	EE	1.62
21	**Slovenia (21)**	**1.47**	**Slovenia (21)**	**1.76**	BG	1.59
22	EE	1.37	EE	1.63	**Slovenia (22)**	**1.58**
...						
29	LT	0.44	LV	0.97	CY	1.02
30	MT	0.32	MT	0.83	MT	0.50

3.3.3. Recombinant Knowledge Production

It is possible to put the two measures of average entropy and relatedness into one framework, and subsequently test for the ability of a region or country to produce novel recombinant knowledge. Combining nodes, i.e. technology classes, that have been previously unconnected and subsequently developing a competitive advantage (RCA > 1) in new recombinant knowledge serves as an indicator of the technological knowledge production capabilities residing in a jurisdiction. The expectation is that a higher value of entropy, which refers to the number and distribution of classes, paired with a high value of average relatedness, which indicates that nodes exhibit a certain level of proximity to each other in the knowledge space, should also lead to more recombinant knowledge to be produced in a place.

Figure 19 illustrated the number of new recombinant knowledge in European NUTS3 regions and metropolitan areas in 2011-2015. The size of the nodes indicates the number of new recombinations a particular jurisdiction has added to its local portfolio compared to the previous period, i.e. 2006-2010. Further, on the two axes of the graph the level of average relatedness and average entropy that are present at individual places is highlighted. A city like Paris, located at the top right-hand corner, is characterized by a high average entropy and relatedness value, but also a very high number of new recombinant knowledge production. Turning out attention to Slovenian cities and regions once can find Ljubljana still in the top right-hand quadrant, above overall average entropy and relatedness scores and with a notable amount of new recombinant knowledge production. A little further down the 45-degree line the Slovenian places like Gorenjska and Maribor follow. The relationship between high recombinant knowledge output and the necessity of higher levels of average entropy and relatedness is clearly evident. **Figure 20** shows the same information, but now at the country level. In this graph we find Slovenia (SI) in the lower left-hand quadrant in close proximity to countries like Croatia, Portugal and Poland. Nevertheless, the amount of competitive advantage in new recombinant knowledge produced in Slovenia is comparable to that in Hungary and definitely higher than, for example, in Poland, Hungary or Czech Republic.

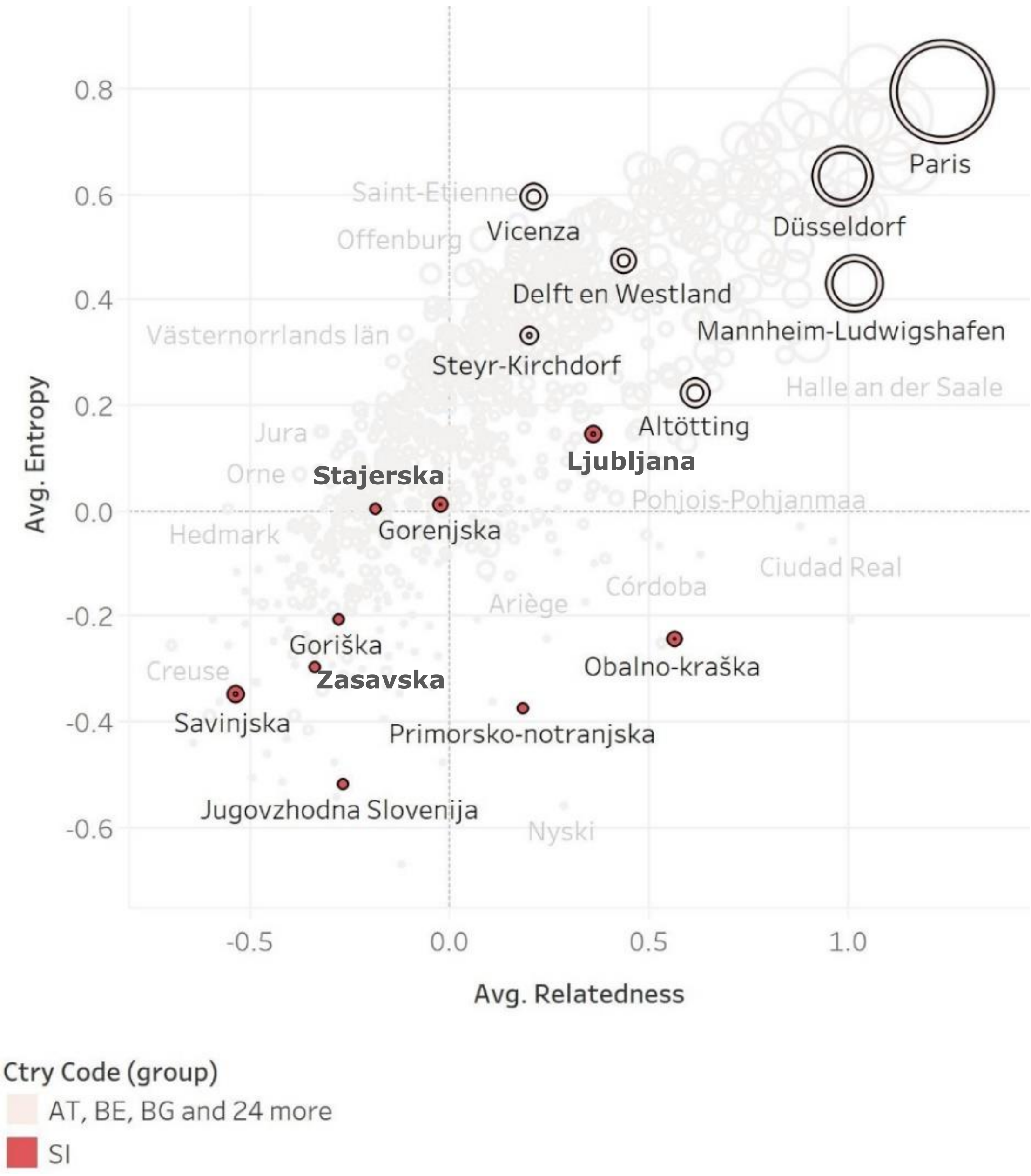


Figure 19. New recombinant knowledge production at the regional scale
Source: PATSTAT, EPO;
author’s calculations.

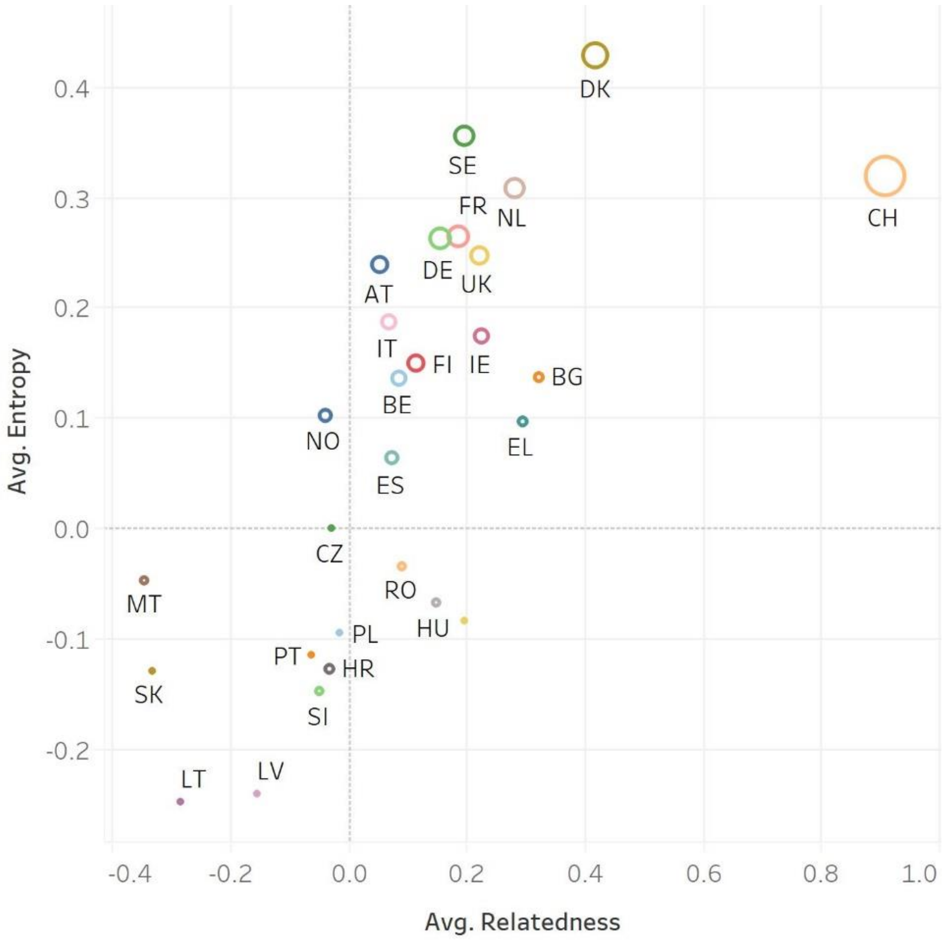


Figure 20. New recombinant knowledge production at the national scale.
Source: PATSTAT, EPO; author's calculations.

3.4. Technological Relatedness Density Scores

In order to take fully advantage of the detailed evaluation of the Slovenian Knowledge Space and associated indicators in terms of suggesting future potential for technological diversification and subsequent specialization along the lines discussed previously, technological relatedness density scores are calculated next. **Figure 21 (A)** takes the 2011-15 Slovenian KS as the starting point and from there it is possible to calculate the Revealed Comparative advantage (RCA) score for each present technology class. An RCA value of 1 or above indicates that Slovenia is specialized in the production of a specific technology class above the level that is observed throughout Europe. In other words, the specific technology class is overrepresented compared to the average that is common in the EU28+2 Knowledge Space. While this is already informative of the existing specialization patterns, it is especially those technology classes that are just below a level of an RCA of 1 that might have the potential to lead to new patterns of specialization and subsequent productivity gains in the production of knowledge that contains economic value for Slovenia. **Figure 21 (B)** indicates the technology classes (nodes) highlighted in red where Slovenia currently has no competitive advantage, i.e. an RCA < 1. **Figure 22** illustrates the priority areas, i.e. specific technologies at are currently close to an RCA value of 1, that have the highest potential to become new areas of specialization within the Slovenian KS. Essentially, the closer a technology' RCA value is to 1, the higher is the probability to develop it into an area of novel specialization with relatively less support than it would be the case for technologies that are considerably underrepresented.

(A) (B)

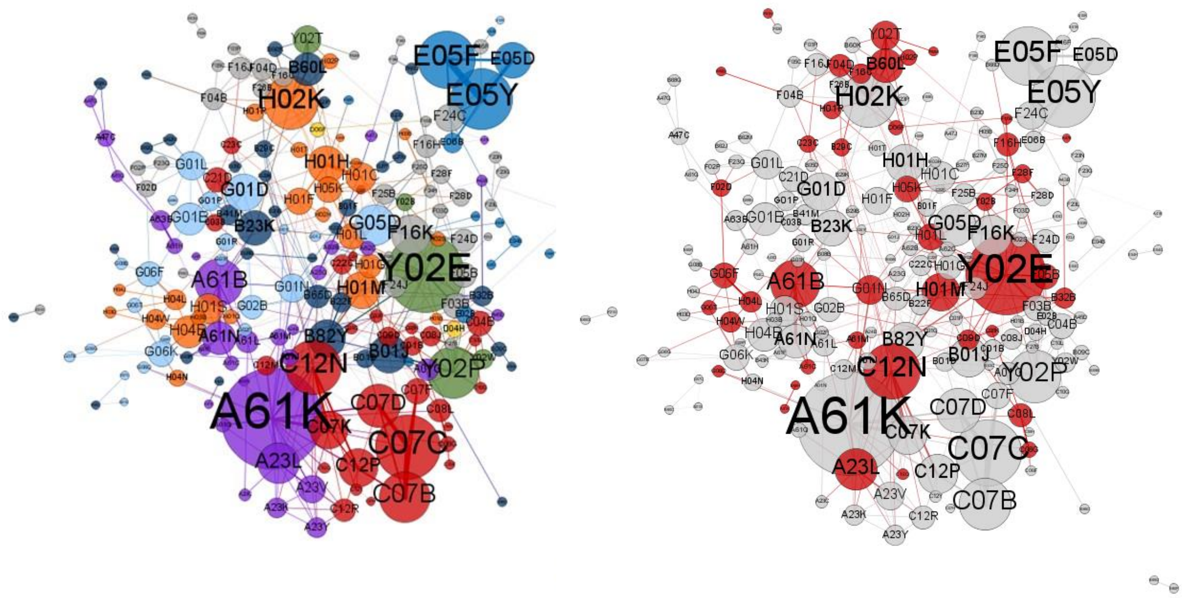


Figure 21. Entry relatedness potential in the Slovenian Knowledge Space
Source: PATSTAT, EPO; author's calculations.

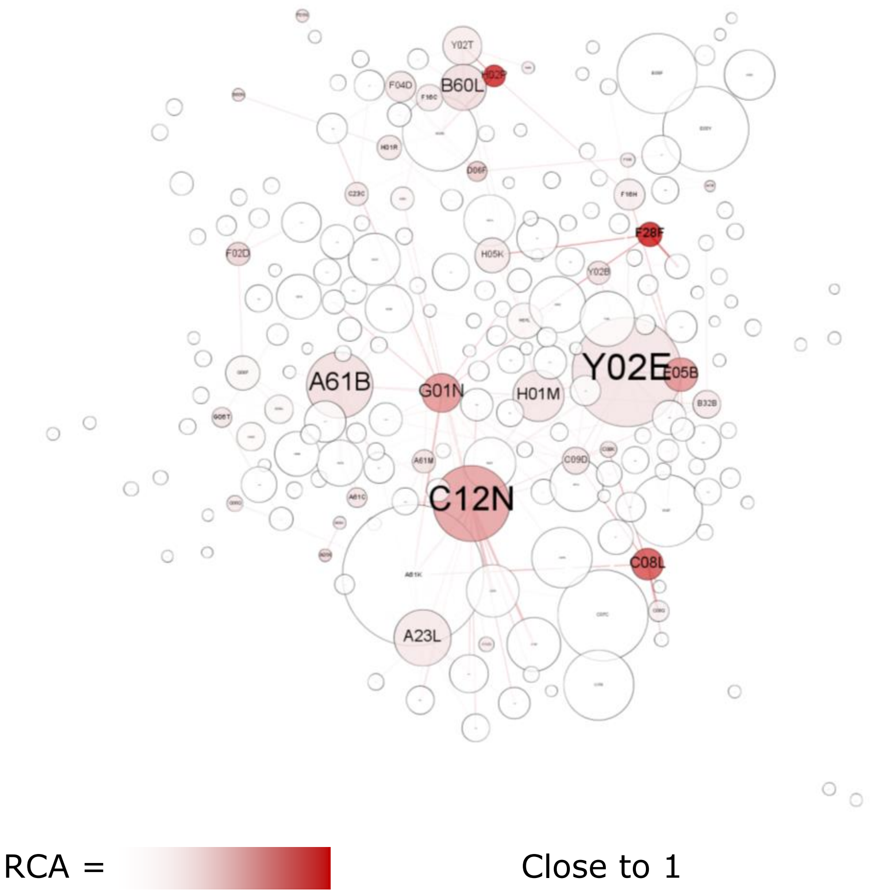


Figure 22. Entry relatedness potential in the Slovenian Knowledge Space
Source: PATSTAT, EPO; author's calculations.

Figure 23 is the scatter plot of technologies (RCA<1) based on their RCA and relatedness density scores. For example, D06F (Laundering, Drying, Ironing, Pressing or Folding Textile Articles) is highly embedded in the current Slovenian KS (Relatedness density=28.15), but still has not reached a relative comparative advantage if compared to EU average (RCA = 0.83). However, based on its high embeddedness and relatively high RCA it is expected that this technology could be developed into a new area of specialization within the Slovenian KS with relatively little efforts. In terms of policy priorities, the following recommendation are made. First priority would be the technologies highlighted in the color purple in **Figure 23**. These are technologies with an RCA range close to a value of 1 (0.75 to 1). The order given by the ranking is as follows: CPC class D06F followed by B62D, A01D, A47L, B60L, etc. The second priority would be technologies that still show a high relatedness density score, i.e. those that are reasonably embedded in the local Knowledge Space, but at least also show an RCA value of 0.5 or above.

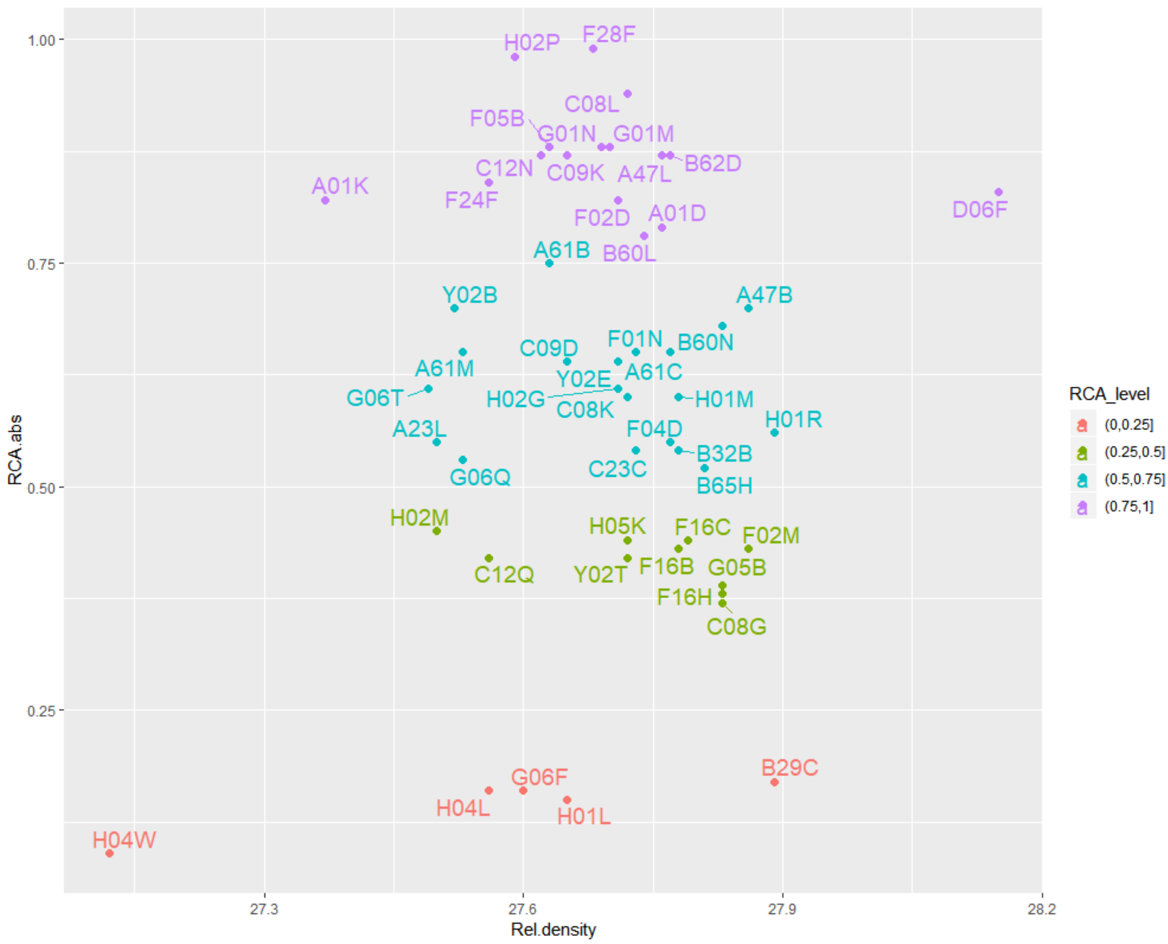


Figure 23. Relatedness density score and RCA values of specific technology classes
Source: PATSTAT, EPO; author's calculations.

Table 13 lists the top 20 CPC subclasses that hold the highest potential to generate new patterns of technology specializations for Slovenia based on the 2011-15 KS. Some of the CPC titles are abbreviated; Technologies that are listed at the top of this table are those subclasses that could be of particular interest for future smart specialisation strategies.[42]

42 For detailed descriptions of the CPC scheme and definitions please refer to the official Cooperative Patent Classification website at: https://www.cooperativepatentclassification.org/cpcSchemeAndDefinitions/table.

Table 13. CPC classes below RCA value 1 in the Slovenian Knowledge Space ranked according to highest technological relatedness density score

CPC	Technology (Label)	RCA	Rel.dst
F28F	Details of Heat-Exchange And Heat-Transfer Apparatus, of General Application	0.99	27.68
H02P	Control or Regulation of Electric Motors, Electric Generators or Dynamo-Electric Converters; Controlling Transformers, Reactors or Choke Coils	0.98	27.59
C08L	Compositions of Macromolecular Compounds	0.94	27.72
G01 M	Testing Static or Dynamic Balance of Machines or Structures; Testing Structures or Apparatus not otherwise provided for	0.88	27.7
G01N	investigating or Analysing Materials by Determining their Chemical or Physical Properties	0.88	27.69
F05B	Indexing Scheme Relating to Machines or Engines Other Thannon-Positive-Displacement Machines or Engines, to Wind Motors, to Non-Positive Displacement Pumps, And to Generating Combustion Products of High Pressure or High Velocity	0.88	27.63
B62D	Motor Vehicles; Trailers	0.87	27.77
A47L	Domestic Washing or Cleaning; Suction Cleaners in General	0.87	27.76
C09K	Materials for Miscellaneous Applications, not provided for Elsewhere	0.87	27.65
C12N	Microorganisms or Enzymes; Compositions thereof; Propagating, Preserving or Maintaining Microorganisms; Mutation or Genetic Engineering; Culture Media	0.87	27.62
F24F	Air-Conditioning, Air-Humidification, Ventilation, Use of Air Currents for Screening	0.84	27.56
D06F	Laundering, Drying, Ironing, Pressing or Folding Textile Articles	0.83	28.15
F02D	Controlling Combustion Engines	0.82	27.71
A01K	Animal Husbandry; Care of Birds, Fishes, insects; Fishing; Rearing or Breeding Animals, not otherwise provided for; New Breeds of Animals	0.82	27.37
A01D	Harvesting; Mowing	0.79	27.76
B60L	Electric Equipment or Propulsion of Electrically-Propelled Vehicles; Magnetic Suspension or Levitation for Vehicles; Electrodynamic Brake Systems for Vehicles, in General	0.78	27.74
A61B	Diagnosis; Surgery; Identification	0.75	27.63
A47B	Tables; Desks; office Furniture; Cabinets; Drawers; General Details of Furniture	0.7	27.86
Y02B	Climate Change Mitigation Technologies Related to Buildings, e.g.Housing, House Appliances or Related End-User Applications	0.7	27.52
B60N	Seats Specially Adapted for Vehicles; Vehicle Passenger Accommodation not otherwise provided for	0.68	27.83
A61C	Dentistry; Apparatus or Methods for oral or Dental Hygiene	0.65	27.77
F01N	Gas-Flow Silencers or Exhaust Apparatus for Machines or Engines in General; Gas-Flow Silencers or Exhaust Apparatus for internal Combustion Engines	0.65	27.73
A61M	Devices for introducing Media into, or Onto, the Body; Devices for Transducing Body Media or for Taking Media From the Body; Devices for Producing or Ending Sleep or Stupor	0.65	27.53
Y02E	Reduction of Greenhouse Gas [Ghg] Emissions, Related to Energy Generation, Transmission or Distribution	0.64	27.71
C09D	Coating Compositions, e.g. Paints, Varnishes or Lacquers; Filling Pastes; Chemical Paint or ink Removers; inks; Correcting Fluids; Woodstains; Pastes or Solids for Colouring or Printing; Use of Materials therefor	0.64	27.65

Source: PATSTAT, EPO; author's calculations.

4. Technological Industry and Occupation Profile

In order to generate a technological industry sector profile for Slovenia it is necessary to translate CPC classes into industry sectors. One advanced approach to achieve this task is to utilize a concordance table based on an algorithmic link with probabilities that matches patent with industry sector data.[43] Following this methodology, each of the previously discussed Slovenian Knowledge Spaces were translated into technological industry profiles for the 3 time periods, respectively. **Table 14** provides a list of the top 10 technology related industry sectors present in Slovenia in 2001-2005. **Figure 24** provides a further overview in the format of a TreeMap chart. Not surprisingly, sectors that manufacture pharmaceutical products or electrical equipment are the industries that produce and utilize technological knowledge present in Slovenia.

More recently, in the period 2011-15, this distribution of industry sectors has slightly changed reflecting the shifting patterns of knowledge production in the country. The manufacturing of electrical equipment sector is now the top technology industry sector followed by manufacturing of machinery. On the other hand, the previously dominating sector of pharmaceutical products manufacturing is now ranked number 4. Notable, the industry sector that relates to the manufacturing of other non-metallic mineral products is one of the new entrants in the list of top 10 technology related industry sectors in Slovenia, 2011-15 as listed in **Table 15**, below. Again, **Figure 25** shows a graphic overview of the sectorial distribution in the format of a TreeMap chart.

Translating technology classes into their application across industry sectors is of particular interest in terms of a) taking stock of what industry sectors produce and exploit technological knowledge, and b) when the aim is to develop more informed smart specialization strategies that either aim to support existing capabilities or have the objective to foster the further establishment of industry sectors that are currently underrepresented based on the technological profile of a region or nation. Based on the results derived and displayed in **Table 15**, but without actually knowing the real distribution of industrial sectors in Slovenia, it is challenging to make specific recommendations, but it appears that sectors that manufacture electrical equipment, machinery and optical as well as pharmaceutical products are critical elements of the knowledge production system. When benchmarked to the actual distribution of industry sectors in the country, i.e. the full set of sectors rather than just those linked to technical knowledge production, policy intervention then should be geared either to supporting those sectors, or to develop strategies to increase the share of such sectors in the national economy as they would find an innovative environment that would allow them to gain a competitive advantage over firms that are located in localities where the specialized knowledge that is essential for these particular sectors is not available.

Table 14. Top 10 technology related industry sectors in Slovenia, 2001-05

Top 10 Industry	Weight
Manufacture of basic pharmaceutical products and pharmaceutical preparations	142
Manufacture of electrical equipment	84.5
Manufacture of machinery and equipment n.e.c.	56.3
Manufacture of computer, electronic and optical products	51
Other manufacturing	34.6
Manufacture of fabricated metal products, except machinery and equipment	32.7
Manufacture of chemicals and chemical products	22.1

43 Lybbert, T. J., and Zolas, N. J. (2014). Getting patents and economic data to speak to each other: An 'algorithmic links with probabilities' approach for joint analyses of patenting and economic activity. Research Policy, 43(3), 530-542.

Manufacture of motor vehicles, trailers and semi-trailers	9.26
Specialised construction activities	9.17
Manufacture of other transport equipment	8.76

Source: author's calculations.

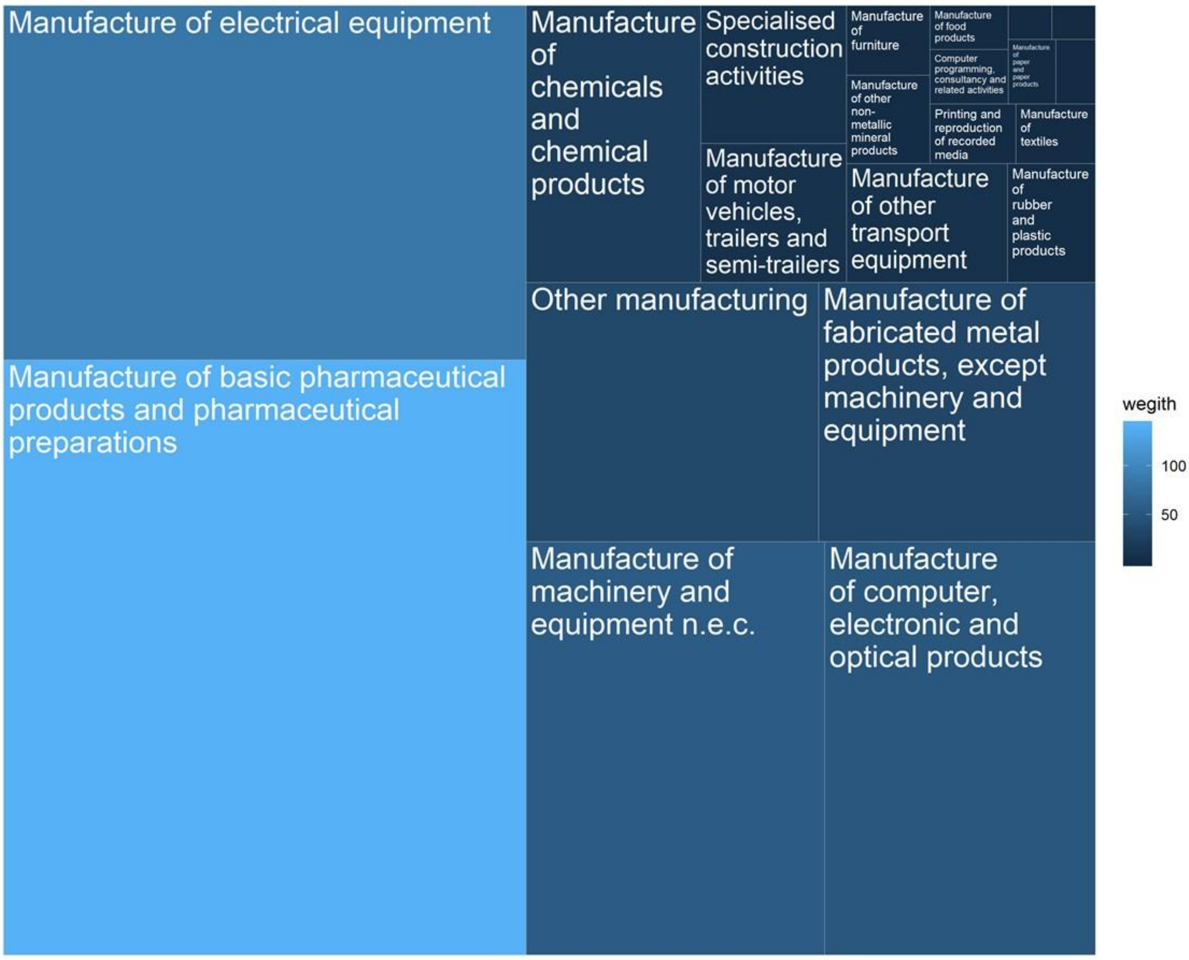


Figure 24. Technological industry sector profile for Slovenia, 2001-05
Source: author's calculations.

Table 15. Top 10 technology related industry sectors in Slovenia, 2011-15

Top 10 Industry	Weight
Manufacture of electrical equipment	108
Manufacture of machinery and equipment n.e.c.	102
Manufacture of computer, electronic and optical products	76
Manufacture of basic pharmaceutical products and pharmaceutical preparations	66.4
Other manufacturing	53.5
Manufacture of chemicals and chemical products	43.1
Manufacture of fabricated metal products, except machinery and equipment	23.7
Manufacture of other non-metallic mineral products	15.2
Manufacture of motor vehicles, trailers and semi-trailers	11.7
Specialised construction activities	7.83

Source: author's calculations.

Figure 25. Technological industry sector profile for Slovenia, 2011-15
Source: author's calculations.

4.1. Technological Skills and Occupation Profile

One of the objectives of the present study is to generate a technological occupations and skill space and though that insights to the potential diversification of the region's workforce as it pertains to the production of knowledge that leads to novel products and processes of economic value. This is a major effort as it extends the original Knowledge

Space methodology that aimed to only identify possible growth avenues for technological diversification. In order identify possible key occupations that might become a particular focus in the future, the industry sector profile then needs to be translated into an occupation profile via an industry/occupation matrix. This is the objective in the final section of this report, and it is expected to provide ample opportunities for local stakeholders to develop a more detailed needs evaluation of future skills for the advancement of the national economy.

The necessary industry sector and occupation categories matrix was provided by the national statistical office with the help of local stakeholders. For confidentiality and strategic national reasons, it is not possible to provide further information as it pertains to this matrix, but in essence it did allow to make a concordance between the industry sectors highlighted in the previous sections to the occupations that are essential for them.

Table 16 highlights the top 10 technological knowledge production related occupation categories that make up the profile of the national economy in 2001-2005. Metal, machinery trades, machine operators and especially science and engineering associated occupations are the most dominant ones in this observed time period.

Figure 26 is a TreeMap chart that displays the full extent of the national technology occupation profile for the same time period. Like previously, it is of course especially the changes that occur over the observed 15-year time period that are of particular interest, especially in light of future smart specialization strategies.

Table 17 indicates the top 10 occupation categories that are present in Slovenia in 2011-15 and how they relate to the knowledge and industry space in the same period. Notable, if compared with the data illustrated in **Figure 26**, health professionals occupations have left the top 10 ranking while food processing, wood working, garment and other craft and related trade workers are now more relevant and have entered the top 10 ranking in the most recent observed time period.

Figure 27 once again shows the top 10 ranking listed in **Table 17** in a TreeMap chart. Taking this information and projecting into the future where once considers the latent diversification potential of the country’s workforce, there are a number of insights that can be drawn from this analysis. Metal, machinery and assemblers occupations are essential skill inputs for the industry sectors that have the highest potential to take advantage of the Slovenian technological knowledge environment. Similar, science and engineering professionals are key as well, which mirrors a pattern that was already evident 10 years prior. However, it’s also noticeable that there are certain occupational categories, such as food processing, wood working and craft related trades, that become more relevant when we consider skills for technological advancements. Developing policy initiatives that are geared towards supporting and furthering skill profiles of workers operating in that part of the occupational space could result into positive reinforcement not only to cement existing patterns of technology specialization, but also fostering new avenues for successful diversification into new, but related, sectors. However, insights deriving from this methodological approach need to be considered carefully before rushing into any kind of policy actions that are solely based on the results of the present analysis and rather should be considered additional evidence that needs to be put in perspective with all aspects of the national economy, many of which will be discussed and investigated in the subsequent sections of this report.

Table 16. Top 10 technology related occupation sectors in Slovenia, 2001-05

Top 10 Occupation	Weight
Metal, machinery and related trades workers	61
Science and engineering associate professionals	61
Stationary plant and machine operators	57.3
Assemblers	43.4
Science and engineering professionals	41.2
Labourers in mining, construction, manufacturing and transport	38.4
Business and administration associate professionals	25
Health professionals	18.1
Numerical and material recording clerks	14.2
Business and administration professionals	14.1

Source: author’s calculations.

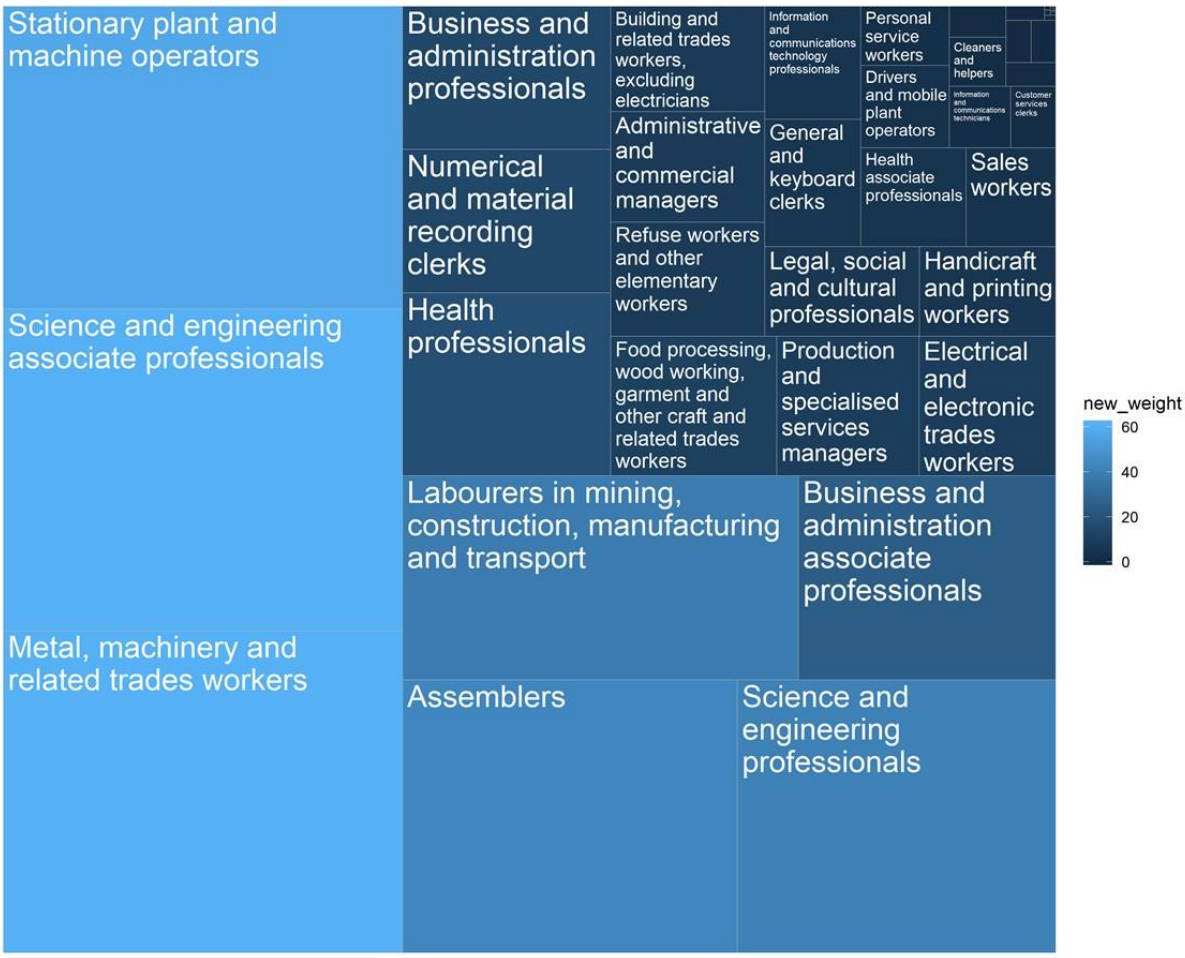


Figure 26. Technological occupation profile for Slovenia, 2001-05
Source: author’s calculations.

Table 17. Top 10 technology related occupation sectors in Slovenia, 2011-15

Top 10 Occupation	Weight
Metal, machinery and related trades workers	79.5
Assemblers	58.4
Science and engineering associate professionals	57.5
Stationary plant and machine operators	55.3
Labourers in mining, construction, manufacturing and transport	53.7
Science and engineering professionals	44.3
Business and administration associate professionals	31
Numerical and material recording clerks	17
Food processing, wood working, garment and other craft and related trade workers	16.8
Business and administration professionals	13

Source: author's calculations.

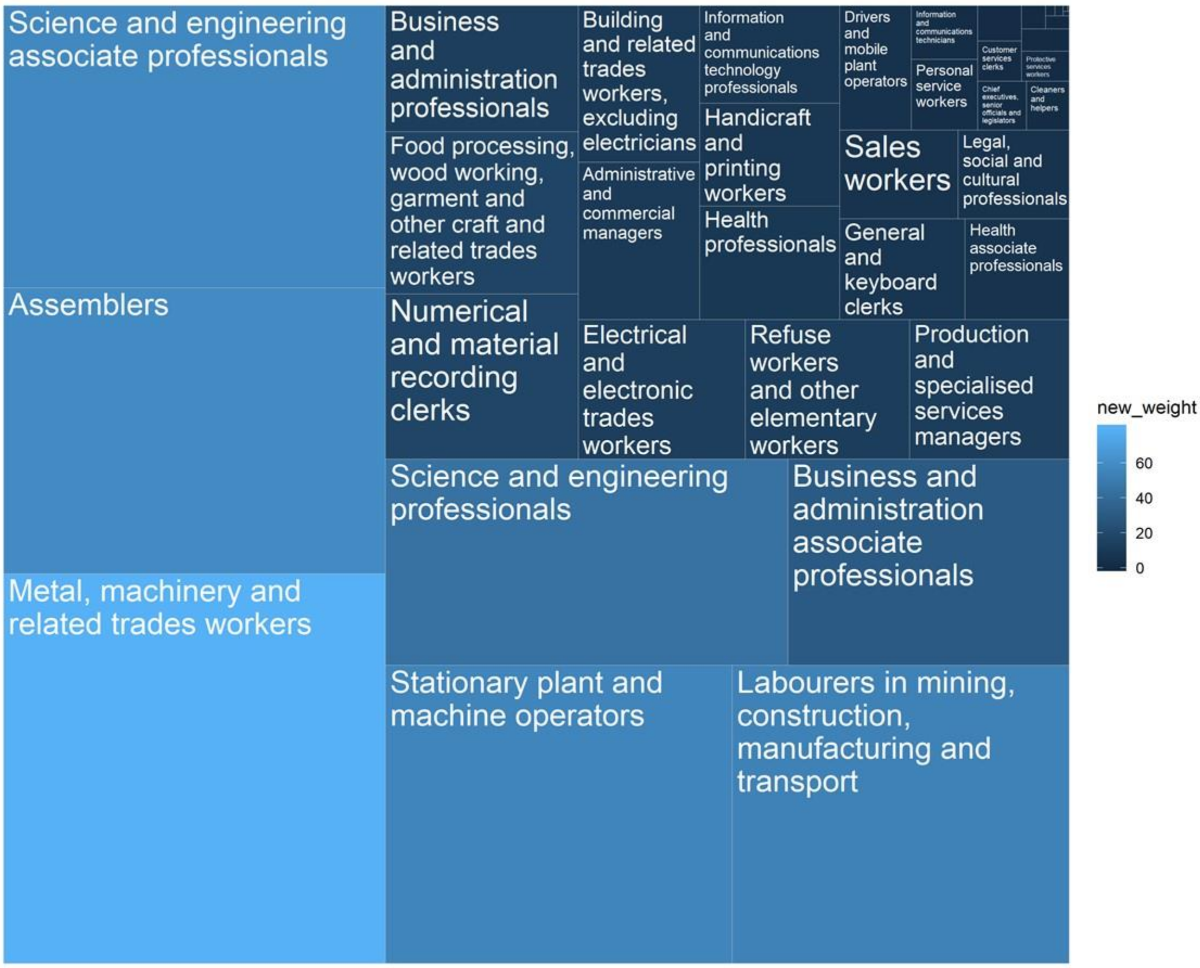


Figure 27. Technological occupation profile for Slovenia, 2011-15
Source: author's calculations.

4.2. Concluding Remarks

The study set out with the objectives to generate, describe and analyse the Slovenian Knowledge, Product & Occupation Space, while also providing further evidence on the skill relatedness based on knowledge production patterns in order to provide insights for the latent diversification potential of the country's workforce. The present report provides a detailed overview and analysis to all these objectives, but then also aimed to offer some preliminary recommendations in regard to the development of a future Slovenian smart specialization strategy that considers local knowledge production patterns and the opportunities that might derive from those. In conjunction with work packages 3 and 4 of the overall study, this should provide the Slovenian government with a report that will ensure that it can pursue the vision of an empirically led internationalization of S3 based on micro data.

5. Tax Policy and the Location of FDI

When discussing methods of attracting foreign direct investment (FDI), nothing gets the degree of attention that tax policy does. This is due to several factors, not the least of which is that when compared to features such as the size of a country's market and geographic location, tax policy is swiftly and (relatively) easily changed. Currently, the taxation of multinationals has gained even greater attention due to increased awareness of firms' profit-shifting activities and concerns over the detrimental impacts of tax competition. With this in mind, it is critical to understand Slovenia's taxes in the context of European competition for FDI.

In this analysis, we examine the location determinants of foreign direct investment (FDI) into Europe. To do so, we use information on 8,200 European cross-border greenfield investments. While merger and acquisition FDI still forms the bulk of the value of FDI, in terms of the number of investments greenfield investments now dominate the FDI landscape.[44] In particular, we focus on the role of corporate tax rates, personal income tax rates, and the tax treatment of research and development (R&D) costs and patent boxes (policies which lower the tax applied to income derived from qualifying intellectual properties). For Slovenia, these three taxes provide an interesting mix because, although its corporate tax is roughly average for Europe, its personal income taxes are about 10 percentage points higher than average. In addition, while it offers accelerated depreciation for R&D expenditures in its tax code, this approach is outdated relative to major FDI hosts. Thus, there is the potential for significant upgrading of Slovenia's tax environment.

In the preferred specification, we find that the estimated host corporate effective average tax rate (EATR) elasticity is -4.67, i.e. a 1% decrease in the host EATR increases the probability of investment by 4.67%. This is comparable to the meta-analysis of de Mooij and Edverdeen (2008) who combine over 400 sets of estimates on the impact of taxes on FDI, finding that on average, a one percentage point decrease in the corporate tax leads to a -3.1% rise in aggregate FDI. In addition, we find that higher personal income taxes deter investment with an elasticity of -1.34. These estimates, however, are the average effect across countries and point to a greater responsiveness when the tax is initially low.

As a result, since the Slovenian corporate tax is relatively low, a one percent reduction in the Slovenia tax increases the probability of an investment project choosing Slovenia as its host by 7.9%, **nearly twice as much as in the average European nation**. This effect is buttressed by Slovenia's small size which means that taxes generally play a larger role it its attractiveness to foreign investors. In contrast, a one percent reduction in the high Slovenian personal income tax is estimated to do nothing to Slovenia's attractiveness to investors. Thus, to use the personal income tax as a method of directly attracting FDI, it would be necessary to implement significant cuts that bring it much closer to the European average. Note, however, that this is a direct effect and does not include "brain drain" effects whereby even a small reduction in the personal income tax might slow emigration of the highly-skilled workers desired by foreign multinationals.

44 Davies, Desbordes, and Ray (2018) provide a detailed comparison of greenfield and merger and acquisition FDI. See also: Davies, Ronald B., Rodolphe Desbordes, and Anna Ray. (2018) "Greenfield vs. Merger and Acquisition FDI: Same Wine, Different Bottles?" *Canadian Journal of Economics*, 51(4), 1151-1190.

Turning to the role of targeted R&D tax policy on FDI, the results are more nuanced with important distinctions across types of policies. Here, we consider three groups of tax treatments. The first is an indicator for when a country uses a more aggressive depreciation schedule for R&D costs relative to its overall accelerated depreciation rules. An alternative approach is to offer a credit against the tax bill. Finally, a third approach is the use of a patent box which lowers the tax rate applied to income derived from qualifying R&D. Box 1 gives an illustrative example comparing the three policies.

When not distinguishing across the three, no significant impact is found, i.e. R&D tax policies do nothing to improve attractiveness to FDI. When differentiating across policies, depending the specification, either tax credits or patent boxes are found to increase the likelihood of investment. Across all specifications, however, countries just offering faster depreciation are at a disadvantage relative to other nations. As this is Slovenia's current approach, this points to the potential need for it to bring its tax treatment of R&D up to the level of European leaders in order to increase inbound investment.

Box 1: A Simple Comparison of R&D Tax Policies

Consider a firm that undertakes R&D expenditures of €100 will depreciate completely over two years while earning €500 in revenue each year. The firm faces a corporate tax rate of 40%.

Depreciation

Under straight line depreciation, this would allow it to reduce its tax bill by €50 per year. Using the 40% tax rate, this lowers its tax bill by €20 in the first year and €20 in the second. If the interest rate is 10%, then the present discounted value of this second year is €18.18, for a total present value of the tax base of €38.18. A depreciation policy accelerates that depreciation to €30 in the first year increases the present value of the tax saving to €39.09.

Credit

Alternatively, suppose that the government offers a 50% tax credit. For the €100 in R&D costs, this would allow the firm to reduce its tax bill by €50 in the first year, increasing the tax savings by more than €10 over the depreciation policy. Note that in contrast to the depreciation, which lowers the tax base and therefore the tax liability, the credit lowers the tax bill directly. Further, note that this credit can be replicated by a subsidy which increases the tax base so that the after-tax profit is €50 higher.

Patent Box

In this scenario, suppose that the government implements a patent box which, as is common, cuts the corporate tax in half. Ignoring the treatment of R&D costs entirely, this reduces the taxes levied against the annual €500 in income by €100 in each year, a benefit on top of R&D tax depreciations and/or credits.

Combining these, although the specific savings will vary country by country (since tax rates, general depreciation regulations, and other policies will vary) and firm by firm (since R&D costs, discount rates, and the return on expenditures will vary), the above example indicates why it is generally perceived that patent boxes are the most favourable tax treatment of R&D whereas simply allowing accelerated depreciation is the least favourable.

5.1. Estimation and Data

In the statistical estimation, we use the common conditional logit estimator, an approach used by Devereux and Griffith (1998), Hebous, Ruf, and Weichenrieder (2011), Barrios et al. (2012), and Davies and Killeen (2018) among others. In this, out of the set of possible hosts *H*, the firm chooses a given location *l* if:

$$\mathrm{l} = \arg\max_{\mathrm{h}}(\pi_{i,o,m,h})$$

that is if this *l* results in the highest after-tax profit. Assuming that $\varepsilon_{i,o,m,h}$ is distributed log-Weibull, the probability that the firm invests in *l* is then:

$$Pr\big(l = arg\,m\,ax_l(\pi_{i,o,m,h})\big) = \frac{e^{\pi_{i,o,m,l}}}{\sum_{h\in H} e^{\pi_{i,o,m,h}}}.$$

Note that factors that do not vary by host fall out of this probability, reducing it to:

$$Pr\big(l = \arg m\,ax_l(\pi_{i,o,m,h})\big) = \frac{e^{X_l\beta_1 + X_{l,m}\beta_3}}{\sum_{h\in H} e^{X_h\beta_1 + X_{h,m}\beta_3}}.$$

This approach has four key features. First, it is based on a decision process in which the investment's owner compares the affiliate's profitability across locations. Thus, the probability here is that *l* is chosen as the host *instead* of some alternative location. This is the intuition behind the probability where the owner is comparing the differences across potential hosts. Second, because this comparison is based only on differences, any factors that do not vary across hosts cancel out. As such, one cannot estimate the impact of home country variables (such as the home tax) or owner characteristics (such as owner size) excepting when they are interacted with host variables. Additionally, this implicitly means that the estimation controls for sectoral fixed effects. Third, for the probability function to be the same, the set of hosts *H* must be the same for all owners. This matters when using data on cross-border investments from multiple home countries as a home country for one owner is a potential host for another. As such, the typical way this is dealt with is to allow for the irrelevant alternative of investing at home even though the data is all cross-border. Finally, as in the existing empirical literature, this takes the timing of investment *i* as given. Thus, in a data set with *H* potential hosts over *T* years, the investment decision is modelled as a choice among *H*, not *TH* choices. This approach is generally followed for two reasons. First, doing so would involve a large number of “no investment” observations.[45] Second, such an approach would impose a stark difference between an investment in the last days of year *t* and one at the beginning of year *t+1*, a distinction which, given the planning horizon for greenfield FDI, is likely arbitrary.

Our firm level data comes from Bureau van Dijk's ORBIS dataset.[46] We define a greenfield FDI project as an affiliate that is owned by a firm not in its country of residence and that did not exist in the prior year. This database provides several key pieces of information. First, it indicates the owner of the affiliate, the global ultimate owner's country of residence (the home country), and location of the investment (the host country). **Table 18** provides the list of home and host countries along with the share of outbound and inbound investments for the set of firms we use. As can be seen, although all of the countries in the data are homes, 12 are not hosts during the sample. This can occur because the ORBIS database does not track those nations' inbound investments or because all of the reported investments in a country were missing the firm-level information used the regressions. In particular, missing owner information was problematic for certain countries (such as the US and Switzerland), hence the small number of investments originating from them. Note that in the data the 32 inbound Slovenian investments make up 0.3% of the observations. Slovenian outbound investments have a share nearly twice that.

45 In our data, if we pursue such an approach for the 28 hosts and 10 years of data, each investment would imply one line of data with an investment indicator equal to 1 and 279 lines where it equalled zero.

46 This can be found at http://www.bvdinfo.com.

Table 18. Home and Host Countries

Country	Number of Inbound Inv.	Share of Inbound Inv.	Number of Outbound Inv.	Share of Outbound Inv.
AT	393	4.32	357	3.93
AU	.		17	0.19
BE	181	1.99	1,049	11.54
BG	.		16	0.18
CH	.		8	0.09
CY	.		11	0.12
CZ	403	4.43	332	3.65
DE	1,068	11.75	770	8.47
DK	249	2.74	124	1.36
EE	178	1.96	126	1.39
ES	402	4.42	577	6.35
FI	120	1.32	236	2.6
FR	451	4.96	378	4.16
GR	9	0.1	14	0.15
HR	.		32	0.35
HU	45	0.49	251	2.76
IE	109	1.2	190	2.09
IL	.		1	0.01
IN	.		15	0.16
IS	12	0.13	27	0.3
IT	608	6.69	525	5.77
KR	.		13	0.14
LT	25	0.27	40	0.44
LU	87	0.96	421	4.63
LV	204	2.24	36	0.4
MT	.		164	1.8
NL	743	8.17	1,398	15.37
NO	261	2.87	244	2.68
PL	517	5.69	62	0.68
PT	235	2.58	170	1.87
RO	929	10.22	12	0.13
RU	104	1.14	5	0.05
SE	299	3.29	711	7.82
SI	32	0.35	51	0.56
SK	468	5.15	206	2.27
TR	2	0.02	35	0.38
UA	.		9	0.1
UK	959	10.55	449	4.94
US	.		6	0.07
ZA	.	.	5	0.05

Second, ORBIS provides the year of the investment. To isolate greenfield FDI from M&A FDI, we examine the location of affiliates in their first year of existence.[47] We restrict the sample to 2007 to 2015 for consistency purposes, with **Table 19** reporting the number of investments in our sample by year. One feature of this time period is that the first half is dominated by the economic crisis (which is likely the cause of the drop in investments during 2009).

47 FDI generated by mergers and acquisitions, in contrast, could not be foreign-owned in its first year of existence since it must first be domestically-owned in order to exist so that a foreigner can buy it.

Table 19. Investments by Year

Year	Number of Investments	Number of Slovenian Investments
2007	1,251	4
2008	1,118	3
2009	985	3
2010	1,162	6
2011	1,232	7
2012	1,261	2
2013	1,201	5
2014	773	1
2015	110	1

In addition to affiliate information, ORBIS provides information on the owner. This includes the size of the owner, measured as total assets in constant 2005 US dollars which is extracted from the unconsolidated statements so as to exclude the affiliate. For an investment that occurs in year t, we use the owner size in $t-1$ or, if that missing, for the closest year for which it was available. This leaves us with 8,219 investments across 6,643 owners for which we have control variables.

Beyond the owner variables, we utilize a set of host and country pair control variables commonly used in FDI regressions. To control for the market size of the host, we utilize GDP and market potential (constructed as the sum of other countries' GDPs weighted by their distance to the country in question). One would generally expect a positive effect from host GDP. Market potential is typically presumed to have positive effects on FDI and indeed, this is commonly found (see for example a review by Fontagné and Mayer, 2005). That said, several studies such as Blonigen et al. (2007) find the opposite, implying that investment prefers the periphery. As shown by Blonigen et al. (2007), the extent of this can vary across industries. Thus, we are initially agnostic about the expected effect of market potential. In addition, we include GDP per capita which can capture both desirable market income effects (encouraging FDI to locate there), higher skill levels (the attractiveness of which may depend on the skill-intensity of the industry), and higher worker wages (driving investment away). Thus, it is unclear what to anticipate for this variable *a priori*.

In addition to market size, we control for the level of tertiary education of the host (measured as the share of population with tertiary education). Much like GDP per capita, this can have a positive effect (reflecting skill) or a negative effect (reflecting labour costs) with the literature often finding very mixed effects. Also, as is common, we control for "openness", i.e. exports and imports relative to GDP. This is one measure of an economy's trade barriers which is generally seen as a hindrance to both outbound and inbound vertical FDI but something that increases horizontal FDI. In addition to this, we include dummies for whether the host is an EU15 member and/or Eurozone member.

We also use three pair-wise proxies for the cost of doing business across borders: contiguity, common language, and distance (measured as the distance between the most populous home and host cities). These were obtained from the CEPII.[48] Beyond these, we include the average FDI investment barrier index developed by the OECD. This index combines data on four subcategories restricting foreign-owned firms (equity restrictions on foreign ownership, screen and approval requirements, the use of key foreign personnel, and other restrictions).[49]

48 See http://www.cepii.fr.

49 Note that this is not origin specific. Particularly in light of the EU, investment barriers may differ between EU members and country pairs involving a non-member. Potential issues are hopefully mitigated by the inclusion of dummies equal to one when the host is EU15 or

Finally, and most importantly for this analysis, we use four tax variables. First, we use the log of the effective average tax rate (EATR) from CBT Tax Database.[50] As discussed by Devereux, et. al (2010), this methodology begins with statutory rates which are then adjusted for a representative firm accounting for each country's particular tax policies.[51] When choosing whether or not to locate in a given host country, the firm would consider the total-after tax profit. In this case, as discussed by Devereux and Griffith (1998), the relevant tax is the average tax which is what we use here. **Figure 28** illustrates the effective average tax for our hosts using the average over the years of our sample. As can be seen, Slovenia's EATR is slightly below the average. Second, we use the highest marginal income tax rate assessed on personal income.[52] This was obtained from the OECD and when information was missing, augmented with data from PWC's *Worldwide Tax Summaries*.[53] As shown in **Figure 28**, Slovenia's personal tax rate is relatively high.

Finally, the PWC summaries were used to collect data on the tax treatment of R&D. Countries were grouped according to whether their tax treatment allowed for accelerated depreciation of R&D investments beyond the regular accelerated depreciation rate for equipment (*R&D Depreciation*), whether it allowed for an R&D credit against the tax bill (*R&D Credit*), and/or whether it provided a patent box that reduces the tax rate applied to qualifying income (*Patent Box*). Note that these are simply indicator variables. As the value of a given policy depends on numerous factors (including the interest rate applied, the return to R&D costs, and the thresholds for qualifying expenditures), it is beyond the scope of this analysis to delve deeply into the specifics of each policy across each of the host countries.
The list of which policies were used by a host during the sample period is found in **Table 20**. Summary statistics for all variables are found in **Table 21**.

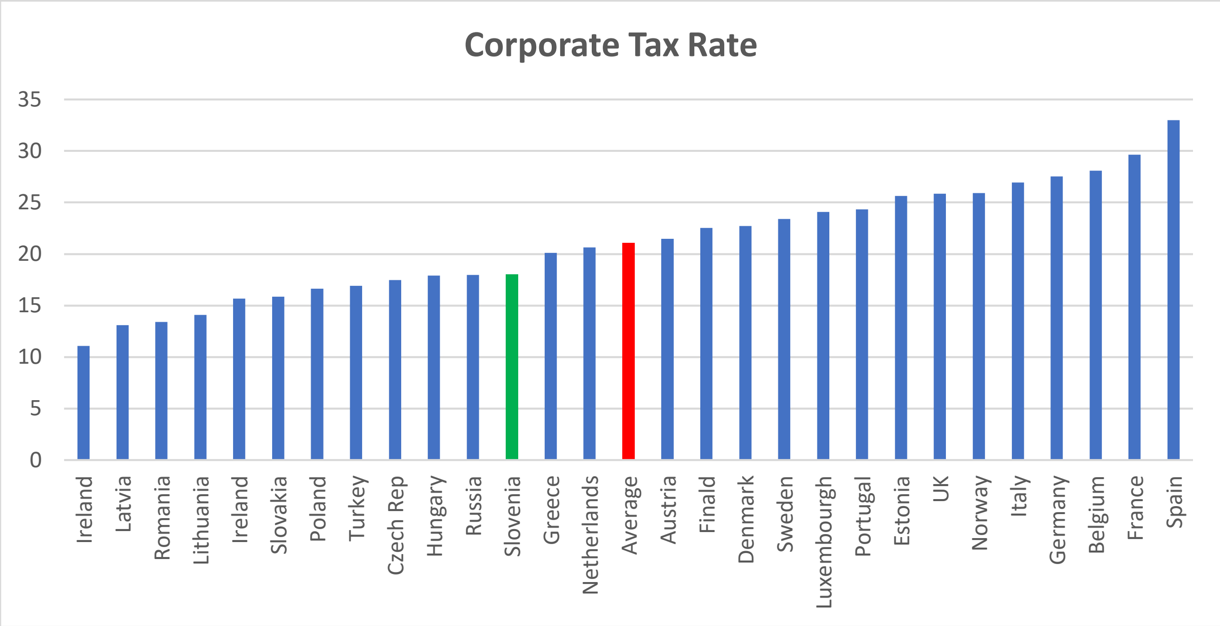
Eurozone. In any case, however, if this measure was a poor indicator of investment barriers one would expect insignificance rather than the consistently significantly negative coefficient we find.

50 This can be found at https://www.sbs.ox.ac.uk/faculty-research/tax/publications/data.

51 See Devereux and Griffith (2010) for a detailed discussion. In unreported results, as an alternative to these constructed tax rates, we used those constructed by Spengel et al. (2014), who use a comparable methodology for European countries. When doing so, similar results were found.

52 Note that this is the marginal, not average rate. This is due to the widely varying progressivity of tax schedules across countries, making a consistent comparison of averages difficult at best and one sensitive to the wage of workers which likely varies by the skill intensity of the FDI project's industry.

53 These can be found at http://www.oecd.org/tax/tax-policy/tax-database.htm and https://www.pwc.com/gx/en/services/tax/worldwide-tax-summaries.html. Earlier years relied on hard copies of the PWC summaries.



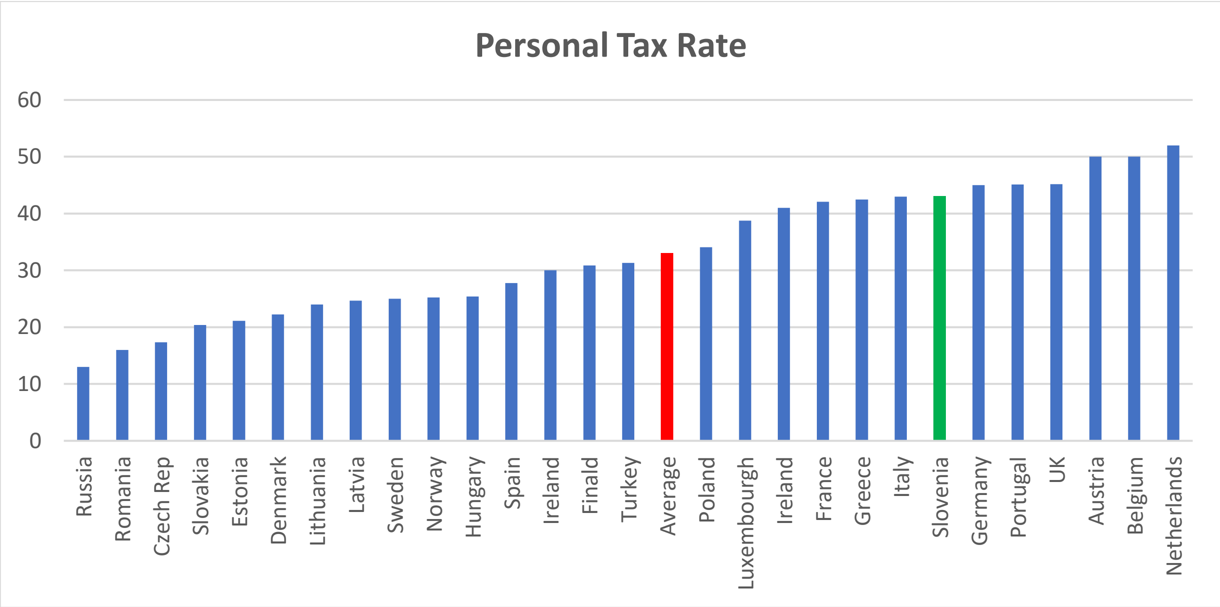


Figure 28. Average Tax Rates

Table 20. R&D Tax Policies

Host	R&D Depreciation	R&D Credit	Patent Box
Austria		X	
Belgium		X	X
Czech Rep.	X		
Germany			
Denmark	X		
Estonia			
Spain		X	X
Finland	X		
France		X	X
Greece			
Hungary	X		X
Ireland	X	X	X
Iceland	X		
Italy		X	
Lithuania	X		
Luxembourg			X
Latvia	X		
Netherlands	X	X	
Norway			
Poland			
Portugal	X		X
Romania	X		
Russia	X		
Sweden			
Slovenia	X		
Slovakia	X	X	
Turkey	X		
United Kingdom	X		X

Table 21. Summary Statistics

	Obs.	Mean	Std. Dev.	Min.	Max.
Corporate Tax	254,604	0.21072	0.05659	0.11088	0.35288
Personal Tax	254,604	0.33075	0.11724	0.13	0.52
R&D Depreciation	254,604	0.33189	0.47089	0	1
R&D Credit	254,604	0.2607	0.43902	0	1
Distance	254,604	6.95305	0.80879	2.9511	9.80866
Contiguity	254,604	0.11528	0.31936	0	1
Common Language	254,604	0.05709	0.23202	0	1
Openness	254,604	4.57187	0.47212	3.82011	6.08258
Education	254,604	3.29844	0.33727	2.56495	4.05872
GDP	254,604	12.369	1.49789	9.50797	14.9826
GDP per capita	254,604	-3.7564	0.75717	-5.281	-2.4519
Market Potential	254,604	9.9911	0.34864	9.41544	10.8239
EU15	254,604	0.53571	0.49872	0	1
Euro	254,604	0.50383	0.49999	0	1
FDI Barriers	254,604	4.45344	0.09026	4.09484	4.54754

5.2. Results

In this section, we first present our baseline specification. Following that, we explore alternative treatments of the data in a series of robustness checks.

5.2.1. Baseline Estimates

In **Table 22**, we present our baseline estimates. Column (1) includes just the host corporate tax. Column (2) includes this as well as personal tax rate. Column (3) introduces non-linearities by including the square of each tax rate. Columns (4) and (5) repeat (2) and (3) but add in host dummy variables to deal with unobserved, time-invariant factors that can affect the location choice.

Table 22. Baseline Results

	(1)	(2)	(3)	(4)	(5)
Corporate Tax	-2.267***	-3.543***	-27.207***	-2.692***	2.998
	(0.386)	(0.400)	(1.849)	(0.931)	(4.520)
Corporate Tax Sqr.			53.487***		-11.425
			(3.994)		(8.887)
Personal Tax		-2.140***	-7.902***	0.550	0.584
		(0.157)	(0.746)	(0.475)	(1.723)
Personal Tax Sqr.			9.922***		-0.016
			(1.155)		(2.505)
Distance	-0.364***	-0.367***	-0.371***	-0.255***	-0.246***
	(0.018)	(0.018)	(0.018)	(0.019)	(0.019)
Contiguity	1.536***	1.492***	1.507***	1.690***	1.680***
	(0.033)	(0.033)	(0.033)	(0.035)	(0.035)
Common Language	0.276***	0.345***	0.329***	0.641***	0.632***
	(0.041)	(0.042)	(0.042)	(0.046)	(0.046)
Openness	-1.018***	-1.265***	-1.201***	0.567*	0.584*
	(0.072)	(0.075)	(0.075)	(0.323)	(0.326)
Education	-1.215***	-1.241***	-1.302***	-1.447***	-1.488***
	(0.042)	(0.042)	(0.042)	(0.313)	(0.315)
GDP	0.092***	0.096***	0.097***	5.116***	4.981***
	(0.020)	(0.020)	(0.020)	(1.096)	(1.064)
GDP per-capita	-0.267***	-0.206***	0.000	-6.008***	-6.061***
	(0.033)	(0.035)	(0.036)	(0.925)	(0.927)
Market Potential	1.254***	1.620***	1.315***	18.845***	19.017***
	(0.075)	(0.080)	(0.085)	(2.777)	(2.804)
EU15	0.718***	0.887***	0.796***		
	(0.054)	(0.057)	(0.057)		
Euro	-0.872***	-0.676***	-0.834***		
	(0.035)	(0.037)	(0.040)		
FDI Barriers	-1.121***	-1.627***	-1.689***	-0.333	
	(0.147)	(0.152)	(0.154)	(0.345)	
Observations	254,604	254,604	254,604	254,604	254,604
Host Dummies				Yes	Yes

In this discussion, we focus on the tax rate variables and merely note that the other controls have their typical signs and significance levels.[54] Focusing on the tax variables, in column (1) we find that as expected, the higher the host tax rate, the lower the probability of that host being chosen for investment. Column (2), which introduces the personal tax rate alongside the corporate one indicates that both negatively affect the probability of investment. In column (3), we allow for non-linear effects of the tax rates. When doing so, the estimates strongly indicate a non-linear impact so that an increase in either of the host taxes has a bigger deterrence effect when it is initially low, i.e. a rise in the Irish corporate tax would put off FDI more so than a rise in the Slovenian corporate tax which would again have a larger impact than the German one. In columns (4) and (5), we introduce host fixed effects. When using the linear approach in column (4), we again find a deterrence effect from the host corporate tax. The personal rate, however, no longer has a significant effect. This is not the case in column (5) where neither is statistically significant. This, however, is unsurprising since tax rates move little year to year within a country. As such, the use of fixed effects commonly wipes out their significance.

To get a read on the magnitude of these effects, **Table 23** presents the estimated marginal effects using the estimates of **Table 22's** columns (1), (2), and (3). Note that as conditional logit is a non-linear estimator, the true marginal effect depends on non-linear changes in the tax as well as the value of the other controls. In column (1) of **Table 23** we see that the marginal effects are all roughly comparable to the sample average in which a 1% rise in the tax lowers the likelihood of investment by 2.544%. Here, Slovenia is slightly more sensitive, with an estimated elasticity of -2.777. This is due to the influence of other variables, most importantly its relatively small GDP. In column (2), where the personal taxes are included, we see that this increases the sensitivity of the average country's investment to the corporate tax. In addition, we find a negative elasticity for the personal tax, albeit one roughly two-thirds as large as the corporate one. Thus, while foreign investors pay attention to both taxes, they seem to pay more attention to the corporate rate than the personal one. One potential reason for this is while the corporate tax has a direct effect on firm after-tax profits, the effect of personal taxes is indirect and operates via workers demanding higher wages and/or brain drain (that is, skilled workers leaving Slovenia due to its higher personal income tax burden). As with column (1), we find that Slovenian investment is slightly more tax sensitive due to its small size.

When turning to the non-linear results in column (3), we find much more variation across countries. In comparison to the average corporate tax elasticity of -4.665, the corporate tax sensitivity of Slovenia is estimated at -7.932, i.e. almost twice as high. This is again due to the small GDP of the nation. More importantly, however, this is due to its smaller than average corporate tax rate. Since this rate is low, the data suggests that tax-sensitive firms may be particularly interested in small changes in corporate tax policy. In contrast, the sensitivity of investment into Slovenia to the personal tax rate is estimated to be positive, i.e. a drop in the tax rate is estimated to actually scare off investment. This, however, is due to the parametric form of the regression. In truth, the data is simply indicating that, in contrast to the average country where a marginal drop in the personal tax would increase investment, a small drop in Slovenia's very high personal tax would do little to increase its attractiveness. **Instead, to make a meaningful impact, Slovenia would need to shave off a significant portion of the ten-percentage point gap between its personal income tax and the average one.**

As a final point, note that tax policy is not the only one that can be used to attract investment. In particular, FDI barriers are found to be a significant deterrent to investment, with the average elasticity estimated at -0.92. **This is particularly important in the Slovenian context as this measure rose by 7.9% from 2007 to**

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54 Note that both per-capita GDP and education are negative and significant. This suggests that labour costs may dominate skill when determining the location of an FDI project. This is explored more in Table 24.

2015 a change that would lower the probability of investment in Slovenia by 8.17%, all else equal.

Table 23. Marginal Effects

	(1)	(2)		(3)	
	Corporate	Corporate	Personal	Corporate	Personal
Average	*-2.544*	*-3.189*	*-1.926*	*-4.665*	*-1.338*
AT	-2.265	-3.015	-1.821	-4.223	2.02
BE	-2.365	-3.078	-1.859	2.829	2.02
CZ	-2.26	-2.856	-1.725	-8.5	-4.46
DE	-1.845	-2.587	-1.562	2.246	1.028
DK	-2.56	-3.089	-1.866	-2.902	-3.488
EE	-2.97	-3.496	-2.111	0.215	-3.709
ES	-2.743	-3.301	-1.994	8.099	-2.389
FI	-2.796	-3.397	-2.052	-3.104	-1.774
FR	-2.009	-2.747	-1.659	4.507	0.453
GR	-2.704	-3.327	-2.009	-5.708	0.526
HU	-2.685	-3.318	-2.004	-8.046	-2.857
IE	-2.877	-3.455	-2.087	-15.343	0.232
IS	-2.956	-3.494	-2.11	-10.452	-1.941
IT	-2.307	-3.078	-1.859	1.612	0.631
LT	-2.875	-3.438	-2.076	-12.153	-3.141
LU	-2.807	-3.359	-2.029	-1.443	-0.215
LV	-2.761	-3.37	-2.036	-13.206	-3.006
NL	-2.273	-3.019	-1.824	-5.115	2.417
NO	-2.77	-3.383	-2.043	0.509	-2.897
PL	-2.305	-3.054	-1.845	-9.429	-1.138
PT	-2.602	-3.291	-1.988	-1.174	1.049
RO	-2.293	-2.949	-1.781	-12.873	-4.726
RU	-2.76	-3.343	-2.019	-7.975	-5.322
SE	-2.683	-3.237	-1.955	-2.159	-2.94
SI	-2.777	-3.426	-2.069	-7.932	0.644
SK	-2.545	-3.17	-1.915	-10.233	-3.858
TR	-2.299	-3.107	-1.877	-9.115	-1.688
UK	-2.145	-2.907	-1.756	0.445	1.061

5.2.2. Sector Differences

To this point, although we have implicitly controlled for sector-specific effects, we have not examined whether there is a difference in the tax responsiveness of investment across different industries. In **Table 24** we do so by using three subsamples, Manufacturing (column (1), 18.7% of the sample), Services (column (2), 57.3% of the sample), and Financial Services (column (3), 24.2% of the sample). When doing so, we find negative corporate tax effects for all three sectors, although the estimated coefficient is not significant for Manufacturing (where the sample size is the smallest and the industries included are more broad that in column (3) in particular). Personal taxes, meanwhile, significantly reduce the probability of investment across all three industries. In column (4), we return to the full sample but employ interactions for the Services and Financial sectors. Now, we again find significant negative effects of both tax rates for all three industries, with a somewhat smaller impact (albeit still negative) of personal taxes on the Services industry as the sole industrial difference. On the whole, this indicates that Manufacturing is perhaps the least sensitive investment, mirroring the findings of Lawless, et. al (2015). This is particularly important in the context of innovation as R&D as an industry falls into the Services grouping, suggesting that tax policy plays an important role in encouraging inbound investment into this critical activity.

Outside of the tax variables, note that FDI in Manufacturing is the most deterred by higher GDP per capita; the coefficient for Financial FDI is half as large whereas that for Services is only one-tenth as large. As noted above, the impact of a higher GDP per capita has conflicting effects since it simultaneous can mean wealthier consumers and higher-skill workers (both of which may attract FDI) as well as higher labour costs (which should deter investment). A similar comparison is found for education. As such, these results might be driven by a particular need for skilled workers in Services FDI as opposed to Manufacturing. **When combined with (unmodelled) "Brain Drain" effects from Slovenia's high personal tax, this might indicate that efforts to mitigate the emigration of its highly-skilled workers would particularly increase FDI in services.**

5.2.3. Heterogenous Tax Effects

A recent body of literature has found that the impact of taxes varies even within a sector according to the firm's characteristics. For example, Davies, et. al (2018) find that transfer pricing is primarily the domain of large multinationals suggesting that their investment decisions may be less sensitive to taxes as they have a greater ability to avoid them. Similarly, in a conditional logit estimation of non-bank financial FDI, Davies and Killeen (2015) find that smaller firms are more sensitive to taxes. With this in mind, we carried out additional estimations where we interacted the host tax with the owners' size (Table 25). When doing so, we find that larger owners are less deterred by host corporate taxation but there is no difference with respect to personal taxes.

The first of these is consistent with the evidence finding that larger firms have more scope for tax avoidance via internal transactions (i.e. transfer pricing and the use of corporate debt) which would make them less put off by host taxation. To my knowledge this is the first time the impact of personal taxes on FDI has been differentiated by firm size, thus there is no existing evidence to compare this to. What it does suggest, however, is an intriguing picture. Although larger firms may be able to dodge the direct effects caused by corporate taxes by profit shifting, they cannot do so for the indirect effects of personal taxes (i.e. brain drain which lowers the pool of skilled workers). **For Slovenia, where its high personal tax rate may require significant and politically infeasible personal tax reductions to make a difference on this front, it might be more effective to consider targeted efforts to reverse emigration of skilled workers in key industries and/or research roles.**

Table 24. Sector Differences

	(1) Manf.	(2) Services	(3) Financial	(4) All
Corporate Tax	-0.272	-4.472***	-3.620***	-3.508***
	(1.433)	(0.510)	(0.813)	(0.633)
Personal Tax	-3.701***	-2.150***	-2.257***	-2.610***
	(0.527)	(0.190)	(0.332)	(0.262)
Corporate Tax - Services				-0.127
				(0.623)
Corporate Tax - Financial				0.191
				(0.723)
Personal Tax - Services				0.693**
				(0.272)
Personal Tax - Financial				0.327
				(0.321)
Distance	-0.216***	-0.507***	-0.129***	-0.367***
	(0.062)	(0.024)	(0.044)	(0.018)

Contiguity	1.329***	1.469***	1.304***	1.494***
	(0.098)	(0.041)	(0.077)	(0.033)
Common Language	0.410***	0.259***	0.385***	0.340***
	(0.159)	(0.054)	(0.095)	(0.042)
Openness	-1.108***	-1.502***	-0.804***	-1.266***
	(0.271)	(0.098)	(0.159)	(0.075)
Education	-1.453***	-1.239***	-1.168***	-1.241***
	(0.138)	(0.055)	(0.083)	(0.042)
GDP	0.225***	0.049*	0.303***	0.096***
	(0.072)	(0.026)	(0.042)	(0.020)
GDP per-capita	-0.774***	-0.078*	-0.338***	-0.206***
	(0.156)	(0.040)	(0.083)	(0.035)
Market Potential	2.235***	1.617***	1.481***	1.620***
	(0.274)	(0.104)	(0.172)	(0.080)
EU15	1.379***		1.141***	0.887***
	(0.249)		(0.135)	(0.057)
Euro	-0.625***		-0.754***	-0.677***
	(0.132)		(0.079)	(0.037)
FDI Barriers	-2.456***	-1.197***	-2.390***	-1.623***
	(0.478)	(0.207)	(0.294)	(0.153)
Observations	22,288	145,964	61,712	254,604

Table 25. Taxes Interacted with Owner Assets

	(1) baseline-select	(2) baseline-select
Corporate Tax	-2.066***	-31.798***
	(0.508)	(2.775)
Corporate Tax Sqr.		65.566***
		(5.950)
Personal Tax	-2.330***	-6.404***
	(0.209)	(1.163)
Personal Tax Sqr.		7.715***
		(1.755)
Corporate Tax * Owner Assets	0.413***	-1.447**
	(0.087)	(0.579)
Corporate Tax Sqr. * Owner Assets		3.806***
		(1.274)
Personal Tax* Owner Assets	-0.059	0.392
	(0.039)	(0.244)
Personal Tax Sqr. * Owner Assets		-0.586
		(0.363)
Distance	-0.369***	-0.370***
	(0.018)	(0.018)
Contiguity	1.487***	1.505***
	(0.033)	(0.033)
Common Language	0.341***	0.329***

	(0.042)	(0.042)
Openness	-1.270***	-1.198***
	(0.075)	(0.075)
Education	-1.247***	-1.304***
	(0.042)	(0.042)
GDP	0.095***	0.097***
	(0.020)	(0.020)
GDP per-capita	-0.201***	0.001
	(0.035)	(0.036)
Market Potential	1.625***	1.315***
	(0.080)	(0.085)
EU15	0.883***	0.794***
	(0.057)	(0.057)
Euro	-0.683***	-0.835***
	(0.037)	(0.040)
FDI Barriers	-1.642***	-1.670***
	(0.152)	(0.155)
Observations	254,604	254,604

5.2.4. R&D Policies

In **Table 26**, we explore the impact of the tax treatment of R&D. In column (1), we augment the baseline specification with an indicator variable equal to 1 when the host has an R&D Depreciation, R&D Credit, and/or Patent Box policy. As can be seen, while the point estimate suggests that this increases its attractiveness, the impact is insignificant.

In column (2), we decompose the policy according to whether or not it is a depreciation or a credit (leaving aside patent boxes for the moment). There, we find that only the R&D credit increases the attractiveness of the country. In fact, we find that an R&D depreciation approach reduces a country's attractiveness compared to the average. This should not, however, be taken to mean that it is actually better to abandon a depreciation policy in favour of nothing. If this policy was introduced due to other unattractive features of the country's economy, then this can bias the R&D depreciation variable downwards. Thus, this coefficient may reflect a nation struggling to retain R&D FDI even as other countries move towards more aggressive policies such as credits.

Column (3) also controls for the use of a patent box which, similar to the R&D depreciation, does nothing to improve a country's attractiveness. One possibility here is that certain countries may be the most likely to introduce patent boxes, generating an omitted variable bias. With this in mind, column (4) includes the host country dummies. When doing so, two patterns emerge. First, in line with prior expectations, patent boxes are now found to significantly increase the likelihood of investment. This suggests that certain types of countries which are relatively unattractive to FDI are those that tend to introduce patent boxes. Second, although the R&D credit is still positive, it becomes insignificant even as the R&D depreciation remains significantly negative. In the data, Belgium, Ireland, the Netherlands, and Slovakia switched from a depreciation to a credit during the sample. These estimates would therefore be consistent with an improvement in their attractiveness when switching from an R&D depreciation to a credit. **Thus, this indicates that not all R&D incentives are created equal and that nations (including Slovenia) that persist in only offering the accelerated depreciation tax breaks may be losing out on FDI as a result.**

Table 26. R&D Policies

	(1) baseline-select	(2) baseline-select	(3) baseline-select	(4) baseline-select
Corporate Tax	-3.529***	-3.621***	1.011**	-2.163**
	(0.400)	(0.398)	(0.454)	(0.962)
Personal Tax	-2.126***	-2.124***	-2.351***	0.256
	(0.157)	(0.158)	(0.161)	(0.492)
R&D Policy	0.032			
	(0.026)			
R&D Depreciation		-0.090***	-0.061**	-0.124**
		(0.031)	(0.031)	(0.058)
R&D Credit		0.101***	0.381***	0.106
		(0.033)	(0.036)	(0.075)
Patent Box			-0.938***	0.181**
			(0.047)	(0.072)
Distance	-0.368***	-0.372***	-0.340***	-0.255***
	(0.018)	(0.018)	(0.018)	(0.019)
Contiguity	1.496***	1.494***	1.523***	1.690***
	(0.033)	(0.033)	(0.033)	(0.035)
Common Language	0.346***	0.342***	0.433***	0.642***
	(0.042)	(0.042)	(0.042)	(0.046)
Openness	-1.246***	-1.206***	-1.408***	0.361
	(0.077)	(0.077)	(0.086)	(0.335)
Education	-1.238***	-1.227***	-0.943***	-1.122***
	(0.042)	(0.042)	(0.042)	(0.338)
GDP	0.100***	0.104***	-0.004	3.806***
	(0.020)	(0.020)	(0.022)	(1.134)
GDP per-capita	-0.207***	-0.232***	-0.531***	-5.226***
	(0.035)	(0.035)	(0.038)	(0.951)
Market Potential	1.597***	1.581***	2.135***	22.866***
	(0.082)	(0.082)	(0.094)	(2.986)
EU15	0.882***	0.939***	0.993***	-5.588**
	(0.057)	(0.058)	(0.058)	(2.239)
Euro	-0.681***	-0.782***	-0.835***	0.253**
	(0.037)	(0.043)	(0.043)	(0.100)
FDI Barriers	-1.658***	-1.610***	-1.237***	-0.455
	(0.154)	(0.154)	(0.165)	(0.354)
Observations	254,604	254,604	254,604	254,604
Host Dummies				YES

5.3. Conclusion

This analysis does three things. First, it puts Slovenian tax policy vis-a-vis FDI into a broader context. We find that FDI into Slovenia is relatively more sensitive to taxes than other nations. This is because Slovenia is relatively small compared to major FDI destinations such as Germany or the UK and because Slovenia's corporate tax is low. Further, while the high Slovenian personal tax is a detriment to FDI, the estimates point to the need for large cuts (potentially combined with other incentives for skilled workers to remain in the country) before there is likely to be a significant increase on FDI inflows. Second, we find that the impact of taxes may well vary by sector and the size of the owner. These more granular analyses then point towards possible investigations on the role of knowledge space heterogeneity when it comes to tax policy. Finally, specifically with regards to R&D tax treatment, it finds that compared with alternative tax incentives for R&D, accelerated depreciation may be less useful for attracting FDI. Instead, moving towards tax credits from R&D or lowering tax rates via a patent box may be more effective.

6. Slovenia and Global Value Chains

Global trade is increasingly dominated by global value chains (GVCs) which provide a key force that binds economies together as firms in one sector purchase inputs from another sector, including those located in other countries. Furthermore, since the evidence suggests that firms connected to GVCs are more productive and more resilient, understanding how Slovenia compares in its connections to GVCs is critical to developing policy.[55] To do so, we employ the measures constructed by Antras and Chor (2018) who use two indices to describe the position of a country-industry combination in terms of its provision of intermediates for use by downstream customers (both at home and abroad) and the amount of value added in its own production that comes from other sectors (both at home and abroad). These ``coordinates" for a sector's position in GVCs can then be compared to other major players in that industry as well as Slovenia's benchmark countries.

6.1. The GVC Box and Data

The data used in this analysis come from two sources. The first is the 2013 version of the World Input-Output Database (WIOD).[56] This provides sales to and purchases by each country-industry to other country-industry pairs (i.e. how much Slovenian chemicals sell to final consumers and, say, the British steel industry, as well as how much it buys from Slovenian rubber and plastics as well as from US machinery). This covers 40 countries and 35 different sectors. These data are then used to construct exports as well as the GVC variables described below. The second data source is the OECD's data on inbound and outbound foreign direct investment (FDI) stocks. This latter is not as granular as the WIOD data, therefore industries were matched and aggregated by hand, resulting in some missing data for some industries. Table 27 lists the industries used and their share of Slovenia's exports and FDI in the data.

The key to this analysis is how to describe how activity fits into GVCs. To do so, we use the WIOD data to construct two GVC measures using the method of Antras and Chor (2017) (which builds from the seminal papers of Fally (2012) and Antras and Chor (2013)).[57] The first of these captures the degree to which an industry's sales are intermediates. A high value of this measure means that a sector's firms tend to sell a lot of output to other firms for use in their production process. It goes even further, however, by accounting for whether those customers themselves produce inputs for other firms. For example, consider three aluminium sectors, one in each of three countries. The Chinese aluminium industry produces aluminium that is sold directly to final consumers as aluminium foil. The German aluminium industry produces aluminium cans that are sold to a soft drink companies who then fill the cans and sell them to final consumers. The American aluminium industry sells its aluminium to a screw manufacturer who turns it into screws that are then sold to an airline company which uses them to make planes. Obviously, the GVC that the Chinese sector feeds into is the shortest - there is one step between it and the final consumer. This would then get a low value for the Output Index. Since both the German and American industries sell

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55 See, for example, the work of Amiti, et al. (2014).

56 See Timmer, et al. (2014a,b) for details.

57 Because of data limitations in constructing these measures, Antras and Chor only have these up to 2011 and we therefore focus on the 2011 values of exports and foreign direct investment to match.

100% of their output as inputs, they would both get a higher value on the Output Index. However, because the value chain for the German sector is shorter (two steps away from the final consumer) than that for the American one, its value would lie between that of China and the USA. Thus, the *Output Index* describes how much the output of an industry-country pair contributes to GVCs with a higher number indicating that it contributes a greater amount of its output to a longer GVC.

Specifically, this is constructed as follows. For a sector *r* in country *i*, denote Y_i^r its gross output, F_i^r the value of gross output sold to final consumers, and Z_{ij}^{rs} the dollar value of sales sold as an intermediate to sector *s* in country *j*. Thus, $Y_r^i = F_r^i + \sum_s \sum_j Z_{ij}^{rs}$, i.e. output equals the sum of what is sold to final consumers and other producers. In addition, denote $\alpha_{ij}^{rs} \frac{Z_{ij}^{rs}}{Y_j^s}$ which is the cost of inputs sector *s* in country *j* needs from sector *r* in country *i* in order to produce one Euro of its own output. This can be used to rewrite output in industry *r* in country *i* as:

$$Y_i^r = F_i^r + \sum_s \sum_j \alpha_{ij}^{rs} F_j^s + \sum_s \sum_j \sum_t \sum_k \alpha_{ij}^{rs}\, \alpha_{jk}^{st} F_k^t + \cdots$$

The first term is one stage from the final consumer, the second is two stages (i.e. *ri* sells to another industry who then sells to the final consumer), the third is three stages, and so forth. Then multiplying each of these terms by the number of stages away from the consumer and normalizing by gross output, we obtain a measure of how much *ri* contributes to the GVC:

$$Output\ Index_i^r = \frac{F_i^r}{Y_i^r} + 2\frac{\sum_s \sum_j \alpha_{ij}^{rs} F_j^s}{Y_i^r} + 3\frac{\sum_s \sum_j \sum_t \sum_k \alpha_{ij}^{rs}\, \alpha_{jk}^{st} F_k^t}{Y_i^r} + \cdots \geq 1$$

In this, firms that sell more as inputs (have higher α_{ij}^{rs}s) that are used in processes further removed from the final consumers will have a higher value for the Output Index. Globally, the Output Index ranges from 1.0 to 4.5 with an average across countries and industries of 2.1.

In comparison to the Output Index which measures a country-industry's contribution to GVCs, the Input Index measures a country-industry's reliance upon the GVC, that is, the degree to which the GVC contributes to its output. One simple way of doing so would be to measure the cost of purchased intermediates relative to output. However, just as using only the share of output sold as intermediates understates the contribution to the GVC, this would understate the reliance on the GVC since a given country-industry's suppliers may themselves purchase intermediates from links further back in the chain. The Input Index accounts for this by decomposing a country-industry's value-added across the various links in the GVC. As an example, consider the electronics industry in Japan, Ireland, and India. Japanese electronics use no inputs other than their own labour. Because they use nothing from the rest of the GVC, their Input Index would be low. The Irish electronics industry, on the other hand, purchases wiring from its suppliers that it uses to make the components that go into its electronics. It therefore has one link before it in the GVC. Finally, the Indian computer industry purchases its components from a supplier which itself purchases the wires from a third firm, i.e. it has two links before it in the GVC. Comparable to the Output Index, an industry drawing from a longer GVC would have a higher Input Index, i.e. the score for India is greater than that of Ireland which is greater than that of Japan. Further, the Input Index also accounts for variation in the amount of purchased intermediates. Thus, the more that a country's industry relies on the GVC for producing its output, the higher its Input Index.

Specifically, define $b_{ij}^{rs} = \frac{Z_{ij}^{rs}}{Y_i^r}$, which is the share of *ri*'s gross output that is sold as an input to *sj*. With this, gross output can be written as $Y_j^s = VA_j^s + \sum_r \sum_i b_{ij}^{rs} Y_i^r$, i.e. gross output for *sj* equals its value added and the sum of its expenditures on non-processed factors of production and on intermediate inputs. Expanding this, we see that:

$$Y_i^s = VA_i^s + \sum_r \sum_i b_{ij}^{rs} VA_i^r + \sum_r \sum_i \sum_t \sum_k b_{ki}^{tr} b_{ij}^{rs} VA_k^t + \cdots$$

i.e. output is the sum of value added along the different links in the production chain feeding into *si*'s output. The first term is one step before *si*'s output, i.e. what it does itself. The second term is the value added coming from the intermediates *si* uses, making that value added two steps away from output, the third term is three steps away and so on. Multiplying each stage by the number of links in the chain before it reaches *si*'s output and dividing by the value of output, we obtain:

$$Input\ Index_j^s = \frac{VA_j^s}{Y_j^s} + 2\frac{\sum_r \sum_i b_{ij}^{rs} VA_i^r}{Y_j^s} + 3\frac{V\sum_r \sum_i \sum_t \sum_k b_{ki}^{tr} b_{ij}^{rs} VA_k^t}{Y_j^s} + \cdots \geq 1$$

where again, the greater the importance of inputs (higher b_{ij}^{rs}s) and the more links before output, the higher this score. Globally the Input Index goes from a low of 1 to a high of 3.73 with an average of 2.09.

Together, we can use the Input and Output indices to place a country-sector in the GVC box, where its position relative to others is indicative of its relationship to GVCs. Putting the Output Index on the vertical axis and the Input Index on the horizontal one, a position in the top left would be an industry with a high Output Index (i.e. it contributes a lot to GVCs) but a low Input Index (i.e. it is largely self-reliant). In comparison, industry-country pairs in the lower left corner have little to do with GVCs while those further to the top right corner would be the most involved in GVCs. We now turn to the 2011 export and FDI data to place Slovenia in the GVC box, both in terms of itself and in terms of its comparator countries.

6.2. Slovenian Exports

In **Figure 29**, we plot Slovenian exports in the GVC box. The size of each circle represents the relative share of exports by that industry. From this, two things are seen. First, Slovenian exports run from about 1.5 to over 3 in terms of the Output Index. Thus, relative to the global average, Slovenian exports feed more into GVCs as intermediate inputs. Second, the Input Index for exports is tightly packed around 2.5, meaning that as a group Slovenia's export industries are relatively reliant on GVCs compared to the global average. The five largest circles relate to Slovenia's five largest export sectors: transport equipment, chemicals and chemical products, machinery, basic and fabricated metals, and electrical and optical equipment. Next, we analyse each of these separately.

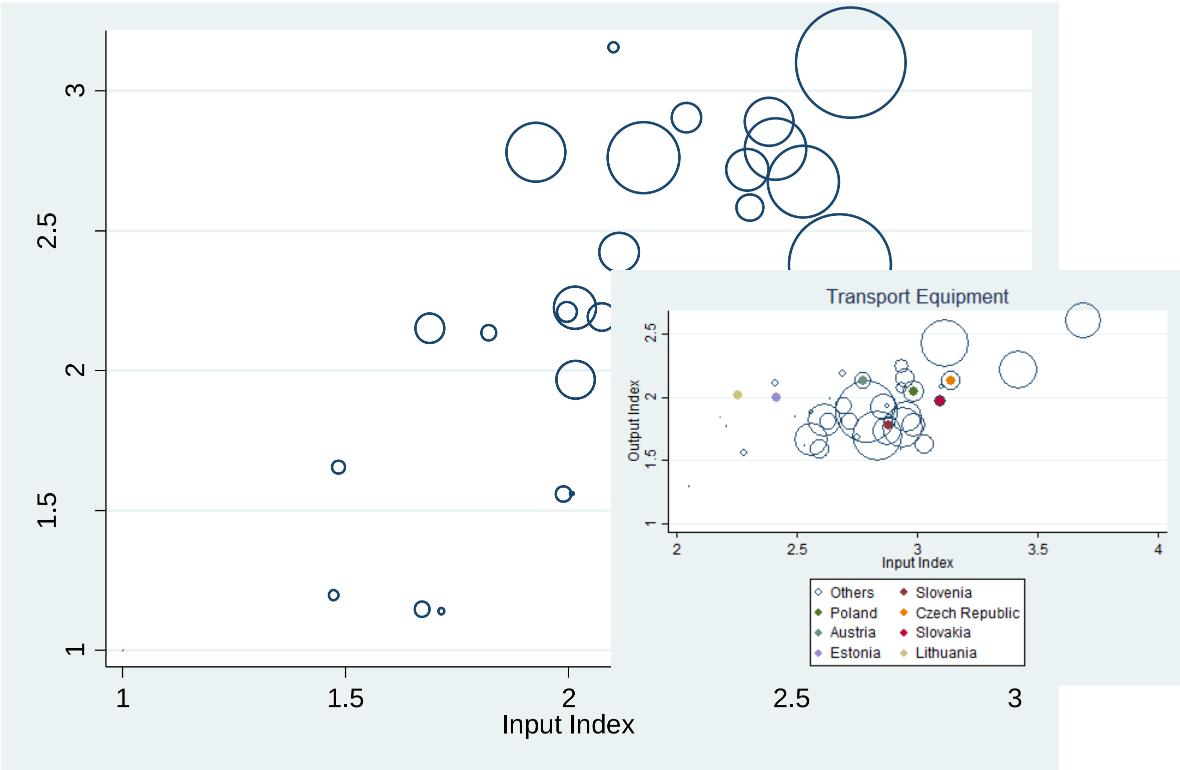

Figure 29. Slovenian Exports

In **Figures 30** through **34**, we focus on the five largest export industries according to **Table 27** and plot Slovenia relative to other countries in the same industry.[58] In particular, we highlight Slovenia relative to its key comparison nations: Poland, the Czech Republic, Austria, Slovakia, Estonia, and Lithuania. For chemicals and chemical products (the largest export industry), **Figure 30** shows that compared to the rest of the world and its comparison countries, Slovenia's chemical industry is fairly oriented towards final consumers and does not draw as much from GVCs for its inputs This is not the case, however, for the next four biggest export industries where, ignoring the size of exports, Slovenia is essentially average. When taking size into account, however, **Figures 32** and **33** show that relative to the largest exporters of machinery or/and metal, Slovenia is slightly higher on the Input Index scale. This is especially notable given that the largest export industry, chemicals, is the one where Slovenia is fairly self-reliant. This might suggest that in order to increase exports, it may be useful to find ways to make these Slovenian industries less reliant on GVCs for inputs.

58 Comparable figures are shown for the next six largest export industries in the Annex. As can be seen, for each of these, Slovenian sectors are essentially average in terms of their Input and Output industries relative to both global norms and those of its comparator countries. The exception to this is the textile industry, where the Input Index is high (although not as high as China's which is 3.5).

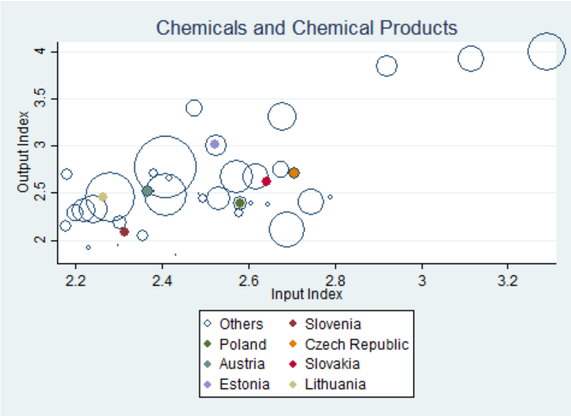

Figure 30. Chemical Exports

Figure 31. Transport Exports

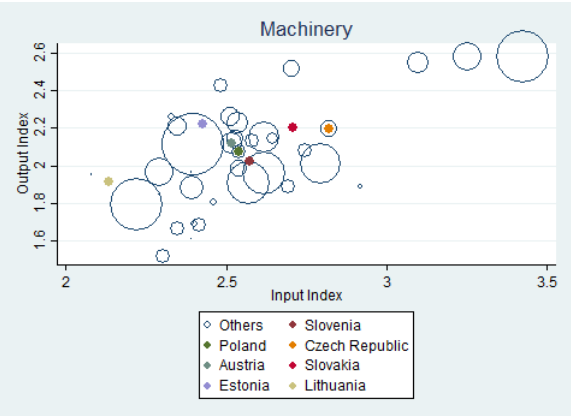

Figure 32. Machinery Exports

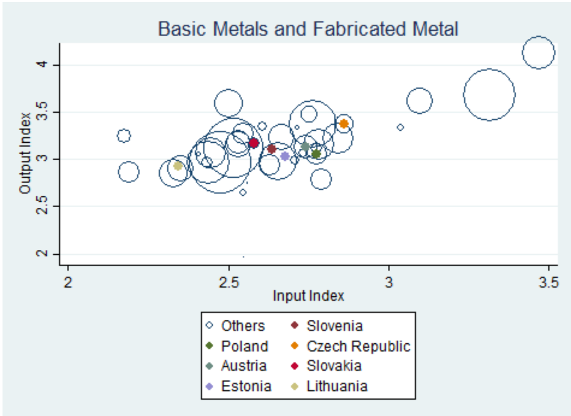

Figure 33. Basic and Fabricated Metal Exports

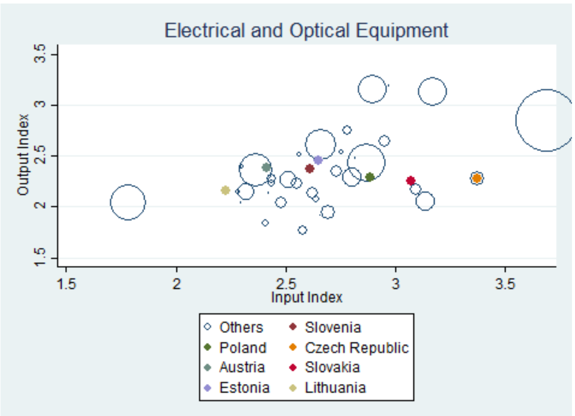

Figure 34. Electrical and Optical Equipment Exports

Table 27. Industrial Shares in Slovenian Exports and FDI

Sector	Export Share	Inbound FDI Share	Outbound FDI Share
Chemicals and Chemical Products	12.8	6.3	5.3
Transport Equipment	12.4	1.5	2.3
Machinery, Nec	11.7	3.4	4.5
Basic Metals and Fabricated Metal	11.2	1.2	2.2
Electrical and Optical Equipment	9.7	0.4	0.3
Rubber and Plastics	4.8	1.6	1.4
Inland Transport	4.7	0.2	0
Pulp, Paper, Paper, Printing and Publishing	3.6	2.6	0.1
Renting of M&Eq. and Other Business Activities	3.3	1.5	2.1
Food, Beverages and Tobacco	3	0.4	4.3
Textiles and Textile Products	2.9	0.4	0.5
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	2.3	0.8	2.9
Wood and Products of Wood and Cork	2.2	.	.
Manufacturing, Nec; Recycling	2.2	20.1	23.9
Other Non-Metallic Mineral	1.6	.	.
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	1.6	6.5	9.6
Electricity, Gas and Water Supply	1.5	2.2	2.4
Agriculture, Hunting, Forestry and Fishing	1.4	0.1	0.4
Construction	1.3	0.4	1
Leather, Leather and Footwear	1.2	.	.
Water Transport	0.8	0.1	3.5
Financial Intermediation	0.8	35.4	12.4
Air Transport	0.7	0	0
Post and Telecommunications	0.7	1	3.5
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	0.4	2.4	3.7
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	0.2	4.3	11.2
Real Estate Activities	0.2	6.6	1.6
Public Admin and Defence; Compulsory Social Security	0.2	.	.
Other Community, Social and Personal Services	0.2	.	.
Mining and Quarrying	0.1	0.3	0
Education	0.1	.	.
Coke, Refined Petroleum and Nuclear Fuel	0	.	.
Hotels and Restaurants	0	0.2	1
Health and Social Work	0	.	.

6.3. Slovenian FDI

Here, we repeat the GVC box exercise but focus on foreign direct investment. In **Figure 35**, we position Slovenia's outbound and inbound FDI across industries in the GVC box. Note that as we lack country pair data here, we use the Slovenian Input and Output indices for both inbound and outbound FDI. The purpose of doing this is to show that, as is the case with most developed countries, the inbound and outbound FDI values track one another, i.e. those industries that host major amounts of foreign investment are also those which provide the most Slovenian-owned investment elsewhere.

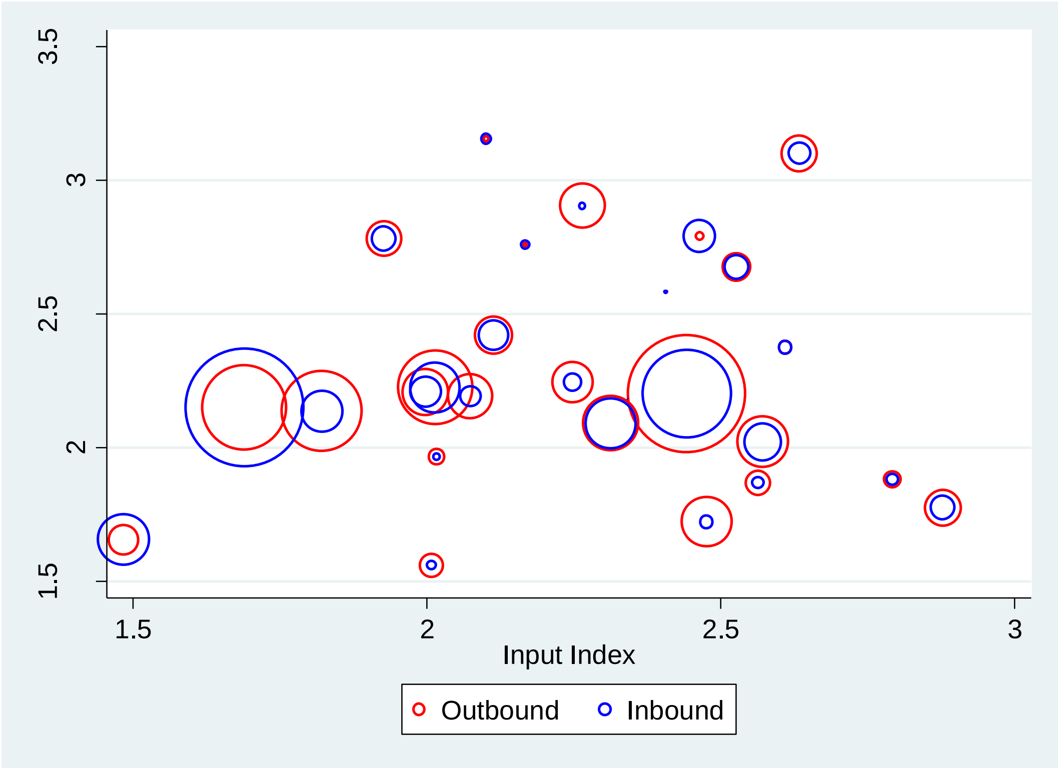

Figure 35. Slovenian FDI

In **Figures 36** to **39**, we repeat the exercise of four of the major export sectors but, rather than comparing export levels across countries, we compare FDI levels. The only primary difference that emerges is that, whereas Slovenia's metal industry is lower in terms of the Input Index when compared to major exporters, this is not the case for major owners of overseas FDI.[59] Instead, as with transport equipment, it is roughly on par with the major sources of investment. In addition, we do so for the two largest FDI industries (again where FDI is measured as stocks as opposed to the sales data used for exports). In **Figure 40**, we find that, comparable to several other industries, Slovenia's financial intermediation sector occupies a similar region of the GVC box as other major sources for FDI in this industry. For the ``catch-all" manufacturing and recycling industry in **Figure 41** it seems that, relative to the major sources of this industries FDI, Slovenian investment is slightly more dependent on GVCs for inputs. However, given the heterogeneity in this across major FDI sources, it seems that this may not be particularly informative.

59 Although it is almost instinctive to assume that a low Input Index (i.e. self-reliance) is a positive attribute, this is not so clear. While it is true that an industry with a low Input Index is less suspectable to external shocks, the evidence also shows that firms that utilize imported inputs are more productive and grow faster. Thus, there is a trade-off between potential stability and growth, the relative value of which has no obvious answer.

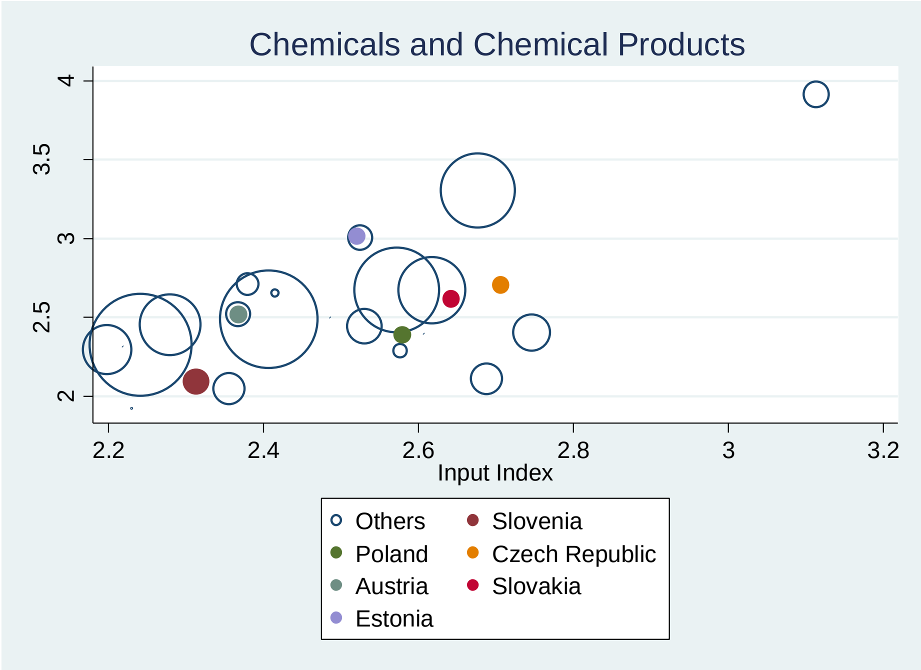

Figure 36. Chemical Outbound FDI

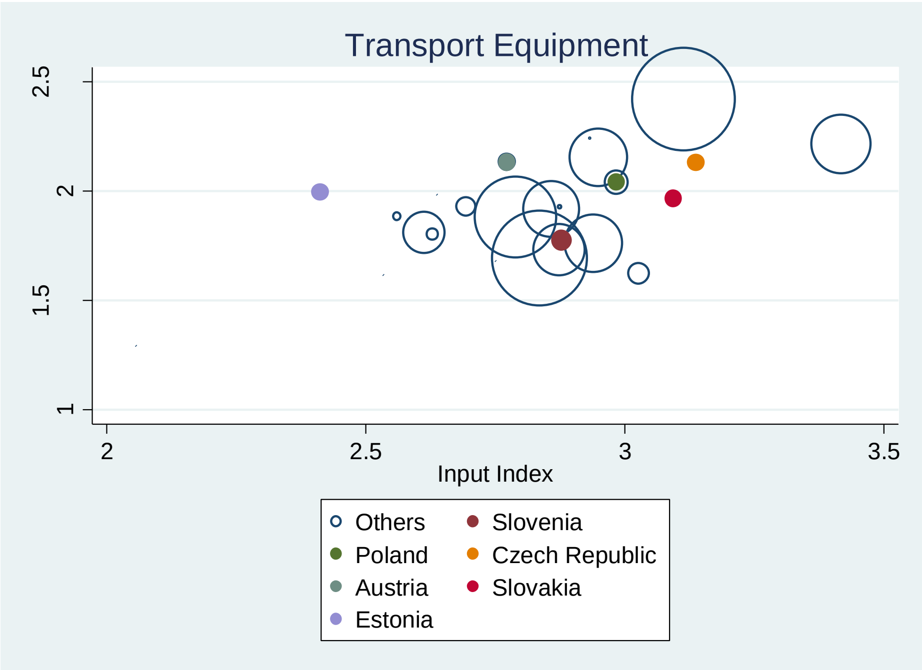

Figure 37. Transport Outbound FDI

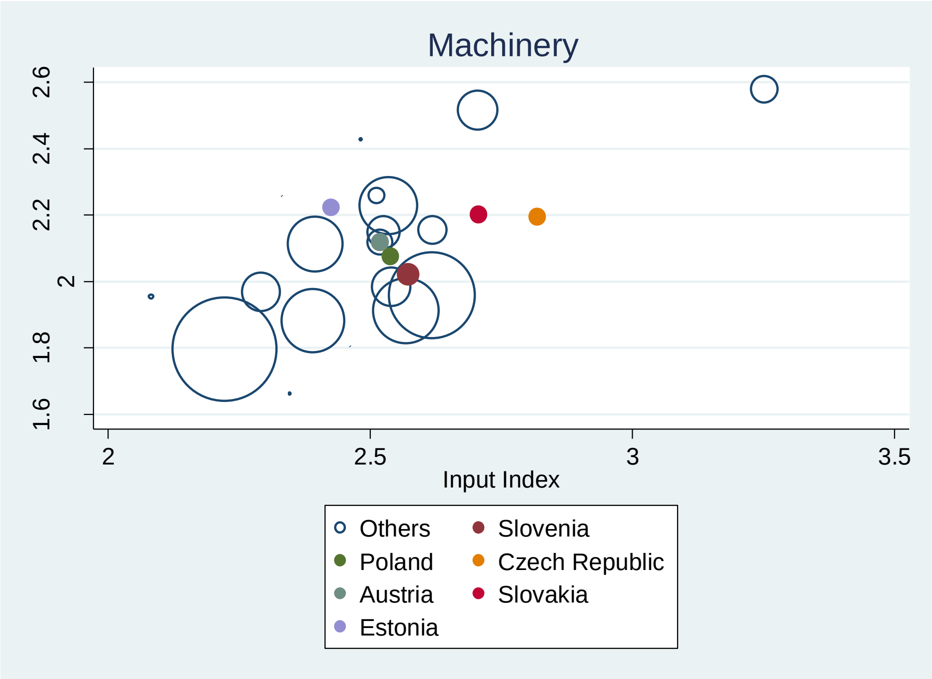

Figure 38. Machinery Outbound FDI

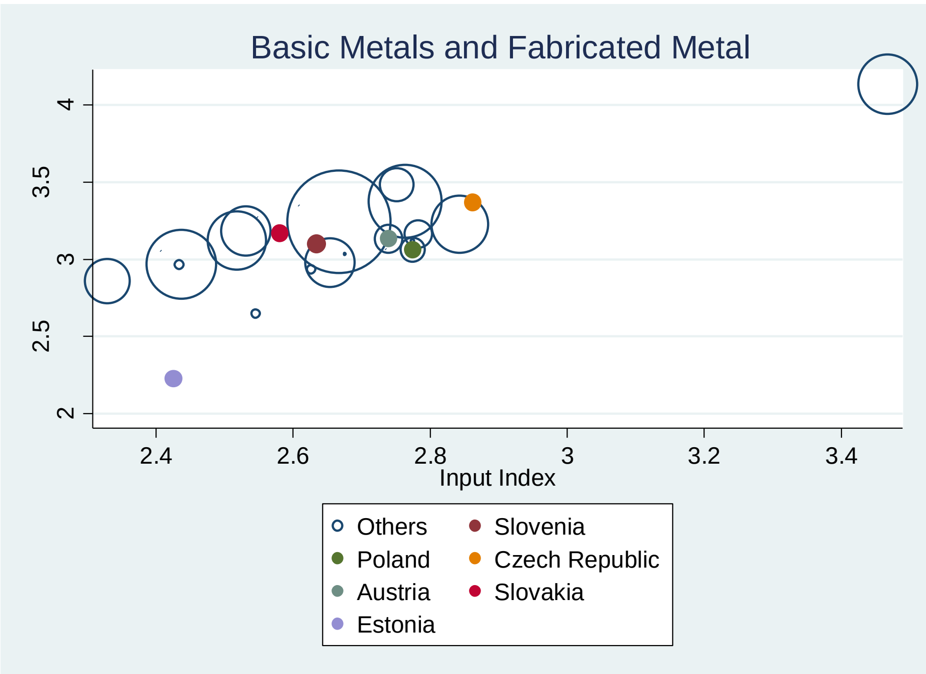

Figure 39. Basic and Fabricated Metal Outbound FDI

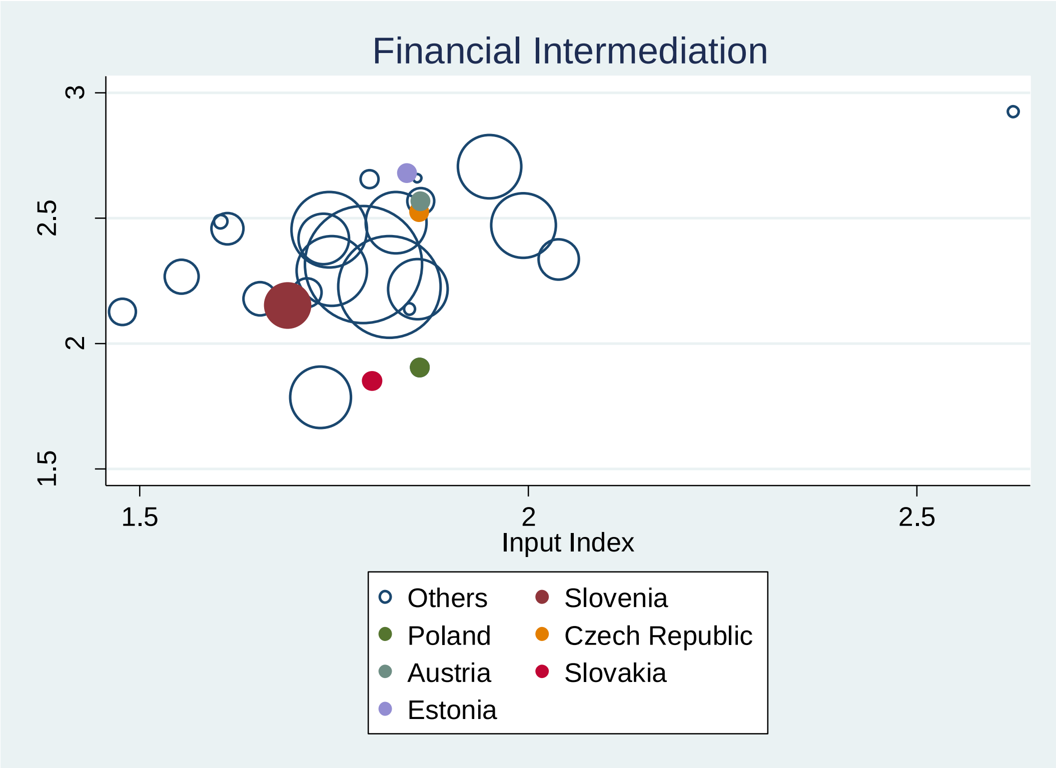

Figure 40. Financial Intermediation Outbound FDI

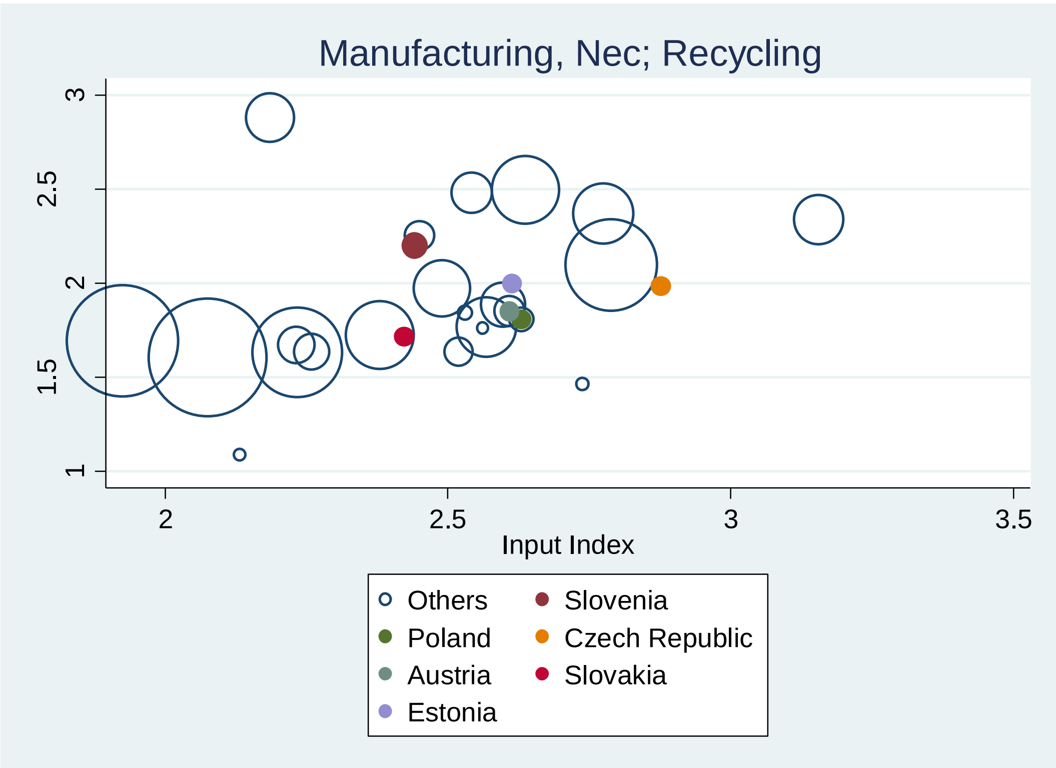

Figure 41. Other Manufacturing and Recycling Outbound FDI

Finally, in **Figures 42** to **47**, we look at Slovenia's inbound investment. Given the parallels between inbound and outbound FDI found in Figure 35, it is no surprise that the results for inbound investment mirror that for the outbound data, i.e. Slovenia is roughly similar to other major hosts of FDI at the industry level with two exceptions: machinery and manufacturing and recycling.

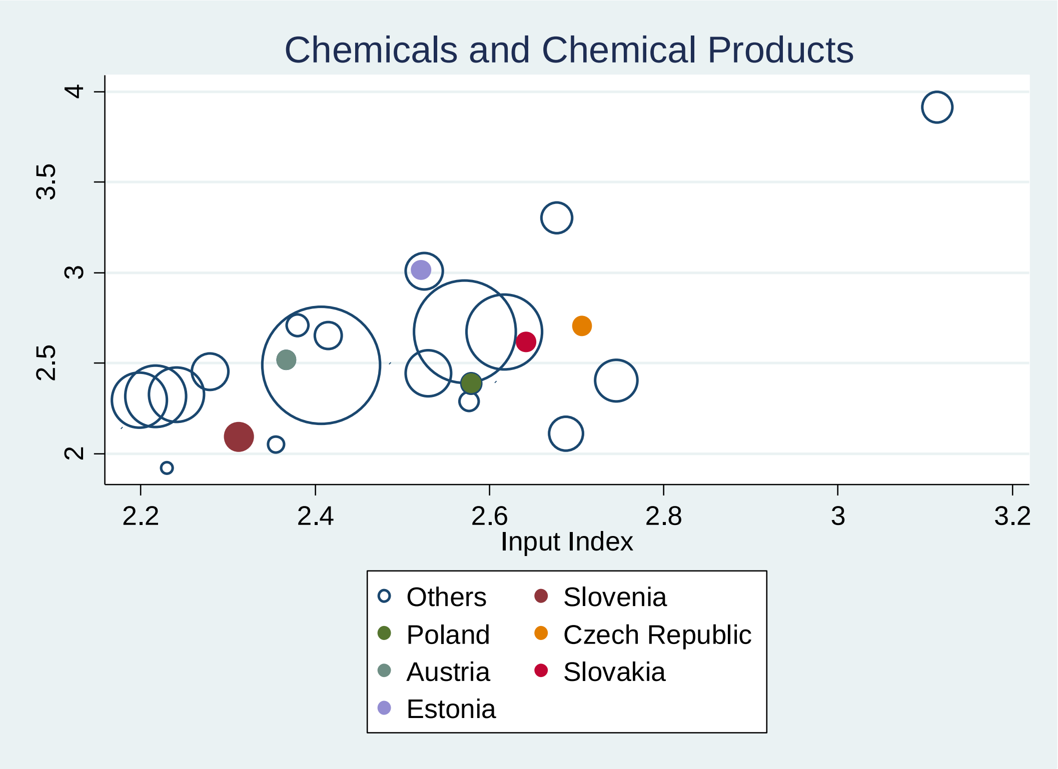

Figure 42. Chemical Inbound FDI

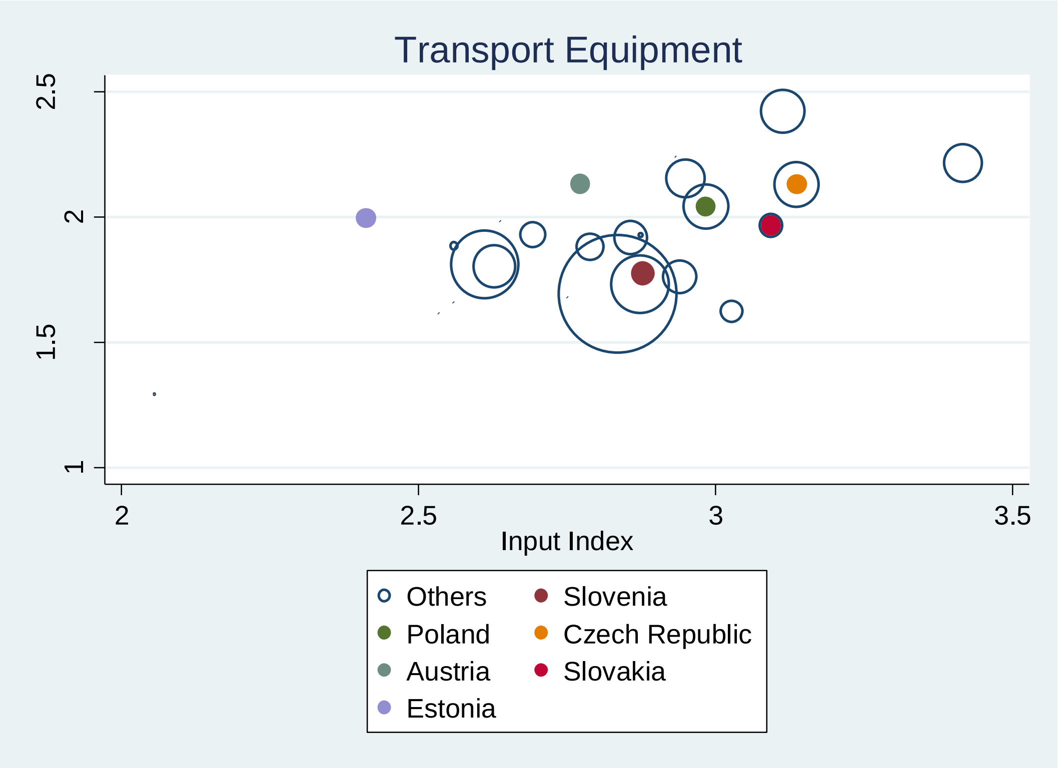

Figure 43. Transport Inbound FDI

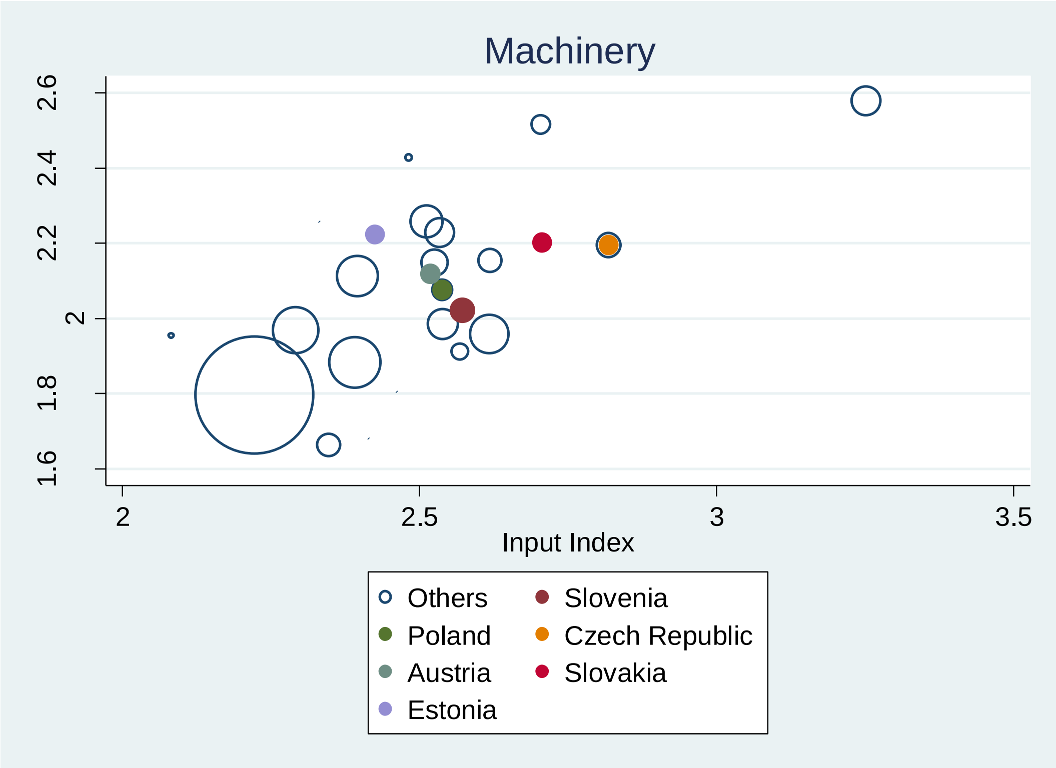

Figure 44. Machinery Inbound FDI

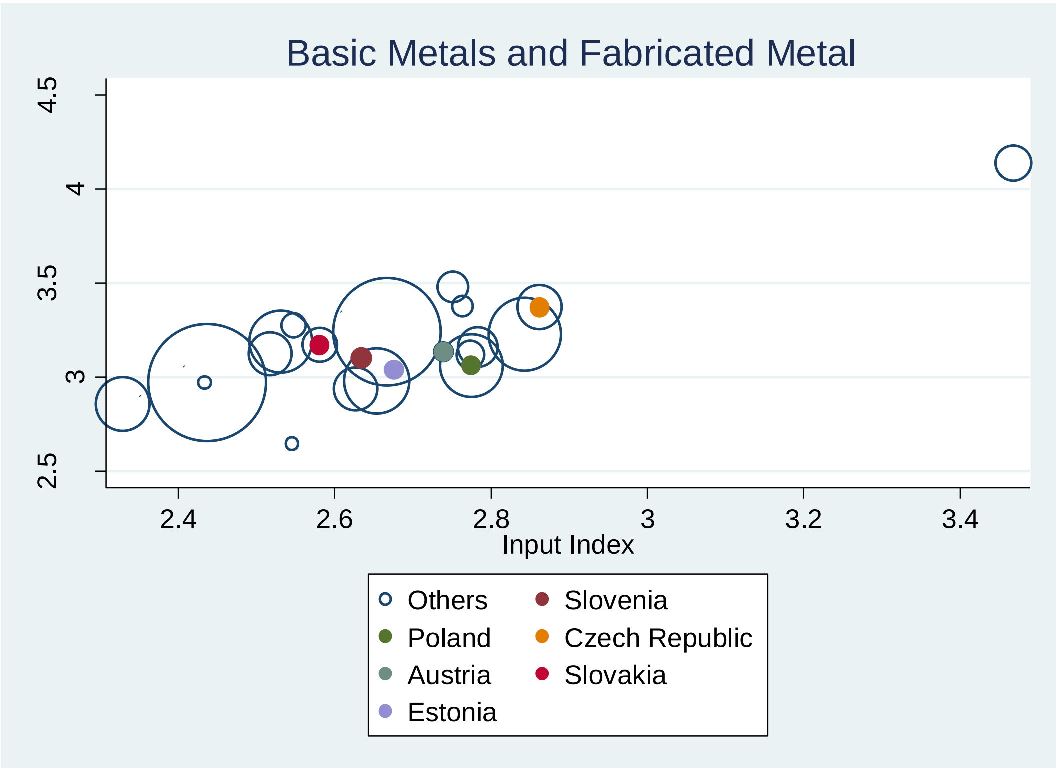

Figure 45. Basic and Fabricated Metal Inbound FDI

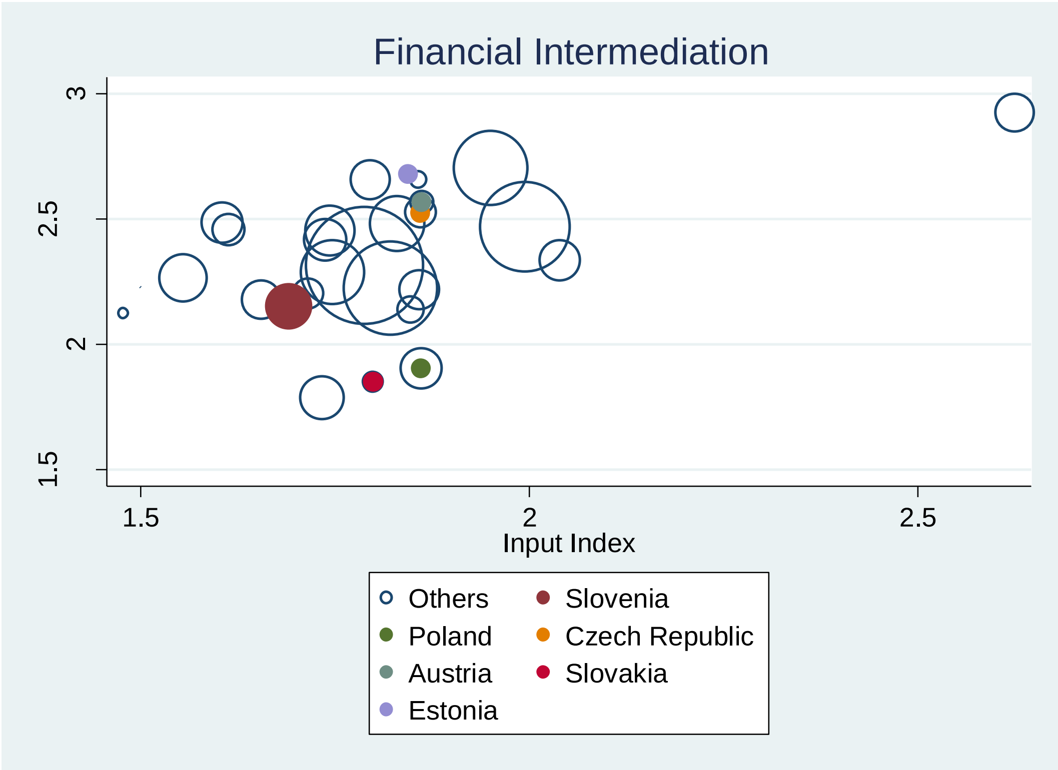

Figure 46. Financial Intermediation Inbound FDI

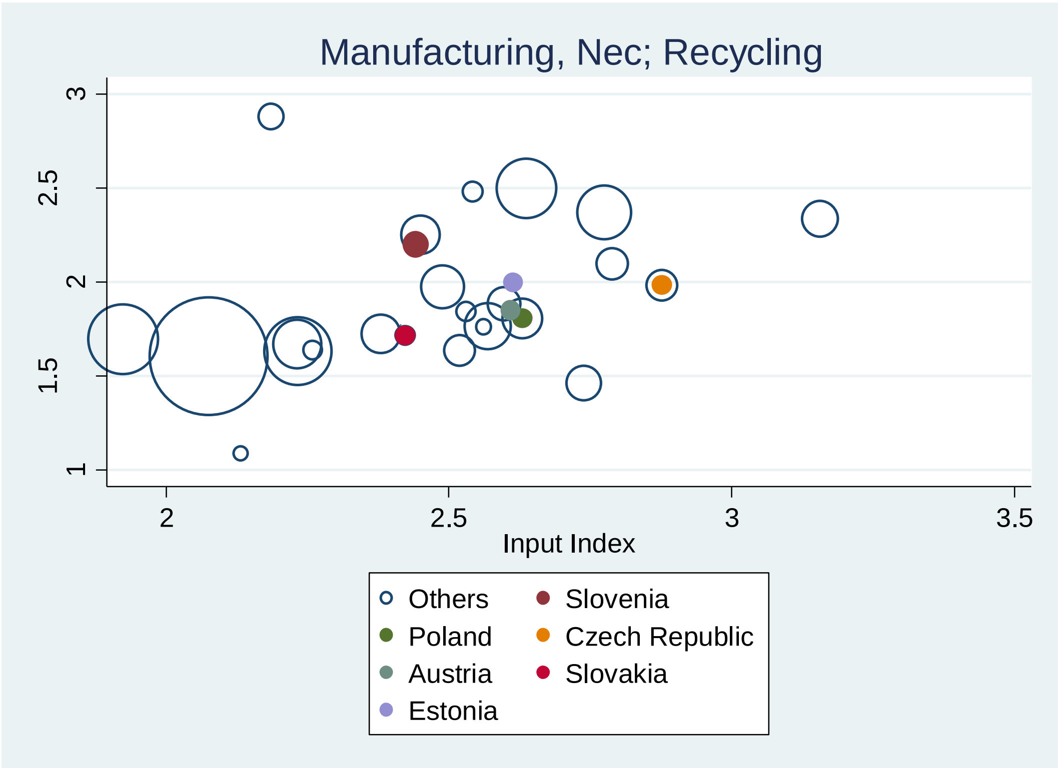

Figure 47. Other Manufacturing and Recycling Inbound FDI

6.4. Conclusion

Compared to the rest of the world, Slovenian industries are slightly more involved in GVCs in terms of providing intermediate inputs and being more reliant on their suppliers for value-added content. Drilling down into exports, outbound FDI, and inward FDI, we find that for the key industries where these measures of globalization are the largest, that within industries Slovenia is roughly comparable to the rest of the world. That said, when comparing Slovenia to major exporters of machinery and metals, Slovenia slightly more reliant on inputs from GVCs. The same is true for machinery and other manufacturing when looking at the FDI data. Thus, in order to expand those economic activities, there may be a rational for encouraging Slovenian firms in these industries to focus on becoming somewhat more self-reliant. That, however, must be taken with a grain of salt because this analysis is at the industry level. Using firm level data, studies such as Halpern, Koren, and Szeidl (2015), Altomonte, et al. (2013), and Nickerson and Konings (2007) tend to find that -- within an industry -- firms that participate in GVCs are generally more productive. Since productivity is typically a driver of exporting and FDI activity, this may suggest that the industry level results might be driven by a handful of major players within that industry.

7. The Technological Content of Slovenian Trade

In this section, rather than look at an industry breakdown of trade as in the separate global value chain (GVC) analysis, we use a technological one. To do so, we employ the correspondence of Lybbert and Zolas (2014) to allocate each Euro of imports and exports to a Cooperative Patent Classification (CPC) code. These codes are used in patent applications to classify the innovations in the patent to various types of technologies. With roughly 250,000 CPC codes at their finest level, this gives an indication of which technologies are most involved in Slovenia's exports and imports.

7.1. Data and Results

In my analysis, we use two key pieces of data. First, we use the Lybbert and Zolas (2014) concordance. As they discuss in their paper, they developed an algorithmic approach to build a concordance between product and technology classifications. Their method provides a probabilistic match between products and all the technology classes used by these products, at the finest level of disaggregation. Using their probabilistic concordances, we can match the number of patents in each class with the probability that a given product uses these patents in its production. Thus, this gives me a measure of how much of a technology class is embodied in a particular product which can then aggregated across products to measure the value of trade in a given CPC code. we do so at the three-digit technology code since, although Lybbert and Zolas (2014) provide a four-digit CPC code correspondence, that resulted in largely empty cell sizes and a noisy measure of trade in technologies. The second key data source is the trade data. we use the 2015 bilateral Slovenian values for exports and imports reported in the UN Comtrade database, which is the gold standard for disaggregated trade data on a global level. Here, we use six-digit product data since the use of disaggregated trade data will further refine our technology-content of trade measure. This matters because even if a Slovenia imports the same aggregate amount from two countries, if the product mix of those imports differs this would imply different technologies embodied in those imports. Finally, once the bilateral trade is broken down by country-CPC code, we aggregate up across trade partners, resulting in a value for Slovenian exports and imports across CPC codes for 2105. This the provides the most detailed measure of the technological content of trade currently available.

Table 28 gives the top 20 most important CPC codes for Slovenian exports. In particular, two technologies -- Vehicles in General (B60) and Medical or Veterinary Science (A61) -- dominate with 24.2% of total exports between them. On the import side, as presented in **Table 29**, Vehicles in General again tops the list with Petroleum, Gas, or Coke Industries in a close second. Although less concentrated than exports, these two again make up nearly 20% of the value of imports.

The fact that Vehicles in General dominates both the import and export lists points to the importance of intra-technology trade which is akin to the known importance of intra-industry trade. In particular, this suggests that, as these patents make up so much trade, this may be suggestive of a high-technology GVC operating in Slovenia's vehicle industry. In a separate analysis of the position of Slovenia's industries in GVCs **Figure 31** in Section 6 that Slovenia's transport sector is in a roughly average GVC position for that industry, **this may indicate an area where further transport innovation may well have a significant impact on GVC activity**. Overall, the results indicate a significant degree of intra-technology trade with fifteen CPC codes appearing on both the top 20 exporting and top 20 importing technologies. In particular, in addition to transportation, **medical sciences may be a fruitful area for innovation and trade since CPC codes covering medical technologies and organic chemistries feature heavily in both imports and exports.**

Table 28. Main Exporting CPC Codes

Export Rank	CPC Code	Description	Share of Exports
1	B60	Vehicles in General	14.52
2	A61	Medical or Veterinary Science	9.66
3	G01	Measuring, Testing	2.64
4	B62	Land Vehicles for Travelling Otherwise than on Rails	2.44
5	A47	Furniture	2.44
6	C10	Petroleum, Gas, or Coke Industries	2.28
7	H01	Basic Electric Elements	2.12
8	H02	Generation or Conversion of Electric Power	2.12
9	F16	Engineering Elements and Units	1.95
10	E04	Building	1.94
11	H05	Other Electric Techniques	1.86
12	F03	Machines or Engines for Liquids	1.86
13	B23	Machine Tools	1.86
14	F25	Refrigeration or Cooling	1.8
15	C22	Metallurgy of Ferrous and Non-Ferrous Alloys	1.78
16	F04	Positive Displacement Machines for Liquids	1.68
17	A23	Food or Foodstuffs	1.55
18	F02	Mechanical Engineering; Lighting and Heating	1.52
19	F24	Heating: Ranges and Ventilation	1.5
20	C08	Organic Macromolecular Compounds	1.5

Table 29. Main Importing CPC Codes

Export Rank	CPC Code	Description	Share of Imports
1	B60	Vehicles in General	9.91
2	C10	Petroleum, Gas, or Coke Industries	9.24
3	A61	Medical or Veterinary Science	4.9
4	A23	Food or Foodstuffs	3.74
5	B62	Land Vehicles for Travelling Otherwise than on Rails	2.96
6	C08	Organic Macromolecular Compounds	2.96
7	H01	Basic Electric Elements	2.42
8	C22	Metallurgy of Ferrous and Non-Ferrous Alloys	2.34
9	C21	Metallurgy of Iron	2.04
10	H04	Electric Communication Techniques	2.02
11	F16	Engineering Elements and Units	1.91
12	C07	Organic Chemistry	1.8
13	B29	Working of Plastics	1.76
14	B23	Machine Tools	1.74
15	B21	Mechanical Metal Working	1.66
16	A47	Furniture	1.63
17	F02	Mechanical Engineering; Lighting and Heating	1.56
18	G01	Measuring, Testing	1.48
19	F03	Machines or Engines for Liquids	1.34
20	E04	Building	1.19

7.2. Conclusion

In this analysis, the goal has been to describe using state of the art methods the technological content of Slovenia's trade. In particular, two patterns emerge. First, transportation technologies are important, something perhaps not surprising given the role of transportation goods in Slovenian trade. Second, there is a great deal of intra-technology trade, i.e. those technological innovations that feed into Slovenian imports also feed into its exports. This suggests an interaction between GVCs and technology that is embodied in trade.

When combined with the studies of Slovenian FDI and Slovenia's position in GVCs, this what reveals that Slovenian industry is comparable to the main players on the global stage in terms of its GVC positioning. In addition, it highlights a linkage between trade, technological innovation, and GVC positioning. Combined with the potential value in using R&D tax incentives to attract FDI found in the initial analysis, this points to the possibility of developing a nexus of tax policy, innovation incentives, and trade promotion that can establish a high value industrial node. In particular, it suggests that the transport and/or medical industries may be particularly good candidates for such a focus.

8. Upgrading through Global Value Chains (GVCs) and Global Investment Flows (GIFs)

This section of Report looks at the role of global value chains (GVCs) and global investment flows (GIFs) in the upgrading of Slovenia's economy within the framework of Slovenia Smart Specialisation Strategy (S4). Both GVCs and GIFs have a role in enhancing Slovenia's trajectory onto a high productivity innovation-led diversified economy – a key element of S4. This is via upgrading through the internationalisation of Slovenia's economy.

Slovenia is regarded as one of the better functioning research and innovation smart specialisation strategy (RIS3) examples. It has been able to set up consistent priorities with an effective policy mix and well-functioning governance structure. The following integrated framework will help underpin further development with reference to the international dimension of S4. The proposed integrated approach to S4 is underpinned empirically and conceptually. GVCs and upgrading provide the conceptual framework with GIFs and internationalisation being the data driven foundation. Together they allow for an empirically led analysis of the public policy space in Slovenia. With this proposed framework, Slovenia could potentially serve as a pilot example of how new cutting-edge research on firm-level internationalisation processes and GVCs can inputs into RIS3 strategies. Policymakers in countries across all income levels have started to take into consideration GVCs in their development strategies at country, regional and local level.[60] However the addition of this empirical underpinning, applied in practice will bring internationalisation and upgrading to the next level.

Internationalisation can encompass many different areas of the public policy space. In order to provide useful evidenced analysis, a more focused view on the role of GVCs and GIFs is taken – particularly that of greenfield investment and Mergers and Acquisitions (M&A). This focused view enables showcasing how one of the biggest challenges on RIS3 could be addressed. The challenge of how to provide a basis for targeted internationalisation, not on the sectoral or product level but on the company and task level. This has not been done before. It would also allow for comparison and preparation of a dedicated policy mix with future micro level data hopefully completing the understanding of future trends. Results of this study would thus serve as a possible benchmark for the preparation of RIS3 strategies in the post 2020 period.

Upgrading is a key theoretical underpinning of the GVC role in value added activities. It represents the increase in skill content of activities and/or the movement into new market niches.[61] Utilised effectively, countries, firms and workers can become more productive and innovative. This can occur in both low tech activities and high tech activities. Upgrading takes innovation and productivity outside the patent driven framework covering all parts of the economy.

Two key approaches can be taken regarding GVCs and a country's respective upgrading through GIFs and internationalisation. Both have particular benefits. The first represents a more passive horizontal strategy, setting an effective receiving ground for investment. It seeks to provide a high-quality socio-economic and institutional eco-system for ensuring interest when MNEs want to invest. This is analysed in previous chapters of the Report looking – for example - at the fiscal part of FDI and R&D incentives. The second represents a more active vertical strategy, seeking and engaging at the global level with MNEs and their investment flows. At the national level a measured approach linking such investment with the correct relevant actors is critical. This latter strategy underpins this section of the Report.

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60 Taglioni, D., and Winkler, D. (2016). Making Global Value Chains Work for Development. Trade and Development. Washington, DC: World Bank. © World Bank.

61 Humphrey, J. and Schmitz, H. (2002). How goes insertion into global value chains affect upgrading in industrial clusters. *Regional Studies, 36(*9), 1017-1027

The approach to the analysis of internationalisation in this Report is empirically embedded.[62,63,64] Interpreted with a GVC lens, policy conclusions and strategic links will help inform S4. Upgrading can be felt by all sectors of the real economy, driving patenting and non-patenting activity. Government has a role in tying in local capabilities to identify, shape, create and capture value opportunities.[65] In order to realise these value opportunities, S4 should not solely focus on high tech sectors and manufacturing. Instead targeted internationalisation, relevant to the local context is required to produce visible effects. If all countries and regions chase similar goals, the gains from scale and specialisation are reduced along with depleted territorial and social cohesion.

A more dedicated focus on tasks rather than sectors for internationalisation is also important. Rather than sectors it seems to be the way goods are produced and the quality of services delivered that is defining matters.[66] Therefore, in understanding and benefitting from the internationalised economy, a task driven lens, regarding low or high value activities within sectors – the intermediate good – is where policy needs action.[67] Location choices of a firm's GIFs, whether HQ location, research and development, design, marketing or branding are all task specific.[67]

This integrated framework will take a positive step in realising the benefits from GVCs and GIFs. Countries and regions can connect with GVCs through the process of building, embedding and reshaping through GIFs. The latter, reshaping, is particularly important as this focuses on territorial upgrading and investment promotion activities. Territorial upgrading is critical for a country or region to utilise to their competitive advantage. Capitalising on technological advancement and enhancing productivity through the value chain is not only reliant on patenting. The process, product, functional or inter-sectoral upgrading[68] represent unique opportunities for national and sub-national economies to increase their skill level, innovative capabilities and productivity in an inclusive manner. Slovenia's recent 2018 established Investment Promotion Act also makes this a timely discussion about GVCs. The nature of GIFs mean that firms enter locations in individual ways, have different effects upon that location and can be influenced in their own distinctive ways. Investment promotion activities can account for this difference. It is important when doing so to look at both inward and outward GIFs in order to assist a country's development. Similarly, they should not just operate through subsidies and incentives but instead through enhancing foreign understanding of local fundamentals.[69,70]

GVCs are able to bring benefits in the form of better access to global markets, productivity increases improved competitiveness and the expansion of jobs. However, these gains are not an automatic conclusion. With the completion of this framework, Slovenian decision makers will be better placed to use the internationalised economy

62 Crescenzi, R., & Rodríguez-Pose, A. (2011). Innovation and regional growth in the European Union. Springer Science & Business Media.

63 Crescenzi, R., & Iammarino, S. (2017). Global Investments and Regional Development: the Missing Links. Regional Studies, 51(1), 97-115.

64 Crescenzi, R., de Blasio, G., & Giua, M. (2020) Cohesion Policy incentives for collaborative industrial research: evaluation of a Smart Specialisation forerunner programme, Regional Studies, 54:10, 1341-1353, .

65 Foray, D. (2015). Smart Specialisation: Opportunities and Challenges for Regional Innovation Policy, London, Routledge

66 Lederman, D., and Maloney, W. (2012). Does what you export matter? In search of empirical guidance for industrial policies. The World Bank, 2012.

67 Taglioni, D., and Winkler, D. (2016). Making Global Value Chains Work for Development. Trade and Development. Washington, DC: World Bank. © World Bank.

68 Gereffi, G., Humphrey, J., and Sturgeon., T. (2005). The governance of global value chains. *Review of International Political Economy*, *12*(1), 78-104.

69 Loewendahl, H. (2001). A framework for FDI promotion. *Transnational Corporations*, *10*(1), 1-42.

70 Lim, H. (2008). SMEs in Asia and globalization. <Accessed 10th August> Available at: http://www.eria.org/publications/research_project_reports/ smes-in-asia-and-globalization.html

and rise of GVCs to capitalise on the case in which today it is *"not only a matter of whether to participate in the global economy, but how to do so gainfully."* [71]

8.1. Slovenia in the international economy: opportunities and challenges for upgrading

An integrated framework for the analysis of internationalisation and upgrading is particularly important for Slovenia. Highly dependent on international trade, the ratio of trade (imports and exports) to GDP is one of the highest in its geographical region. External trade (imports and exports combined) corresponds to nearly 150% of GDP.[72] Consistent with this, the economy also highly participates in GVCs, with 59% of gross exports in a GVC, compared to 48% in similar developed economies.[72] This figure is particularly driven by backward participation in GVCs. Backward participation is the amount of foreign content (or intermediate goods) in Slovenia's own exports. The country has 50% more foreign value added than developed economies average. This indicates a high reliance on value chains and other countries for Slovenia's growth.

This dependency has not been a sudden change, with participation in GVCs rising on average 8% a year since 1995. This rise is in line with similar developed economies. However it is lower than developing economies who expand their global reach at 13% a year.[72] Latest 2014 figures show this increasing participation has seen foreign value added content of exports remain high relative to OECD peers at 34% of the total.[73] Slovenia has also seen an increase of domestic value added exported to other countries as an input, rising at 0.5% per year between 1995 and 2011. These figures highlight both the backward and forward ties Slovenia's economy has with the global chain of value added. The high growth of these exports has led to the internationalisation of the Slovenian economy. Its integration in GVCs significantly increasing.[74]

In conjunction with backward and forward linkages, it is important to understand the role both inward and outward GIFs have in embedding GVCs in Slovenia. 2015 figures show the stock of inward global investment over double the size of outward global investment. Both stocks were stable relative to GDP during the crisis. Inward stocks of global investment have since increased as outward stocks fell away since 2012.[75] There is a difference in makeup for inward and outward global investment flows. 70% of the former is concentrated in services with a further 26% manufacturing. This compares to 55% in services for outward global investment and 25% in manufacturing.

Inward GIFs are necessary for upgrading in the role they play for inward technological diffusion. Likewise, outward GIFs flows are necessary as technological knowledge can be received from abroad. Both therefore have roles to play in internationalisation for S4.

Evidence shows that companies in Slovenia which have been involved with GIFs, having some degree of international ownership structure performed better – foreign ownership had a positive influence on performance.[76] At an aggregate scale Slovenian firms with direct investment and foreign ownership in 2016 accounted for less than 5% total firms. Yet, they employed almost a quarter of all employees and generated almost a third of sales revenue. A considerable benefit to the Slovenian economy. Unsurprisingly their role in internationalisation was substantial with four of every ten exports or imports

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71 Gereffi, G., and Fernandez-Stark, K. (2016). Global Value Chain Analysis: A Primer, 2nd Edition. <Accessed 10th July 2018> Available at http://hdl.handle.net/10161/12488.

72 Invest Slovenia. <Accessed 10th January 2019> Available at https://www.investslovenia.org

73 OECD (2019), "Domestic value added in gross exports" (indicator),https://doi.org/10.1787/3959a0c6-en (accessed on 16 March 2019).

74 Institute of Macroeconomic Analysis and Development. (2018) Development Report

75 OECD (2017). International trade, foreign direct investment and global value chains. *Slovenia Trade and Investment Statistical Note*

76 Lahovnik, (2011). Corporate Strategies In The Post-Transition Economy: The Case Of Slovenian Companies. *The Journal of Applied Business Research*

coming from this 5% of firms.[77] Post recession, (2013 – 2017) Slovenian firms engaged with GIFs have provided wages 11% higher than non GIF counterparts, higher net profit and higher value added.[78] GIF is therefore a key economic actor for placement in GVCs as well as (potentially) for upgrading. It must however be utilised with ambitious caution, 2017 saw the number of firms with direct ownership decrease from less than 5% to less than 2%. Figures point to a large decrease in foreign ownership of firms in service sector with current consequences of this capital exodus unclear.

In all global economies the potential for technological change to disrupt value chains is prevalent. This makes it even more critical to use data to path a way forward for Slovenia. It also emphasises the task driven perspective such a path must take. Different approaches provide estimations of between 9%[79] to 47%[80] of jobs being at risk from computerisation. Ensuring such internationalisation in Slovenia avoids the tasks at risk, benefits from their automation and the value chain is organised accounting for these changes is of importance. There is geographical significance in automation as well. Since the 1990s, much of the investment in CEECs was efficiency seeking – wanting to minimise production costs through greenfield investment building production plants.[81] With the potential rise of automated production, the previous competitive advantage on labour intensive manufacturing industries[82] will likely erode away.

Similarly, recent global forecasts show expansion is losing momentum with particular large downward revisions of growth projections in the Euro area. Trade tensions and uncertain policy have eroded business and consumer growth with investment and living standards suffering.[83]There is a real risk to Slovenia. If policymakers do not upgrade into higher value activities and internationalisation is not empirically led then similar consequences from the global financial crash may be repeated.

This exposure of Slovenia to the internationalised economy therefore represents opportunities and threats. Policymakers should seek success in building, embedding and reshaping GVCs within their respective regions and Slovenia as a whole. Empirics are critical to underpin such decisions, in order to ensure GVC benefits received in times of growth will be strengthened and the negatives expected in times of decline. A national level, Slovenia should build a level of socio-economic resilience to the global economy. At an individual level, through upgrading workers across the economy can enhance skills leading to higher wages and the benefit of such global exposure being felt more widely.

8.2. What upgrading is all about and what it means for Slovenia

Between 1995 – 2011, many CEECs were unable to upgrade through the value chain and generate higher value tasks.

Upgrading looks at how countries, regions, firms and workers can move onto higher value activities in GVCs. With this change, participants increase the benefits from engaging in global production and services.[68] Upgrading makes an important divergence from the pursuit of patent driven innovation. There are a number of upgrading successes

77 Republic of Slovenia: Ministry of Economic Development and Technology Available at < http://www.mgrt.gov.si/en/areas_of_work/internationalisation/foreign_direct_investments/>

78 Banka Slovenije (2013 – 2017) Direct Investment. Available at < https://www.bsi.si/en/publications/statistical-reports/direct-investment>

79 Arntz, M., Gregory, T., and Zierahn, U. (2016). The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. *OECD Social, Employment and Migration Working Paper*, No. 189.

80 Frey, C. and Osborne, M. (2017). The Future of Employment: How Susceptible Are Jobs to Computerisation? *Technological Forecasting & Social Change*, *114*, 254-280.

81 Miškinis, A. and Reinbold, B. (2010) Investments of German MNEs into production networks in central European and Baltic states. *Technological and Economic Development of Economy*, *16*(4), pp.717-735.

82 Soós, K.A. (2015) Geographical and sectorial concentration in Czech, Hungarian and Slovak exports.

83 OECD (2019) Global growth weakening as some risks materialise. *Interim Economic Outlook*

that alter the usual approach that often narrowly focuses on productivity and (technological) product innovation. The GVC framework lends itself to this approach, focusing on four initial types of upgrading[84] with a further three additions later.[85]

1. Process upgrading – the transformation of inputs to outputs more efficiently
2. Product upgrading – the movement into more sophisticated product lines
3. Functional upgrading – the increase of activities' skill content
4. Chain or inter-sectoral upgrading – the movement of firms into new but likely related industries

The additions are:

5. Entry into the supply chain – the first time participation in a domestic or global value chain
6. Backward linkages upgrading – when local firms (domestic or foreign SMEs) in one industry start to supply goods and/or services to a MNE in a foreign country which is already inserted in a GVC
7. End market upgrading – the movement to more sophisticated markets requiring new more demanding standards.

A focus on these types of upgrading is useful for lower tech firms and regions. It reiterates the necessity of an empirical internationalisation approach and mapping of GVCs. Upgrading patterns can differ depending on the structure of the value chain and local context.[86] Between 1995 – 2011, many CEECs were unable to upgrade through the value chain and generate higher value tasks.[87] Although some sectors were exceptions, such as the automotive industry.[88] This wider failure in CEEC emphasises the necessity to embed properly GVCs in a region. This embedding is important for upgrading at both firm and worker level. The former firm upgrading does not necessarily lead to the latter worker upgrading[89] and it can mean an economy is exposed if MNEs leave. Embedding GVCs ensures their longevity of impact.

Similarly, with economic expansion or contraction, the nature of the goods an internationalised economy is focused upon leads to different effects. The CEECs for example, due to producing intermediate inputs for more durable final goods saw a more marked decline in flows of goods during the financial crisis.[90] Households would have held off purchasing new motor vehicles for example. This is a risk that can be mitigated through public policy and smart specialisation strategies.

It is also necessary for decision makers to recognise where their country, region and firms are on the chain. With this knowledge they can make informed decisions on how to upgrade and informed decisions on how to avoid declines in the flows of goods.

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84 Humphrey, J., and Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies*, *36*(9), 1017–1028.

85 Fernandez-Stark, K., Bamber, P., and Gereffi, G. (2014). Global value chains in Latin America: A development perspective for upgrading. *Global value chains and world trade: Prospects and challenges for Latin America. Santiago: ECLAC, 2014. LC/G. 2617-P.* 79-106.

86 Gereffi, G., and Fernandez-Stark, K. (2016). Global Value Chain Analysis: A Primer, 2nd Edition. <Accessed 10th July 2018> Available at http://hdl.handle.net/10161/12488.

87 Olczyk, M. and Kordalska, A. (2017) Gross Exports Versus Value-Added Exports: Determinants and Policy Implications for Manufacturing Sectors in Selected CEE Countries. *Eastern European Economics*, *55*(1), pp.91-109.

88 Pavlínek, P., Domański, B. and Guzik, R. (2009) Industrial upgrading through foreign direct investment in Central European automotive manufacturing. *European Urban and Regional Studies*, *16*(1), pp.43-63.

89 Barrientos, S., Gereffi, G., & Rossi, A. (2011). Economic and social upgrading in global production networks: A new paradigm for a changing world. International Labour Review, 150(3-4), 319-340.

90 Stehrer, R. and Stöllinger, R., (2013) *Positioning Austria in the global economy: Value added trade, international production sharing and global linkages* (No. 2013/14-02). FIW Research Reports.

8.2.1. The Role of the Multinational Enterprise (MNE) – The Lead Firm

MNEs count for half of global exports with their allocation of global investment flows being central to their importance.

MNEs have a critical role in the global economy. Together they account for half of global exports and are believed to be a key driver behind the past decades' growing fragmentation of production. **Error! Bookmark not defined.**The MNE (or lead firm) is therefore a main governance actor of GVC.

GIFs is one element of the GVC that can be influenced by national and regional decision makers. This is because certain equity investments (greenfield, mergers & acquisitions) are made by the key actor – the firm. Moving up and into GVCs requires alignment with the MNEs of choice and establishing of close links with these lead firms' vale chains who control the activities.[91]

Targeted internationalisation at a firm level, as opposed to a sectoral or product level aligns with the theoretical underpinnings of GVCs. Task driven change is more important in innovation policies than sectoral driven change.[92]

In utilising internationalisation to underpin S4, task driven focus is more important that sectoral focus.

The importance of MNEs is through their GIFs. Both in how these flows 'touch down' to geographic space and link up 'places' through GVC connectivity. This spatial link is important when considering the placed based approach of industrial and regional policy. Particularly to capitalise on increased focus of utilising policy to develop knowledge and innovation opportunities – building upon existing national and regional advantages and capabilities.[93]

8.2.2. The Role of Global Investment Flows (GIFs)

Smaller economies, such as Slovenia's, in general source more inputs from abroad.[94] However, this sourcing does not necessarily correspond to GVC integration. The critical factor seems to be equity-based GIFs.[95] A level of firm governance in investment. This makes the firm a key actor in the internationalising Slovenian economy. MNEs can build, embed and reshape GVCs through the GIFs they establish.[96] The investment flows that can be influenced by policymakers are owner linked 'directed' investment flows where the MNE has some governance and decision making oversight. This institutional form of

91 Gereffi, G. (1999) International trade and industrial upgrading in the apparel commodity chain. *Journal of international economics*, *48*(1), pp.37-70.

92 Taglioni, D., and Winkler, D. (2016). Making Global Value Chains Work for Development. Trade and Development. Washington, DC: World Bank. © World Bank.

93 Barca, F., McCann, P. and Rodríguez, P. (2012).The case for regional development intervention: place-based versus place-neutral approaches, *Journal of Regional Science*, 52(1), 134–152.

94 Vlčková, J. (2015) Measuring GVCs and Policy Implications. *How to Benefit from Global Value Chains*, p.7.

95 Ambroziak, L. (2018) The CEECs in Global Value Chains: The Role of Germany

96 For detail see Crescenzi, R., Harman, O., and Arnold, D. (2019). Move on up! Building, embedding and reshaping Global Value Chains through investment flows. *OECD Broadening Innovation Policy: New insights for regions and cities*

GIFs allows MNEs to control and coordinate activities abroad.[97,98,99,100] It also represents a key vehicle to guide and enhance national and regional dynamics for policymakers. This is through its facilitation of the transfer of capability, good management practice and potential innovation.[101]

Policymakers have two key approaches to attracting GIFs. Horizontal measures such as spending in basic R&D and tertiary education. These actions passively set the foundation for GIFs and let the market dictate the inward or outward investment flows. Slovenia has had these policies in place through its stimulating tax environment for RDI, an educated labour force and long term research, development and innovation policy.[102] In contrast vertical measures such as mapping and investment promotion agencies actively seek out the GIFs building, embedding and reshaping regions in a certain direction. Although innovation benefits are sometimes difficult to be derived,[103] a pro-active industrial policy, in which governments more actively target GIFs into their tasks of choice is finding favourable response.[104]

In setting S4 direction an often-negated area of GIFs is the potential benefit from both the internationalisation of inward and outward flows.

When upgrading, both are important. Inward GIFs form the traditional story of positive innovation externalities: knowledge spillovers,[105] labour market benefits[106] and productivity gains.[107] These changes often leading to a structural shift onto higher value added activities.[108] However outward GIFs, take shape most usefully as either outsourcing or important for smart specialisation – offshoring. With outward flows externalities cross geographical scale with the knowledge benefits not requiring geographical proximity.[109] Knowledge gained overseas in the host country can find its way back to the home country – Slovenia.

Related to this inward/outward flow is the upstream and downstream nature of global investment connections. Slovenia is involved in the vertically fragmented production as both a user and provider of foreign value.[67] If a country lies upstream then its tasks are more heavily focused on producing inputs for others who export the final good. Downstream relies more heavily on other country's intermediate inputs to produce their own final goods for export. [110]

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97 Buckley, P. (2009). The impact of the global factory on economic development. *Journal of World Business, 44*(2), 131.143.

98 Cantwell, J., Dunning, J., and Lundan, S. (2010). An evolutionary approach to understanding international business activity: The co-evolution of MNEs and the institutional environment. *Journal of International Business Studies*, *41*(4), 567-586.

99 Beugelsdijk, S., McCann, P., and Mudambi, R. (2010). Introduction: Place, space and organization— economic geography and the multinational enterprise, *Journal of Economic Geography*, *10*(4), 485–493.

100 Narula, R., and Dunning, J. (2010) Multinational enterprises, development and globalization: Some clarifications and a research agenda. *Oxford Development Studies*, *38*(3), 263-287.

101 Prasad, E., Rogoff, K., Wei, S-J., and Kose, M.A. (2003) Effects of financial globalisation on developing countries: Some empirical evidence. International Monetary Fund.

102 Ibid Kolesa, S

103 Draper, P., and Freytag, A. (2014). Who Captures the Value in the Global Value Chain? High Level Implications for the World Trade Organization. International Centre for Trade and Sustainable Development (ICTSD)

104 Stiglitz, J., Lin, J., and Monga, C. (2013). The Rejuvenation of Industrial Policy. *Policy Research Working Paper*; No. 6628. World Bank, Washington, DC. World Bank

105 For example see Jaffe, A., Trajtenberg, M., and Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *The Quarterly Journal of Economics*, *108*(3), 577-598.

106 For example see McCann, P., and Simonen, J. (2005) Innovation, knowledge spillovers and local labour markets. *Papers in Regional Science*, *84*(3), pp.465-485.

107 For example see Blomström, M., and Kokko, A. (1998). Multinational corporations and spillovers. *Journal of Economic surveys*, *12*(3), 247-277.

108 Farole, T. and Winkler, D. eds., 2014. *Making foreign direct investment work for Sub-Saharan Africa: local spillovers and competitiveness in global value chains*. The World Bank.

109 See Bathelt, H., Malmberg, A., and Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in human geography*, *28*(1), 31-56.

110 Koopman, R., Powers, W., Wang, Z., and Wei, S-J. (2010). Give Credit Where Credit Is Due: Tracing Value Added In Global Production Chains. *NBER Working Paper Series*. Working Paper 16426

Neither upstream/downstream or inward/outward flows represent end goals for policymakers. It is more critical that leaders grasp how to best benefit from the flows themselves with their relative exposure to upturns or downturns. Particularly which are the tasks or activities which they want to change.

The analysis of internationalisation and territorial upgrading in Slovenia demands the simultaneous use of multiple data and dialogue methods of analysis. Top-down perspective based on statistical data and international comparisons is a first step. Where possible these should be integrated with information and bottom-up inputs deriving from listening to local actors.

8.3. How to upgrade effectively through Global Investment Flows and Global Value Chains

There are five main pillars (**Figure 48**) behind national and regional economic development:[111]

- investment in R&D and human capital;
- local knowledge flows, agglomeration economies, and urbanisation;
- global networks, value chains, and investment flows;
- national, regional, and local policies; and
- regional system of innovation and institutions (and their quality).

A coherent approach to economic growth and development must consider all these pillars simultaneously. Particular emphasis must be on how they may interact. Investments in human capital and in R&D are two fundamental elements for regional and national economic development. The relationship however, is not linear. Investing more in R&D does not automatically produce more innovation and higher economic growth rates.[112] The relationship between investments in R&D, human capital, the generation of product (proxied by patents) and process innovation is extremely complex and influenced by the interdependence of other factors. Among these, internationalisation processes, inter- and intra- firm global networks, offshoring and international outsourcing have been indicated as the conduit of R&D intensity. Together they lead a higher level of technological competence. MNE networks of production and innovative activities represent the integration of many distinct paths of innovation.[113]

111 Crescenzi, R. and Rodríguez-Pose, A., 2011. Reconciling top-down and bottom-up development policies. *Environment and planning A*, *43*(4), pp.773-780.

112 Charlot, S., Crescenzi, R., & Musolesi, A. (2015). Econometric Modelling of the Regional Knowledge Production Function in Europe. Journal of Economic Geography,15(6), 1227-1259

113 Cantwell, J. (1989). Technological innovation and multinational corporations. Blackwell

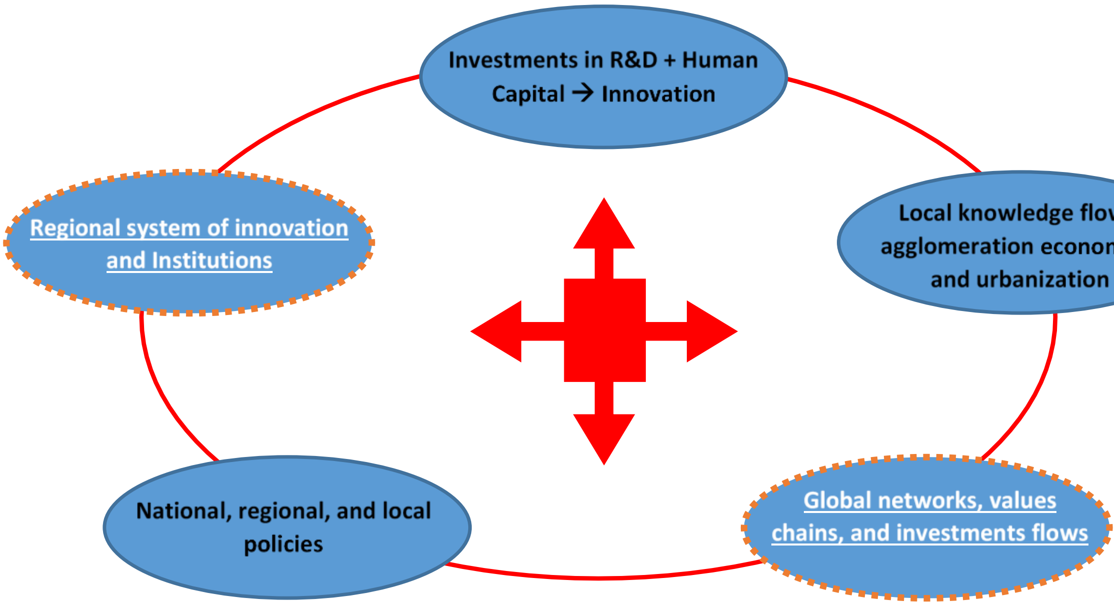

Figure 48. Integrated approach to regional economic development
Source: Adapted from Crescenzi and Rodriguez-Pose 2013

This framework emphasises the connectivity of a region. Connected regions lead to connected nations. Exposure to the knowledge flows coming to and from other economies of the world are crucial for development. A fundamental concept is that of the system of innovation, defined[114] as *"the network of actors and institutions in the public and private sectors whose activities and interactions generate, import, modify and disseminate new knowledge in the country or region and in its trade with the outside world".*[115,116]

Taking a system integrated approach to national and regional economic development underlines the role of connectivity for economic resilience. Foreign owned firms and plants may be the first to close locally in a deep contraction. This may be the result of the parent company pulling activity back home, shedding lower-skilled labour or seeking out a cheaper offshore location elsewhere. Despite this, these same firms are often more resilient than domestic SMEs, with greater capabilities, diversified knowledge, financial sources and networks. They also have the ability for higher risk and are prone to undertaking innovative projects even in time of crisis.[117] This trade-off is critical for policymakers. Therefore current local economic development can only take place following an integrated approach of alignment between local resources, and global capabilities and expertise based on the nature and quality of inbound and outbound connectivity to/from the domestic economy.[118, 119, 120]

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114 Similarly to the definition of the national system of innovation provided by Lundvall, B. A. (1992). National systems of innovation: An analytical framework. London: Pinter. & Nelson, R. R. (Ed.). (1993). National innovation systems: a comparative analysis. Oxford university press.

115 Evangelista, R., Iammarino, S., Mastrostefano, V., & Silvani, A. (2002). Looking for regional systems of innovation: evidence from the Italian innovation survey. Regional Studies, 36(2), 173-186.

116 Iammarino, S. (2005). An evolutionary integrated view of regional systems of innovation: concepts, measures and historical perspectives. European planning studies, 13(4), 497-519.

117 Gagliardi L. and Iammarino S. (2017). Innovation in risky markets. Multinational and domestic firms in the UK regions. CIMR research Working Paper Series, No. 37, Birkbeck University of London.

118 Iammarino, S., & McCann, P. (2013). Multinationals and economic geography: location, technology and innovation. Edward Elgar Publishing.

119 Crescenzi, R., Pietrobelli, C., & Rabellotti, R. (2014). Innovation drivers, value chains and the geography of multinational corporations in Europe. Journal of Economic Geography, 14(6), 1053-1086.

120 Crescenzi, R., & Iammarino, S. (2017). Global Investments and Regional Development: the Missing Links. Regional Studies, 51(1), 97-115.

8.4. Channels through which Global Investments Flows and Global Value Chains influence innovation and technological development

8.4.1. Effective internationalisation and the role of GVCs

> Technological benefit from GVCs relies on active engagement with foreign firms along the Value Chain

Internationalisation and territorial upgrading through GVCs and GIFs should focus on three key areas with three specific lenses. Those of building, embedding and reshaping.[121] Policies directed to attract GVCs (integrate or build GVCs) are very different from those meant to capture the potential gains (embed GVCs).[122] They should be accounted for as such.

Building GVCs represents the locational factors of an economy, how to drive GIFs to a country or a region through either greenfield investment or mergers & acquisitions (M&A). Both the type of location and the type of firm matter in championing GIFs.

Embedding GVCs represents how to gain most impact from GIFs. The diffusion of the investment benefit across the host economy can be through the onshoring of activity and through the offshoring of domestic activity. Both are necessary. That is so a region and nation can capture the positive externalities from both the entry of an MNE are generated, as well as the benefits that are reciprocated and flow back from the MNE's external connectivity abroad.

Reshaping GVCs represents the public policy factors that are available to policymakers to action change upon the GVCs. Policy can alter host economy attractiveness to relevant sections of the GVC, reduce impediments to their entry, as well as help understand the host economy's current location in the GVC. Taken together, these actions help sketch an area's future and provide a way in which to implement this vision. All these are vertical public policy changes that can be taken in order to influence territorial upgrading.

8.4.2. Building GVCs through GIFs

For Slovenia, building the link to the GVC is the first key step in utilising value chains for national benefit. With no connection, cities and regions remain unlinked to the chain, unable to embed or reshape and create local value. As GVCs are built through the actions of firms, MNEs are integral in the process. This is because one of the key ways GVCs can be built is through the MNE's internationalisation efforts – delocalising activities beyond national borders. This process makes them critical for potential innovation flows. Both national and sub-national policy makers can leverage these local locational factors to attract greenfield investments and M&A. Both help connect the region to the GVC. However, to do so they must facilitate the 'right' investments from the 'right' firms to match their location conditions. Both the characteristics of their area, the characteristics of the investing company and the characteristics of the investment matter. Only in bridging these differences can GVCs be effectively built through GIFs.

Investment flows matter in their quality, not their quantity.

121 For detail see Crescenzi, R., Harman, O., and Arnold, D. (2019). Move on up! Building, embedding and reshaping Global Value Chains through investment flows. *OECD Broadening Innovation Policy: New insights for regions and cities*

122 Pietrobelli, C. and Staritz, C. (2018). Upgrading, Interactive Learning, and Innovation Systems in Value Chain Interventions, *European Journal of Development Research* and Lema R., Pietrobelli C., and Rabellotti R., forthcoming. Innovation in global value chains. In G. Gereffi, S. Ponte & G. Raj-Reichert, 2019, Handbook on Global Value Chains, Edward Elgar: Cheltenham, UK and Lyme, US.

For Slovenia, in dictating S4 this will mean utilising information on who is investing and where they are investing to ensure the best GVC links are built through GIFs. This information is detailed in the following Chapter.

8.4.3. Embedding GVCs through GIFs

After locational factors driving the link to the GVC through GIFs have been established, emphasis must be placed on embedding the MNE in the host economy. As MNEs have delocalised certain functions, differing degrees of embeddedness and local linkages can occur.[123] The impacts upon the region from the embedment of GVCs can be felt in two ways.

- Firstly, those benefits from technology and knowledge that diffuse from MNE activities in the host economy
- Secondly, those benefits from flow back from MNE activities that have been offshored.

Through embedding GVCs via GIFs, local economies should aim to become 'sticky places'[124], and with this, activities will become more difficult to shift elsewhere.

For Slovenia, this means active efforts to build connections with MNEs at the local level are important. The process of learning, collaboration and resultant upgrading will not occur automatically. Similarly, at the global level the decline in outward greenfield investment in recent years outlined in the following chapter would ideally be reversed. The proactive search of new knowledge from firms internationalising can positively stimulate R&D in Slovenia and this important stream of technological advancement would benefit from policy engagement. To begin embedding GVCs through GIFs, policymakers should look at flows identified in specific areas of value chains. Ensuring that after one part of a MNE's value chain enters a region, the area can become a sticky place and incorporate related elements such as their production, sales or service functions.

8.4.4. Reshaping GVCs through GIFs

Reshaping GVCs ensures governments create the best possible environment to facilitate inserting their firms into GVCs. In this sense, it is suggested this part of the GVC policy agenda is domestic.[125] Reshaping GVCs through targeted industrial policies and specific interventions allows such parts of the value chain to be on the receiving ends of investment flows into tasks of their choice.[126] Through the development of specific skills, relevant technologies and partnerships, opportunity for upgrading investment and innovation should follow.[127]

The sole targeting of a country's policies must act within an international government framework. The rules that govern the GVC at a systemic level are also critical.[128] International agreements that influence a firm's ability to trade and invest within GVCs need to be aligned with the GIFs sought.

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123 Jordaan, J. (2009). Foreign Direct Investment, Agglomeration and Externalities, Ashgate, Farnham. *Journal of Economic Geography*, *8*(3), 297–321.

124 Ibid Bailey, D et al (2018)

125 Stephenson, S., and Pfister, A-K. (2016). Who Governs Global Value Chains? In "The Intangible Economy: How Services Shape Global Production and Consumption", Chapter 5 edited by Patrick Low and Deborah Elms, Cambridge University Press, 2016

126 Draper, P., and Freytag, A. (2014). Who Captures the Value in the Global Value Chain? High Level Implications for the World Trade Organization. International Centre for Trade and Sustainable Development (ICTSD)

127 Singh, H. (2014). Reinvigorating Manufacturing through Industrial Policy and the WTO. Background paper prepared for E15 Expert Group on Reinvigorating Industrial Policy. E15 Initiative. Geneva: ICTSD and World Economic Forum.

128 Ibid Stephenson, S., and Pfitster, A-K (2016)

Therefore, in reshaping GVCs through GIFs, policymakers need to focus on both the long term fixed environment and short term flexible environment. The former fixes the rules of the game and the latter provides flexible tools to interact successfully within that framework.

For Slovenia this represents fixed European Union trade agreements upon which S4 should sit within. It also represents flexible inward and outward investment promotion agencies, upon which S4 should coordinate with.

Instead, the focus is on shorter term mapping of GVCs, the understanding of a region's internationalisation and how to actively engage with global markets. Combining these to co-create value and upgrade firms which is of importance. In Slovenia's case, in order to reshape GVCs, a key area of focus is the role of national and regional institutions. Evidence shows there is a lack of coordination between government institutions within Slovenia's internationalised bodies[129] with an overlap of responsibilities. In order to reshape GVCs effectively, the roles would benefit from clarification. In conjunction, an understanding (developed in this framework) of where the geographical influences and stakeholder activities is taking place through mapping GVCs ensures an informed approach. National and sub-national governments can be confident to approach the relevant MNEs with the relevant types of investment for their desired territorial upgrading.

8.4.5. Practical examples of policy for effective internationalisation

There is precedence for success in bridging the divide between a region and the global value chain, actively championing upgrading from a public policy perspective.

The framework for analysis of internationalisation draws evidence for vertical pro-active policy – engaging directly with MNEs in the chain. This will help territorial upgrading in GVCs. Particularly when focusing decisions around the policies of building, embedding and reshaping policies. This approach has been successful utilised elsewhere. In Ireland the Irish National Linkages Programme targeted both global MNEs and local firms. Its aim was to find appropriate links between the two and build capacity[130]. The focus was on a combination of product, process and functional upgrading. The programme's success led to a wider initiative incorporating Irish companies more fully into GVCs.

Similarly, in Singapore, upgrading of local firms occurred at a worker level. This was through matching MNEs and their employees to local needs. Territorial upgrading occurred as skilled employees were seconded to local SMEs allowing direct knowledge transfer. For this, the salary was paid for. This focus on capacity and upgrading can be useful to both regions at the technological frontier and those lagging. Skill increase through knowledge transfer would lead to higher value added activities in future at both high tech and low tech firms.
Finally, Costa Rica operated a business matchmaking service acting between larger exporters and local firms. Between 2001 – 2012 over 1,355 linkages were created between 400 local firms and 300 MNE exporters.[131] Although only 20% of these linkages

129 Koleša, S (DATE TBC) Global Value Chains: Government Policies for Enhancing the Role of Small and Medium Enterprises in Global Value Chains – A Case Study of Slovenia. Management *13(*1)

130 Crespi, G., Fernández-Arias, E., and Stein, E. (2014). A World of Possibilities: Internationalisation for Productive Development. 233–278 In Crespi G., Fernández-Arias E., Stein E. (eds) Rethinking Productive Development. Palgrave Macmillan, New York

131 Ibid Crespi et al (2014)

were incorporated into final high technology products[132], many of these firms still see knowledge transfer benefits resulting from these relationships.[133] This knowledge transfer can lead to territorial upgrading.

Closer to Slovenia, in a rethinking of traditional trade policies, Austria has been recommended to enhance GIFs with South and East European countries who share their GVCs.[134] In doing so the hopes are to improve competitiveness and Austria's role as a high technology base. Evidence of this policy's change is as yet unanalysed.

Therefore, by bridging the divide between a region and the GVC, actively championing upgrading from a public policy perspective there is precedence for success.

9. The position of Slovenia in Global Investment Flows and Global Value Chains

9.1. The position of Slovenia in Global Investment Flows: greenfield investments and M&A

Foreign Direct Investments are important for upgrading and internationalisation. The investing firm holds effective control of, or at least substantial influence over, the decision-making of new activities in the host economy. The entry mode into a foreign market can be through greenfield investment or mergers and acquisitions (M&A). Greenfield investment requires building a new wholly owned subsidiary. M&A involves partial or full purchase of an existing firm – leading to ownership. They are two sources of the same internationalisation story together with joint ventures. Joint ventures however are more difficult to capture and monitor in the data so will not be analysed.

The nature of investment through M&A or greenfield investment depends both on the MNE and the receiving economy. Different entry modes have different consequences in terms of local impacts (in the sending and the receiving economy) as well as in terms of knowledge flows. For example, with US firms, greenfield is favoured over acquisitions if the investing firm is more efficient, the host country is less developed and if there is closer geographical proximity between firm and host economy.[135]

9.1.1. Greenfield investment

Given the importance of GIFs as a pillar of economic development, detailed analysis of the position of Slovenia is critical. This is particularly in terms of greenfield and brownfield investments both with respect to inward and outward flows. The focus on greenfield investments allows to capture the capacity of internationalisation process to bring to the national economy new activities. This is as opposed to acquisitions that relate to the change in ownership but ultimately control of pre-existing local businesses.

The **Figure 49** below shows the trend of greenfield investment into Slovenia between January 2003 and December 2017. Over this period of greenfield investments, Slovenia secured new 293 inward foreign investment projects for a total of USD$7.7B. This compared to investing USD$8.8B outward into 376 projects abroad. As a share of GDP inward greenfield investment has been one of the lowest in the region since 2006.

132 Groote, R. (2005). Costa Rica. Proyecto de Desarrollo de Proveedores para Empresas Multinacionales de Alta Tecnología. ATN/ME-6751-CR. Final Evaluation. Washington, DC, United States: Inter-American Development Bank.

133 Monge-González, R., and Rodriguez-Alvarez, J. (2013). Impact evaluation of innovation and linkage development programs in Costa Rica: The cases of Propyme and CR Provee.

134 Kulmer, V., Kernitzkyi, M., Judith Köberl, J. and Andreas Niederl. (2015) Global Value Chains: Implications for the Austrian economy. FIW-Research Reports 2014/15 03 April 2015

135 Nocke, V., and Yeaple, S. (2008). An assignment theory of foreign direct investment. The Review of Economic Studies, 75(2), 529-557.

Conversely, outward greenfield investment saw Slovenia deliver the highest capex as share of GDP vis-à-vis similar economies in the region over the 2004 – 2010 period before recently falling in line with other *'comparison economies'*.

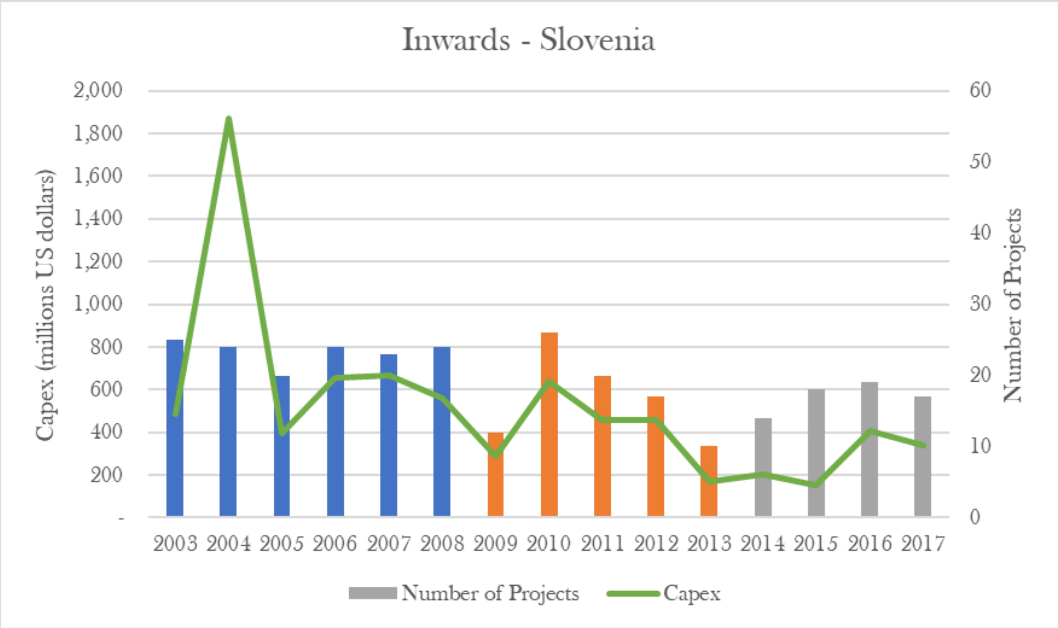

Figure 49. Greenfield investments to Slovenia: Number of projects and Capex, 2003-2017

Looking at the time trend evolution of investments it is clear the impact of the crisis.[136] There was a positive trend since 2003, in line with similar trends of increased internationalisation of the European economies. However since this period investments have either plateaued or dropped. With the exception of 2010, both capex and number of projects have not rebounded to pre-crisis levels.

More than 60% of new total greenfield foreign investment in Slovenia between 2003 and 2017 was secured before the economic crisis (2003-2008), and only 14% in the post crisis years (2014-2017). Inward annual investment rates have dropped from USD$770M to USD$275M. This is a sign of concern.

This compares to following **Figure 50** highlighting more than 70% of new total foreign greenfield investment from Slovenia between 2003 and 2017 was delivered before the economic crisis (2003-2008). This compares to only 7% in post crisis years (2014-2017). Outward annual investment rates have dropped from USD$1050M to USD$150M.

Although both decreasing, the downturn seems especially prominent for outflow greenfield investment – investments abroad by firms located in Slovenia. Outflows of greenfield investment dropped substantially.

- In 2008, Slovenia invested USD$1.6B in investments for a total 31 projects abroad (consistently with the previous five years of data on FDI flows)
- In 2014 this fell to USD$63M through 7 projects in total with a partial recovery in the following years.

136 For comparability with previous chapters the bars have been coloured with different colours: blue (pre-crisis), orange (during crisis), and grey (post crisis).

This deterioration process has still not been completely reversed. This may suggest that some Slovenian-based MNEs decided to reduce the rate of growth of their international expansion limiting the number of new projects. It may also signal the inability of firms/sectors in a post crisis economy to fully recover and return to pre-existing internationalisation patterns. Effective internationalisation policies can help build resilience to these changes in GIFs.

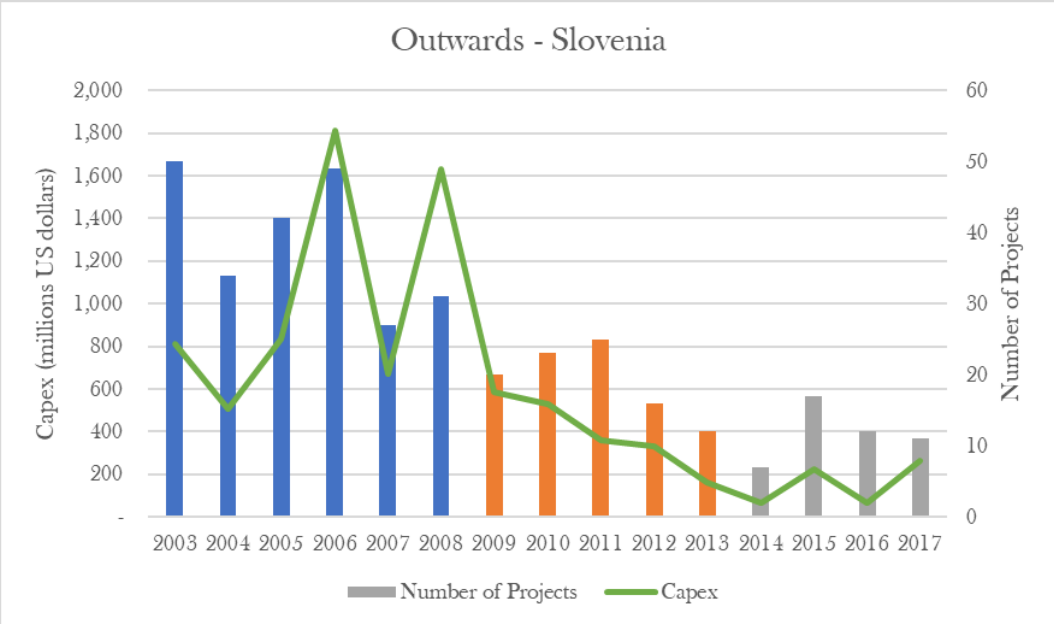

Figure 50. Foreign direct investments from Slovenia: Number of projects and Capex, 2003-2017

9.1.2. Mergers & Acquisitions

This mode of investment, or entry mode into a new economy changes the structure of firms. Regarding GVCs in Slovenia, M&As can potentially offer a more direct channel for knowledge diffusion than greenfield investments. When operating in a foreign economy through greenfield investment, MNEs need to create new local linkages and connections. Conversely, when foreign MNEs acquire (or merge with) existing domestic firms they can leverage their pre-existing networks and connections (for example in terms of buyer-supplier linkages etc.)[137] and this can facilitate local innovation and knowledge diffusion.

Therefore, M&A activity should play a central part to any innovation strategy and to S4 in particular, looking at both inward and outward M&A investment flows. However, far too often policymakers shy from M&A activity. Having foreign firms acquire or 'take-over' national firms can cause public dissent – particularly if perceived negative changes occur.[138] However, Slovenia should view M&A as a key part of its internationalisation strategy in order to internalise potential knowledge spillovers.

The link that M&As show with domestic patenting should lead to strategies that factor in M&As more carefully in particular at the local level. Location is an important variable affecting the global competitiveness of firms[139] and subnational actors are often in an ideal position to reinforce linkages with foreign-owned firms to the benefit of the local economy.

137 Crescenzi, R., and Jaax, A. (2017). Innovation in Russia: the territorial dimension. *Economic* Geography, 93(1), 66-88.

138 See for example Kraft and Cadbury Available at <https://www.bbc.co.uk/news/business-27258143> and < https://www.ft.com/content/03559624-8571-11e0-ae32-00144feabdc0>

139 Dunning, J. (1998) Location and the multinational enterprise: A neglected factor? Journal of International Business Studies. 29(1)

If Slovenia is to deliver on its S4 and further shift towards a high productivity economy, M&As should be a key part of the strategy. M&As can lead to knowledge flows boosting technological upgrading.

Since 1995, OECD countries have shown a positive relationship between participation in GVCs and labour productivity growth.[140] This can potentially be leveraged by S4. Slovenia outperformed the average of the other 33 countries, recording productivity gains significantly larger than what would be predicted based on its increasing GVC participation. Continued active engagement with GVCs could therefore have a particularly positive effect on future productivity and wage growth.

Figures 51 and **52** show the trend of M&As into and from Slovenia between 2003 and 2018. Data covers majority acquisition deals and all other cross-border M&A deals. Over this period Slovenian companies were involved in 250 M&A deals generating transactions for a total of USD$2.7 billion. In contrast Slovenian companies acquiring foreign companies abroad finalised 190 deals for a total value of USD$1.2 billion.

Regarding time trends, M&A investment flows were fairly stable pre-crisis. However inward M&A (foreign companies acquiring Slovenian firms) dramatically contracted during the 2009 crash with only 3 deals recorded in 2010. A partial recovery occurred, peaking with 36 deals recorded in 2015, however this trend has not been sustained. In contrast, outward M&As – Slovenian companies acquiring foreign firms - have not seen a post-crash recovery.

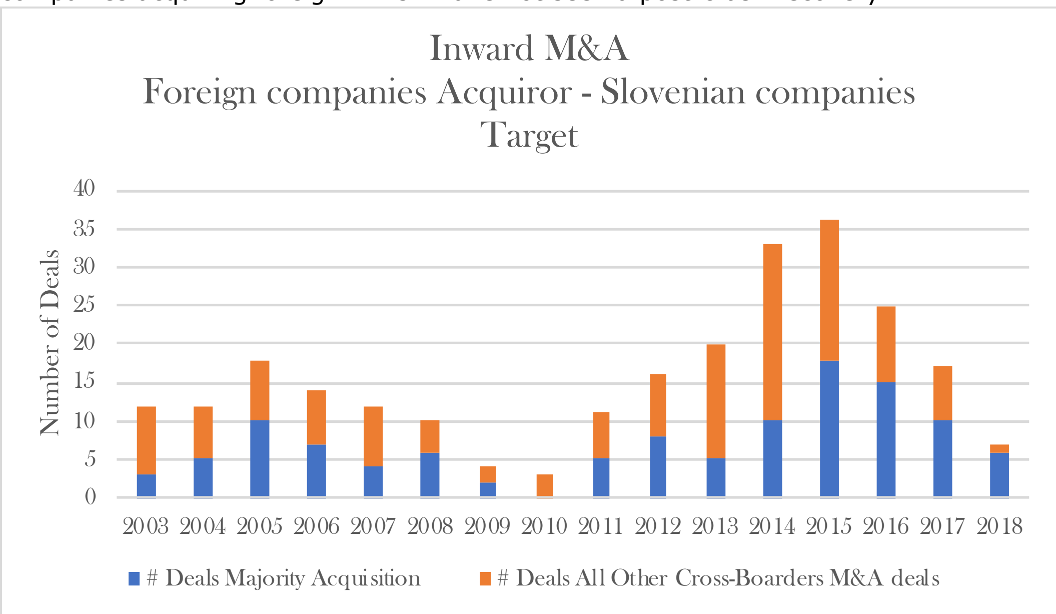

Figure 51. M&A targeting Slovenia: Number of projects and Capex, 2003 – 2018[141]

140 OECD (2017). OECD Skills Outlook 2017: Skills and Global Value Chains, OECD Publishing, Paris

141 Data is from Zephyr database and related to all cross-border deals which have been completed. This leads to 637 total deals over the period 1997-2018. Since analysis focuses on the deals with a majority acquisition over 50% thereby leaving out: capital increase, joint venture, institutional buy-out, management buy-out, minority stake, acquisition with already the majority/control of the company. Furthermore, for symmetry with FDI Market data, deals occurred between 2003 and 2018 are taken into consideration – reducing the total number of inward M&A deals at 250 and outward M&A deals at 190.

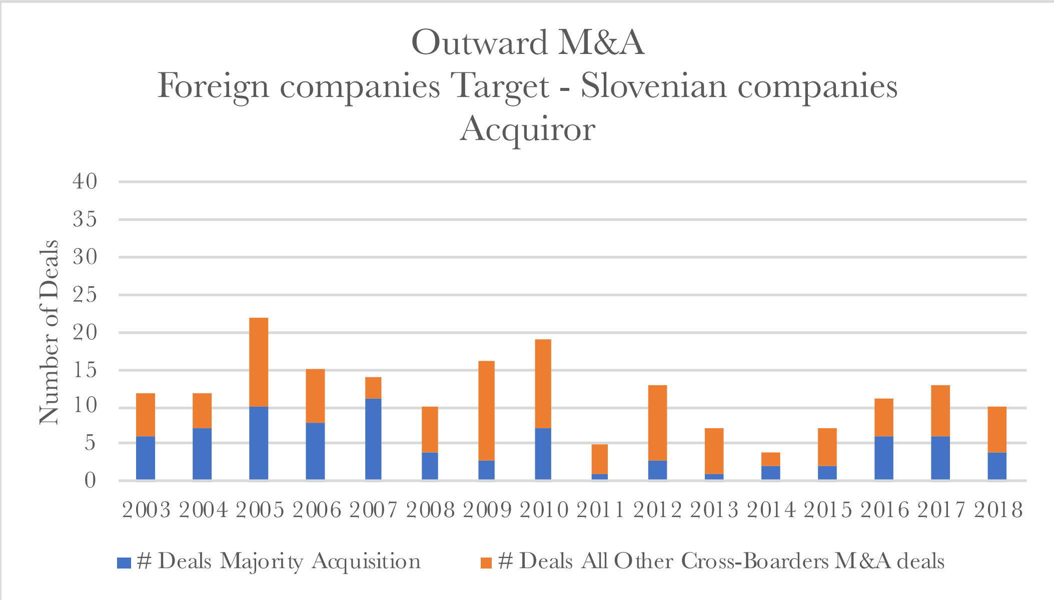

Figure 52. M&A from Slovenia: Number of projects and Capex, 2003 - 2018

If Slovenia aims to leverage M&As as a means to access external knowledge to support and complement the internal strengths of its innovation system, the number and value of inward and outward M&A deals are important, but even more critical is the nature of these M&A deals in terms of key sectors, knowledge intensity and business function/GVC stage.

Focus should be on the type of business activities Slovenia aims to chase, these should be explicitly linked with S4 priority areas. Knowledge areas such as I.1 Smart Cities, I.2 Smart Buildings and III.1 Factories of the Future would be key areas that could benefit from M&A focus by bringing into the country relevant foreign knowledge and know how.

M&As have the potential to offer more direct knowledge linkages when compared to greenfield investment. Therefore, by targeting higher value added activities within selected S4 sectors Slovenia could maximise the benefits from internationalisation by facilitating the 'local' embeddedness of 'global' knowledge linkages within its economy. Whether this be 'upstream' – concept design, R&D or 'downstream' – sales, marketing. By focusing on more skill-intensive activities, the growth effects of investment flows in the form of M&A will be maximised.[142] These incremental steps, harnessing existing activities and with new knowledge upgrading value add is an approach all outward looking Slovenian firms can take.

9.2. The Geography of greenfield investments and M&A

9.2.1. The global geography of greenfield investment flows – macro regions

Almost 80% of Slovenian inward greenfield investment comes from firms based in Western Europe

142 Alfaro, L. and Charlton, A., (2007). Growth and the quality of foreign direct investment: is all FDI equal.

To assess the participation of Slovenia in GVCs and production network, therefore understanding its two-way global connectivity, it is essential to grasp the nature of the activities taking place. Those activities which are being located abroad and those which are attracted to the national economy. Particularly understanding their balance and their geographical composition. Whether they are to/from advanced economies or to/from emerging and developing countries. It is also necessarily to understand their business function, or GVC stage. It is important to note the analysis of GIFs provides only a partial perspective of more complex value chains and production networks. These are composed of a variety of links between domestic firms and those in the rest of the world. Together they contribute to the formation of value by integrating different economic actors. This is not only through greenfield investments but also acquisitions, joint ventures, outsourcing and supply agreements amongst other methods.[143]

Looking at the distribution of inflow and outflow investments it is possible to observe the position of Slovenia with respect to the macro-areas of the world. For inward greenfield investment in Slovenia (Figure 53) the majority of projects comes from Western European countries (almost 80%). Although large this figure must be viewed with caution as intermediary firms in countries such as Austria are often used to channel GIFs.[144] It may hide the true ultimate investor and country of origin. Often in Slovenia, Germany, the US, France, Russia and Mexico are much more important in real GIFs than official data on the investing country might suggest.[145]

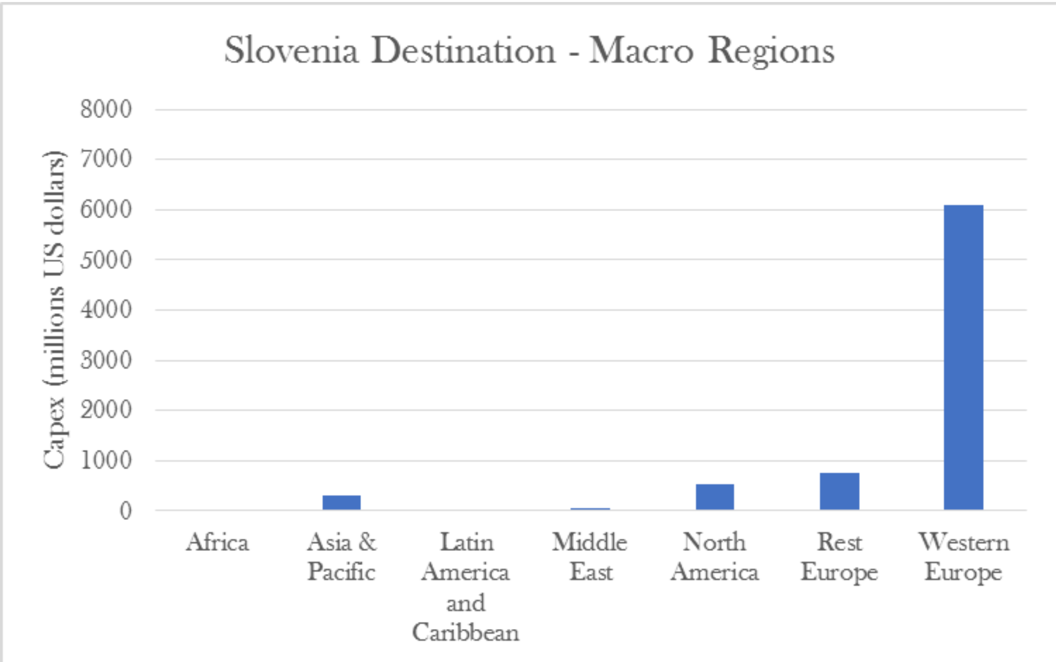

Figure 53. Greenfield investment to Slovenia – Macro-Regions of the World, 2003-2017

In other European countries, greenfield investment from 'intermediary investing firms' is less present. Similarly emerging countries appear to have a stronger presence as greenfield investment actors. In Slovenia this is not the case. As shown in **Figure 53** Slovenia lacks in investment from this group of emerging economies, especially with respect to Africa, Latin America & Caribbean, and Middle East. If Slovenia is to

143 These ties are difficult to analyse with quantitative indicators to a subnational geographical scale such as the regional one.

144 https://en.portal.santandertrade.com/establish-overseas/slovenia/investing?

145 Bank of Slovenia. Direct Investment. <Available at https://www.bsi.si/en/publications/statistical-reports/direct-investment>

internationalise fully and de-risk its economy from a few select GVCs, investment from these economies would be beneficial.

Moreover, Central Eastern European countries are still under-represented in GIFs in Slovenia. The heavy dependence of the Slovenian economy on EU-15 greenfield investment can in part explain the sharp drop in the capital secured by the region during the crash period. As European MNEs stopped investing in the region, the overall capex drastically decreased. Chart 10.a shows which countries were most significant in the USD$7.7B inward greenfield investment and 293 projects to Slovenia.

It highlights the distinct lack of investment flows from emerging countries. This may be due to the difficulty firms from further geographies have in understanding the Slovenian institutional context. Emerging country MNEs (EMNEs), if conducting innovation related activities abroad are drawn towards regions where other EMNEs in a similar field are located. The perceived risk is lower and ability to learn maximised. Once one starts and others may follow. This re-emphasises the critical role of Slovenia's Investment Promotion Agency (Invest Slovenia) should play in ensuring the gap in knowledge for foreign investors regarding Slovenia's processes and procedures is mitigated in the framework of the S4 strategy.

In **Figure 54** a different perspective emerges by looking at greenfield investment outflows from Slovenia. In the last 15 years MNEs based in the country have invested mainly in CEECs, showing a limited breadth in their outward FDI portfolio.

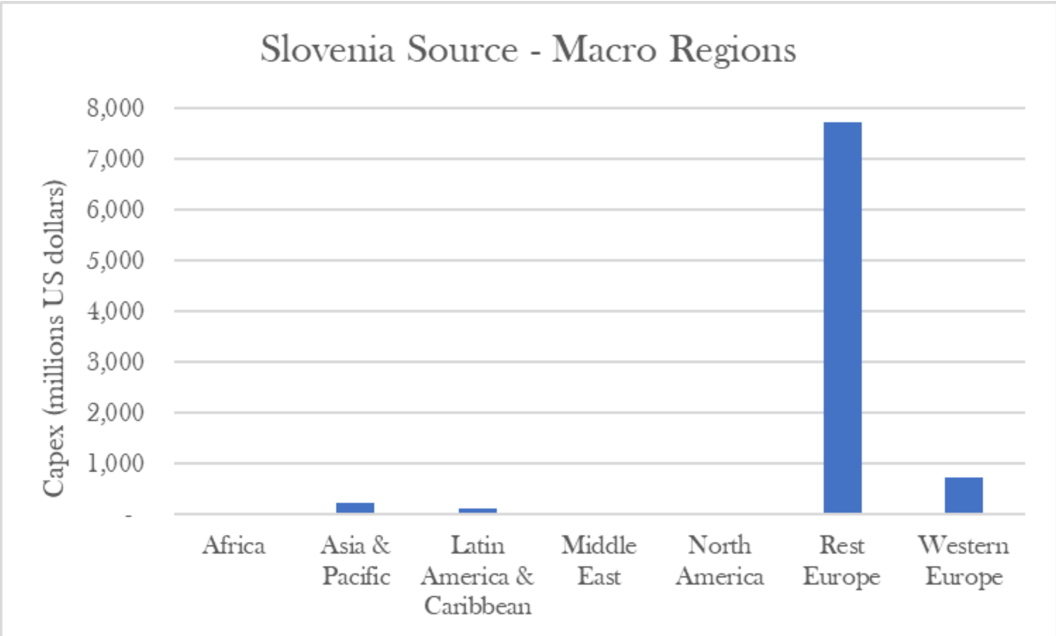

Figure 54. Greenfield investment from Slovenia to Macro-Regions of the World, 2003-2017

9.2.2. The global geography of greenfield investment flows – national dimension of origins and destinations

Slovenia received most greenfield investment from Austria with Macedonia and Serbia being key destinations for Slovenian firms

Figure 55 shows which countries were most prominently featuring among the key investors accounting for USD$7.7Bn total inward greenfield investment distributed over 293 FDI projects targeting Slovenia as their destination.

It highlights the distinct lack of investment flows from emerging countries. This may be due to the difficulties faced by Emerging country MNEs (EMNEs) in linking with local eco-system opportunities. EMNEs have a stronger tendency to cluster geographically vis-à-vis investments from advanced economies, in particular when conducting innovation-related activities abroad.[146] A key task for S4 is to facilitate this form of investments from emerging countries in order to lower perceived risks and investment barriers. Once a few 'anchor' investors signal the quality of the domestic eco-system others may follow in a cumulative process. This re-emphasises the critical role of Slovenia's Investment Promotion Agency in building a suitable investment eco-system in the framework of the S4 strategy.

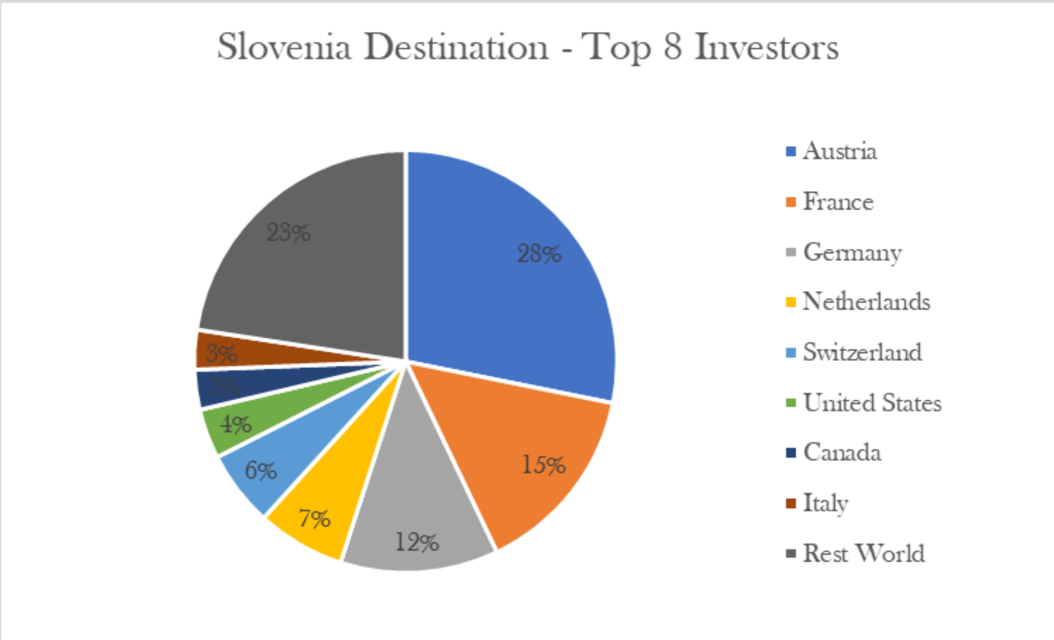

Figure 55. Greenfield investment to and from Slovenia - Top 8 Countries, 2003-2017

Figure 56 looks at outward greenfield investment. Slovenian firms invested abroad through Greenfield FDI a total of USD$8,8Bn over the period 2003-2017, for a total of 376 individual new greenfield projects. Investing companies based in Slovenia have a strong orientation towards other economies of the area: Macedonia, Serbia and Croatia. The orientation of outward flow is mostly towards Eastern European Countries, highlighting the relevant role of Slovenia as 'stepping stone' towards an area of strategic importance for the EU and its Value Chains.

146 Crescenzi, R., Pietrobelli, C., and Rabellotti, R. (2016). Regional strategic assets and the location strategies of emerging countries' multinationals in Europe. *European Planning Studies*, *24*(4), 645-667.

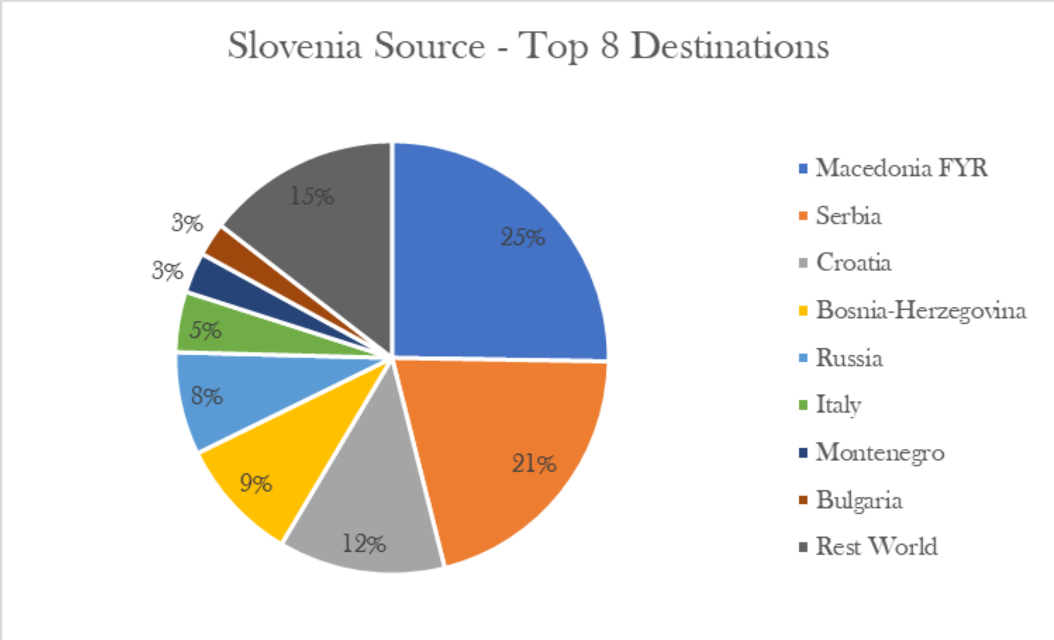

Figure 56. Greenfield investment from Slovenia to Top 8 Receiving Countries, 2003-2017

9.2.3. The global geography of M&As – macro-regions

2/3rds of inward Mergers and Acquisition activity originates from Central and Eastern Europe (CEEC). The rest mainly comes from Western Europe. In contrast 90% of Slovenian firms' outwards M&A activity was with firms in CEEC. A geographical mismatch.

Figure 57 and **58** show the position of Slovenia with respect to the macro-areas of the world. Both inward and outward M&A charts highlight the clear predominance of deals with other Eastern European companies. This is 58% and 88% of total deals respectively.

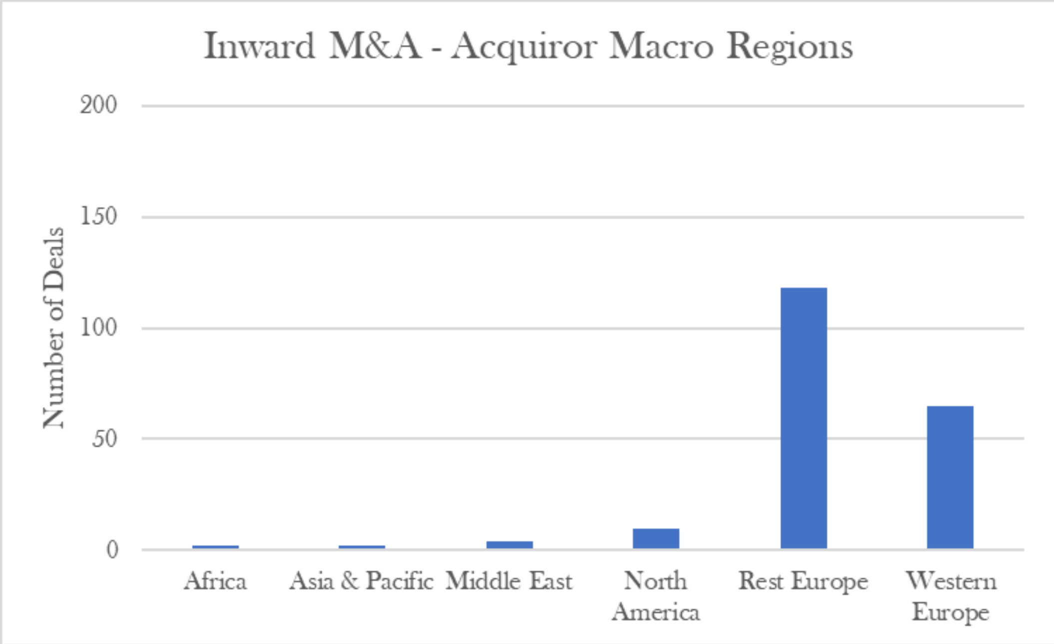

Figure 57. M&As to and from Slovenia - Macro-Regions of the World 2003 – 2018

With the exception of other Western European countries there is almost a complete absence of M&A deals with firms from other Macro-Regions. Only one deal occurs with Asia-Pacific and the Middle-East.

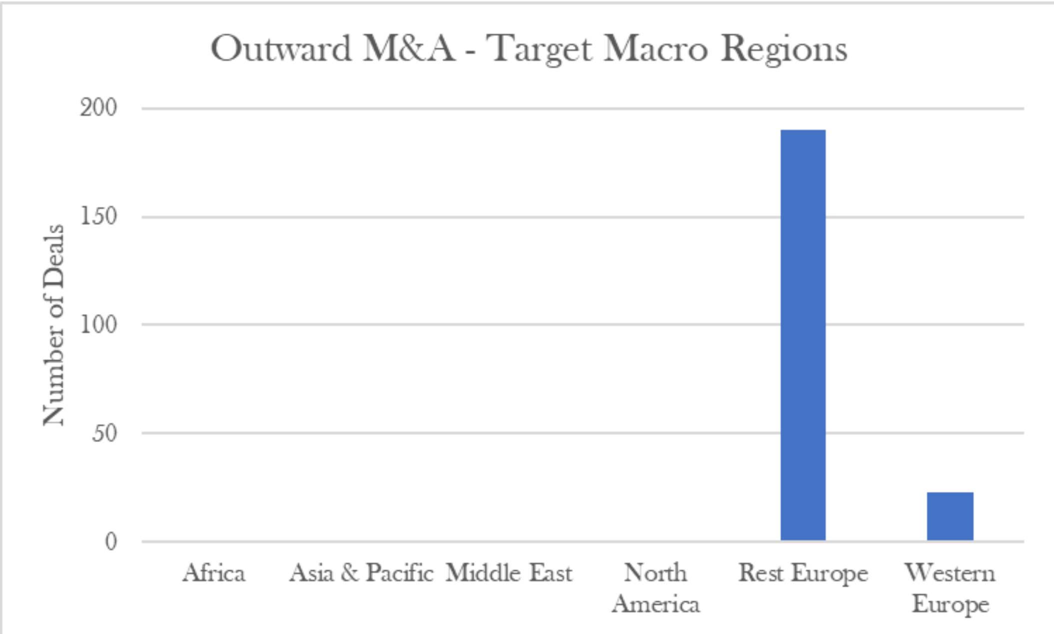

Figure 58. M&A from Slovenia to Macro-Regions of the World, 2003-2018

There is an interesting comparison in GIFs from Slovenia when looking at the differences in macro region sources and destination with respect to greenfield investment and M&A. Inward both greenfield investment and M&A see GIFs from Western and Eastern of Europe. However outward flows are much more focused on CEECs. In active internationalisation for upgrading, GIFs and macro regions of focus should align to benefit from potential knowledge flows consistently with S4. Depending on the type of knowledge that the strategy aims to pursue, a different macro region sets precedence.

This again calls for coordination of both inward and outward investment promotion efforts with the objectives and priorities of S4.

In the pursuit of skill upgrading, perhaps direct knowledge flows from M&A further afield in more skill intensive environments could be encouraged. Slovenia is in the bottom 25% of OECD countries with regards to its share of low skills people as well as skills to specialise in technological advanced industries.[147] Fortunately, the country's ability to face the challenges of GVCs are developing rapidly.[148] However if it is to effectively benefit from internationalisation, an expansion of sources and destinations would provide more diverse knowledge flows.

Similarly, to greenfield investment, with the MNEs working in response to the financing of global production networks, regulation and tax burdens the ultimate source of M&A may be slightly different as well **Error! Reference source not found.**.[149]

9.2.4. The global geography of M&As – national

Croatian firms are both the largest M&A acquirers for M&A and targets for M&A with Slovenian firms.

Figure 59 suggests that at a country level Croatia is the most likely M&A actor in deals involving Slovenian firms. Similarly, Slovenian firms are most likely to complete M&A activity in Croatia.

Mapping which of these acquirer and target countries have similar priority domains to Slovenia's 9 priority domains could be a useful exercise in helping targeting M&A activity. For example in neighbouring Austrian region of Styria, clusters have been established operating in the field of automotive industry, design, energy and environment, food, human resources, logistics, materials and wood and furniture respectively.[150] There is potential cross over with Slovenia's priority domain of wood chain as well as others.

When targeting certain countries and firms for inward and outward M&A activity, the level of innovative activity aiming to attract or invest is important. Knowledge does not always flow linearly from high to low. Firms that have much higher levels of technical capacity will not see their knowledge transfer to firms of lower capacity.[151] With upgrading, firms with more comparable levels of understanding are more like to see knowledge sharing and spillovers – realising the associated productivity growth.

147 OECD (2017). OECD Skills Outlook 2017: Skills and Global Value Chains, OECD Publishing, Paris.

148 Ibid OECD (2017)

149 Republic of Slovenia: Ministry of Economic Development and Technology Available at <http://www.mgrt.gov.si/en/areas_of_work/internationalisation/foreign_direct_investments/>

150 Slovenia's Smart Specialisation Strategy S4

151 Crescenzi, R., Dyevre, A., and Neffke, F. (2018). (2018, June) Catalysts of Regional Innovation: How foreign firms allow new places to join the global innovation contest. Workshop on Multinationals, Value Chains and Innovation. LSE. Manuscript in Preparation.

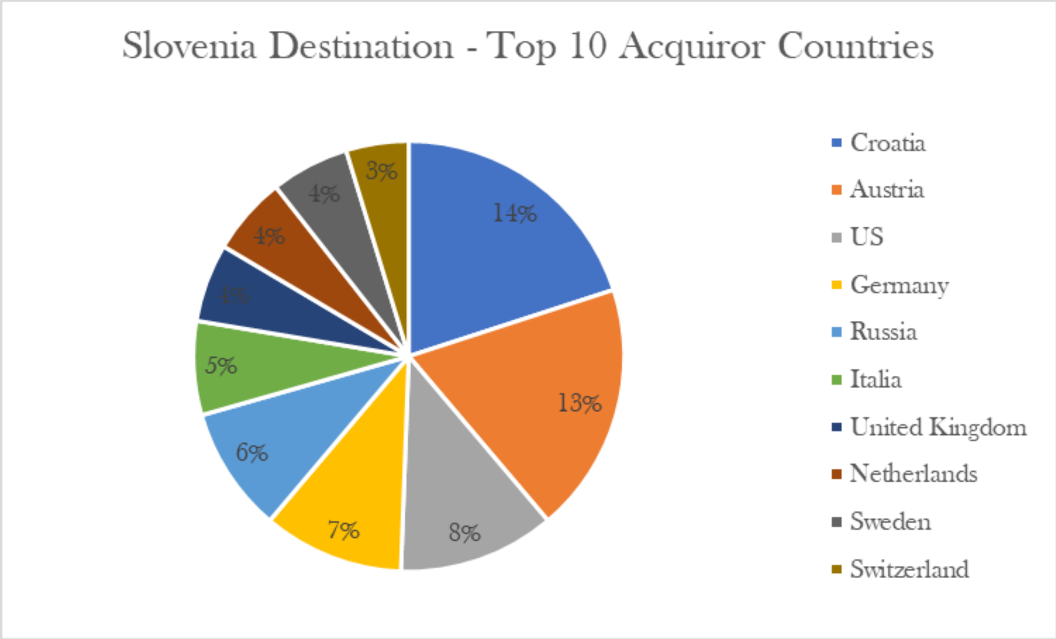

Figure 59. M&A to and from Slovenia - Top 8 Countries, 2003-2018

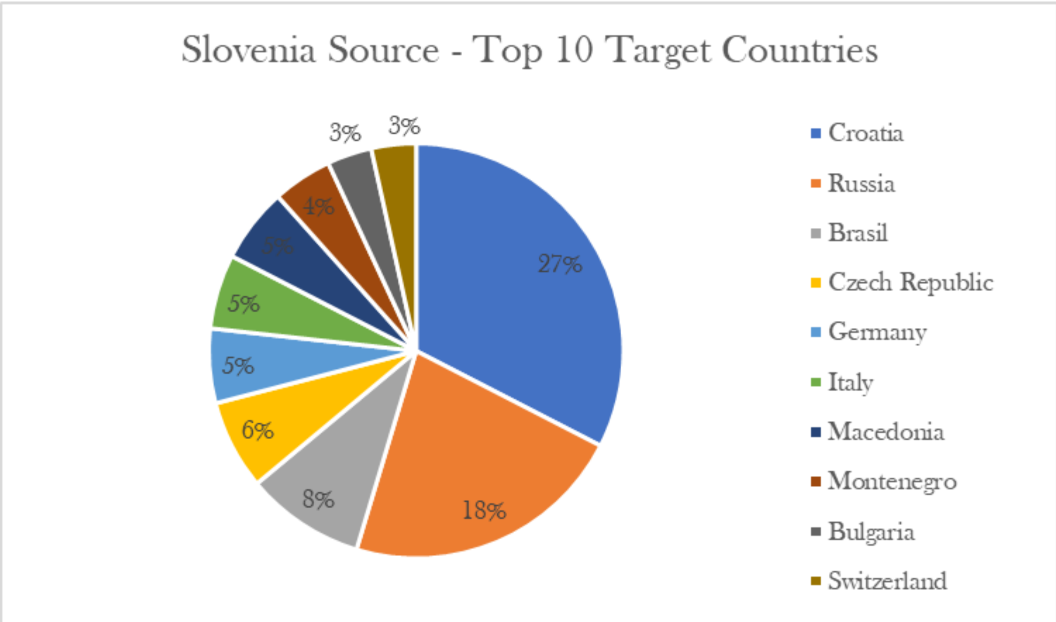

Figure 60. M&A from Slovenia to Top 10 Investing Countries, 2003-2017

9.3. Sectors, Functions and GVCs

Production related FDI activities account for 50% of total inward and outward investments. Followed by Sales (30%) and Logistics (10%)

The distribution by sectors and business functions (Global Value Chain stages) for both greenfield investment and M&A plays an essential role in the analysis of the process of Slovenian internationalisation.

As shown by **Figure 61**, inward investment covers multiple sectors. Top three sectors are:

- Automotive OEM leading with almost 14% of total capital secured (14 investments with over 1bn total value)
- Coal, Oil and Natural Gas (10.6%) and
- Transportation (10%).

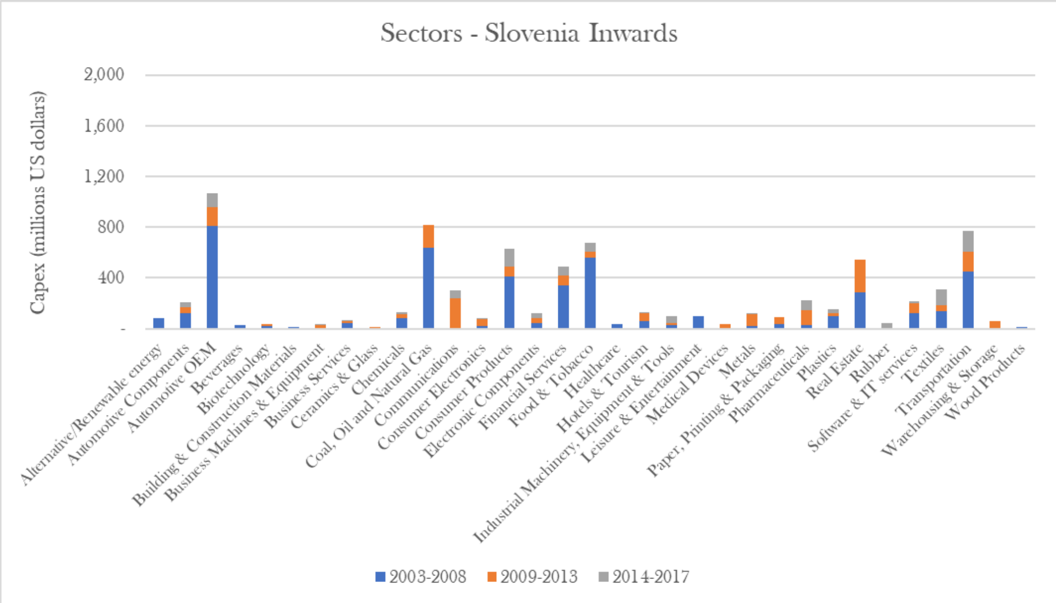

Figure 61. Greenfield investment to and from Slovenia, Distribution by sector, 2003-2017

The Automotive industry, accounting for 10% of Slovenian GDP, is one of the main players in the Slovenian economy. Particularly structured around the manufacture of car components. Renault Group is an interesting example in this regard with several investment projects since 2004 for the production of its 3rd generation Twingo. These projects were concentrated in Revoz in Novo Mesto. Although most projects are in production-related activities, with a new partnership with Daimler in Novo Mesto the capacity to manufacture electric vehicles is emerging. Due to Slovenia's location and size, a key S4 area is the Strategic Research & Innovation Partnership of mobility – particularly green mobility positioning the country as a leader in the field.[152] This is a clear example of alignment of S4 focus and capital inflow that could be leveraged in future.

Other key sectors in FDI attraction are: Food & Tobacco, Consumer Products, Real Estate and Financial Services.

The seven sectors mentioned above combined received more than 60% of total foreign capital invested in Slovenia over the 2003-2017 period through greenfield activities. However, most of the investments in these leading sectors have arrived in the pre-crisis crisis period (60% of total capital invested). Only a small share has materialised in the most recent years (25% during the financial crisis and 14% in the post crisis years).

New sectors have secured investments during and after the crisis such as:

- Communications,
- Medical Devices, and
- Warehousing & Storage.

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152 Republic of Slovenia Ministry of Economic Development and Technology. (2017) Key Orientations of SRIP: Mobility

Investments in Communications, which have been mainly characterized by ICT & Internet Infrastructure business activities, have received the highest share of capital invested among all sectors since 2010. The government commitment to boosting the ICT sector as one of the national development priorities together with well-developed ICT infrastructure in Slovenia have created the conditions for foreign companies to invest.

The relatively small size of Slovenia economy means that establishing links with neighbouring regions in order to collaboratively develop new capabilities in these sectors is of key importance.[153] These emerging sectors could mean policy-supported linkages between areas of investment with - for example - Croatian telecommunications R&D clusters. Or as is already developing, utilising strong international partnerships and platforms to link companies, research institutions and leading manufactures in the field of medicine.[154]

In contrast, the below **Figure 62** shows outward investments have a different emphasis. They display a strong sectoral concentration in:

- Real Estate (20%)
- Food & Tobacco (19%), and
- Transportation (8%)

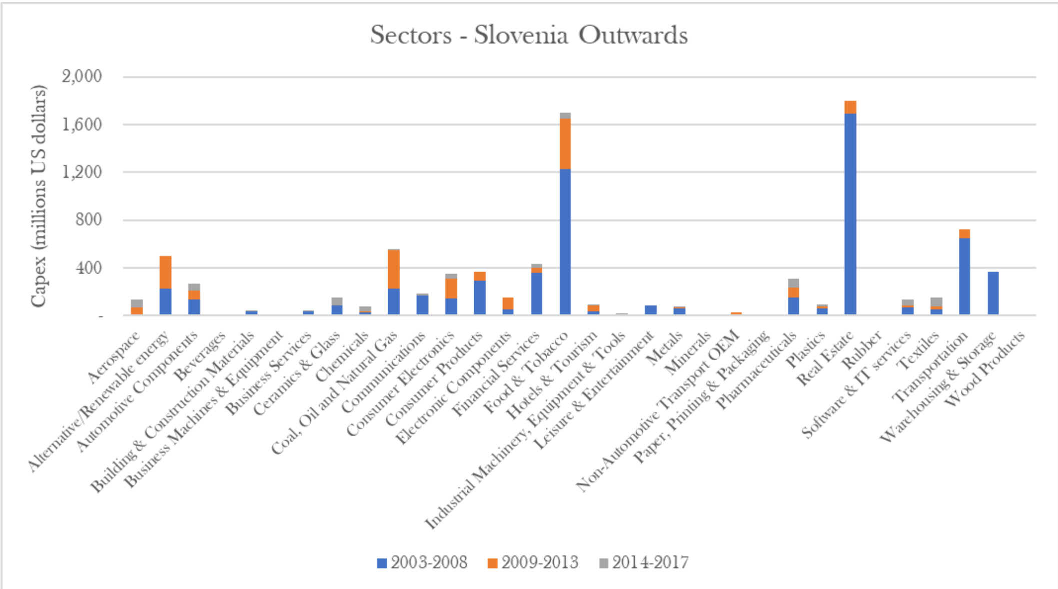

Figure 62. Greenfield investment from Slovenia, Distribution by sector, pre/during/post crisis

Taken together this represents half of total capital invested by Slovenian companies. As with inward investments the biggest sectors have seen large investments in the years before the financial crisis, but they have struggled to maintain such investment values during and after the crisis.

The Transportation sector, ranked number three in terms of capital invested in both inward and outward greenfield investment, seems to play a crucial role in the Slovenian economy. On the one hand Slovenia’s strategic geopolitical position can be a strong attraction factor for foreign firms.

153 OECD (2014) Regions and Innovation: Collaborating Across Borders. *OECD Publishing*

154 Slovenia’s Smart Specialisation Strategy S4

Yet on the other hand Slovenia firms are mainly investing in this sector in neighbouring countries. Not necessarily creating a knowledge network but instead creating a network for the distribution of products.

Post crisis areas of greenfield investment from Slovenian firms have been in new sectors such as:

- Aerospace,
- Minerals and
- Non-Automotive Transport OEM.

The sectoral breakdown of inward and outward greenfield investment is crucially important when thinking about GVCs. However, this must be complemented with a task lens. It is not necessarily the sector that matters for upgrading, but what tasks firms pursue within that sector.

For internationalisation and territorial upgrading to be effectively implemented as part of S4, both inward and outward greenfield investment needs to be relaunched.

Figure 63 outlines M&A deals by sector, both inward and outward with regards to Slovenia. By sector, foreign companies targeting Slovenian firms have undertaken M&A deals mainly in services. Particularly Business Services, Financial Services and Software & IT with a large number of deals taking place in the post crisis period. FinTech deserves a special attention with its online and mobile banking. It is currently transforming the Financial Services sector across the world. Other areas where technology is driving change are cryptocurrencies (powered by blockchain technology), cybersecurity and various products based on data analytics and artificial intelligence. Slovenia hosts a lively cryptocurrency business community, with a number of firms plausibly qualifying as FinTech.

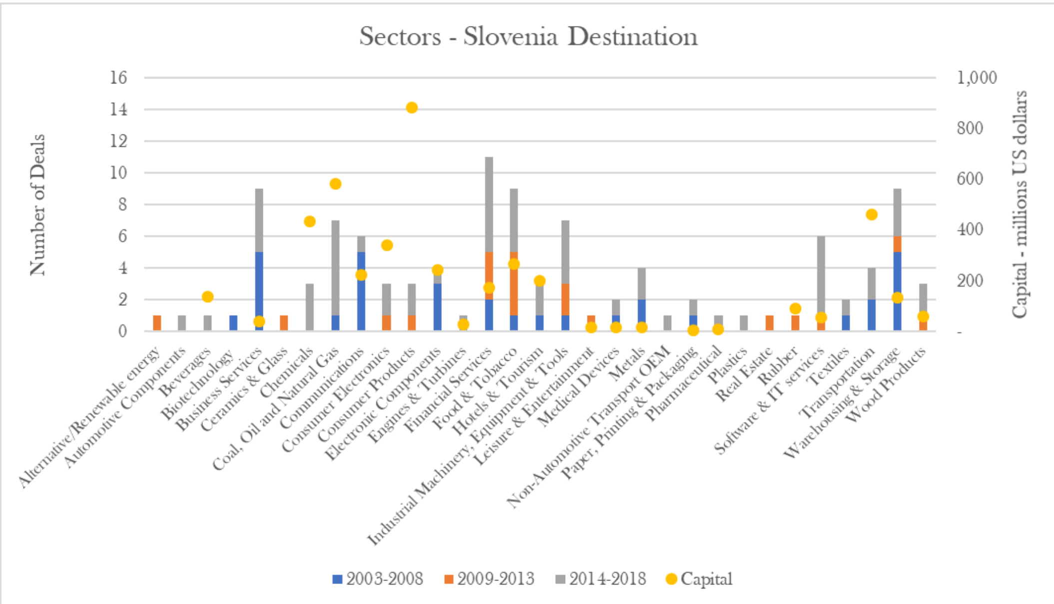

Figure 63. M&A in Slovenia, Distribution by sector, 2003 – 2018[155]

S4 priority sectors of Wood Products and Hotels & Tourism have also seen some relevant foreign acquisition activity. However, it remains to be seen through further research

155 Given the limited data available for deal value, the capital variable is only present in the for the statistics in M&A Sectors and Function. In order to provide a useful indicator of the deal value an estimation has been calculated in each sector/function. First, given the observations with deal value information the average capital in each sector has been calculated. Second, the average value has been allocated to all the observation in a specific sector, regardless of the previous values that has been now substituted. When no yellow dots are present there is no data for the given sector.

whether this will contribute to 2023 targets in terms of both value added increase (for tourism) and better use of inputs (for wood). This will fundamentally depend on the nature of M&A activity.

When looking at the value of the deals by taking into account the total value of the corresponding transactions (where reported), it becomes apparent that considerable investment flows through M&A targeted the following sectors:

- Chemicals,
- Transportation,
- Coal, Oil and Natural Gas,
- Consumer Products.

The first two sectors are also the top export industries for domestic and foreign value-added content of exports.[156] In order to capitalise on this high degree of internationalisation and GVC integration policymakers should ensure that employment levels and investments in local skills remain a top priority. Transportation as well as Coal, Oil and Natural Gas are still key sectors for the Slovenian economy as for greenfield foreign investments.

Unfortunately, other S4 areas of interest - such as for example the *wood chain* – remain peripheral in global investment flow activity. With the significant exception of the pharmaceutical sector, all areas of Slovenia's S4 need significant efforts in order to catch up with technological leaders.[157] However, increase in value added should not be pursued by focusing exclusively on R&D intensity. Conversely, some key low-tech sectors have a significant potential of upgrading through GVC participation, learning by doing, accumulation of skills and absorption of external knowledge.

By contrast, **Figure 64** shows that foreign M&As by Slovenian companies are targeting foreign firms primarily in:

- Chemicals,
- Food & Tobacco,
- Financial Services and
- Metals.

The chemical industry is one of the most competitive industries in Slovenia with potential for further expansion of technological capabilities.[158] With neighbouring Croatia also focusing innovative efforts on biochemistry, the use of M&A outflows to harness this source knowledge for domestic technological upgrading is a prevalent strategy by Slovenian firms.

Similarly, in metal products, Slovenia shows a revealed comparative advantage representing a higher than average share of global exports.[159] Knowledge flows from M&A abroad could enhance the value added in these areas.

156 WTO Slovenia Trade in Value Added and Global Value Chains

157 Burger A., and Kotnik P. (2014) Professional analysis as the basis for the Smart Specialisation Strategy.

158 Slovenia's Smart Specialisation Strategy S4

159 Ibid Burger A., and Kotnik P. (2014).

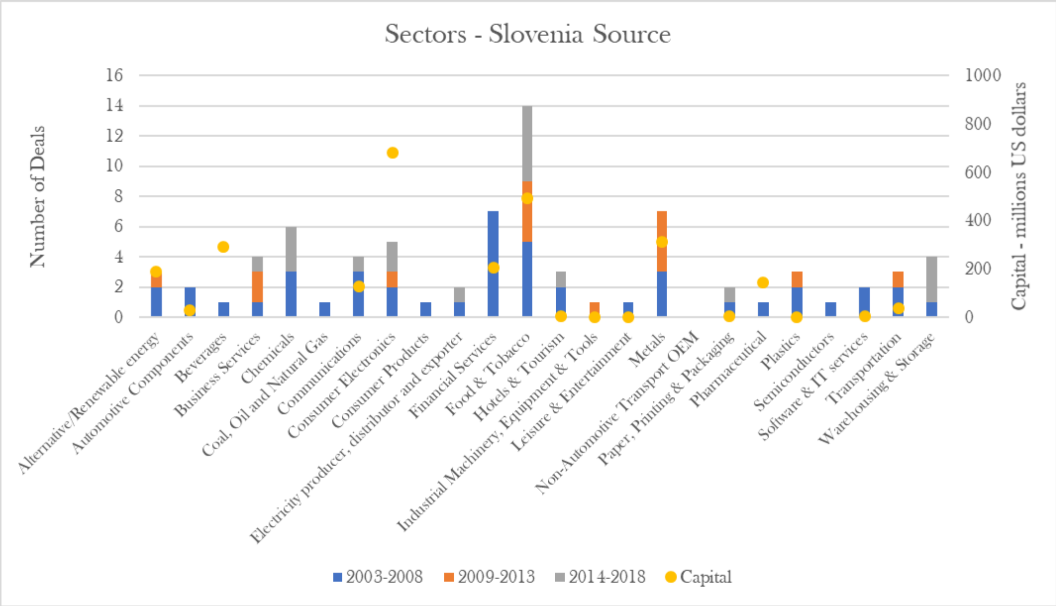

Figure 64. M&A by companies based in Slovenia, Distribution by sector, pre/during/post crisis

9.4. Global investment flows and patenting by sector

Active internationalisation may benefit from patenting activities and GIFs aligning. Since currently most of Slovenia's GIFs are with Europe, the patenting focus is on these countries. If Slovenia is able to align internationalised sectors (those receiving and sending high GIFs) with their high patenting sectors they may be able to replicate the positive impact on creation and survival of knowledge intensive firms as seen elsewhere.[160] S4 should carefully consider the international and GVC positioning of various priorities in order to align domestic innovation efforts with access to external knowledge and skills as previously discussed.

At the sectoral level, over the period 2001 to 2015 Slovenia and Europe’s key patenting cross over areas where domestic patenting activity is recorded are:

- chemistry,
- consumer goods,
- electricity,
- physics
- transport and operation

These sectors represent areas where Slovenian patenting progression and EU patenting progression align. Making a useful potential ‘knowledge bridge’.[161] Contrasting these knowledge areas over time, the patenting leading sectors of Chemistry and Consumer Goods have been at the forefront. This is since the begin of the Century. However their patenting centrality index has under performed in the last years. This is in contrast to patenting in Electricity and Transportation in which after the crisis patenting has constantly increased. Similar results apply to these sectors’ centrality indexes in EU30.

160 Monge-González R and Rodríguez Álvarez JA. (2012) Impact Evaluation of Innovation and Linkage Development Programs in Costa Rica: the cases of Propyme and CR Provee. *IDB*

161 Kogler, D., and Davies, R. (2019) The Slovenian Knowledge Space. FDI & Tax Policy. EC 2018CE160BAT090 Presentation - Ljubljana, Slovenia, November 16th, 2018.

Rather than sectorally, at the firm level, of Slovenia's top 10 patenting firms, 2/3rds of them are in the Pharmaceuticals sector.[162] This should also remain a key area of potential GIF. In fact, the top patenting firm Novartis has strongly invested in Slovenia (4th for total capital invested) in the pharmaceutical and biotechnology sectors. At the same time the highest Slovenian company in patenting (and 3rd at the aggregate level), Krka, is also active in the process of internationalisation. The Slovenian firm invested around USD$300M abroad.

Comparing these areas of knowledge crossover with greenfield inward and outward investment flow crossover the following is apparent.

1. Transportation is a key sector for both inward & outward greenfield investment. The positive trend in patenting in this sector is critical.
2. There is partial cross over with high greenfield inward investment in areas of consumer products and chemistry. Gorenje, one of the eight largest manufacturers of home appliances (consumer electronics) in Europe, is one of the top patenting firm in Slovenia and among the top investing firm (ranked 8th with other USD$250M).
3. However, greenfield investment in other key knowledge areas of electricity and physics is negligible.
4. There is limited knowledge crossover with high greenfield outward investment. Here all new facilities being set up abroad by Slovenian firms are focused on Food & Tobacco as well as Real Estate. Trimo, a leading company in the area of fire-proof roofs and façades, ranked in the top 20 patenting firms in Slovenia has also invested over USD$200M in construction projects.

Regarding correlation with inward and outward M&A, and looking specific at deals made, there is limited crossover with EU/Slovenia (EU/SL) knowledge space sectors as well.

1. In terms of number of deals, high amounts of inward M&A deals were not made in EU/SL knowledge cross overs. However, looking at the capital invested into the country there are possible cross-over in the chemical sector. In 2002 Novartis acquired the Slovenian pharmaceutical manufacturer.
2. With outward M&A, more grouping around consumer electronics and chemicals is seen. This is a potential area that could be leveraged upon to encourage knowledge seeking M&A investments. Krka has acquired two pharmaceutical companies in the past years, and in 2017 formed a Joint Venture with a Chinese pharmaceutical company. This was to promote the integration of pharmacy manufacturing business. Similarly ETI Elektroelement, involved in consumer electronics and ranked 5th in Slovenia for patenting, has been involved in the acquisition of a foreign company.

The low greenfield investment capex, low number of M&A deals, yet high concentration of patenting in the pharmaceutical sector would indicate this is an area where more active internationalisation policy could benefit the value chain.

Fortunately however, in upgrading through internationalisation, patenting is an addition rather than a core element of the process. Of Slovenia's patenting organisations, over half of total activity is delivered by two pharmaceutical firms and one individual. The potential for country-wide firm and worker upgrading will likely be able to result in wider increase values added. The following sections regarding GVC function reflect this.

162 Ibid above

9.5. Greenfield investment flows by GVC stage

The majority of greenfield investment is focused on production activities, however, Slovenia shows larger relative levels of higher value added functions than its 'comparison economies'.

Since the 1990s, Slovenia and other CEECs were locations for greenfield investment building 'from scratch' production plants. These were efficiency seeking investments aimed at reducing production costs.[163],[164]

The following **Figure 65** shows how production-related activities still play a major role in both inward and outward investment. Around 50% of total inward and outward investment in Slovenia is categorized in this function. This is followed by Sales (31% inward and 33% outward) and Logistic & Distribution (10% and 12%). The bias toward production investment is not surprising given the significant presence of firm in the 'transport equipment' cluster (aggregation of Automotive OEM, Automotive Components, and Metals sectors) seen above. Large international automotive companies such as Renault and Carthago have invested in new production plants since the beginning of the century. Similarly, around 50% of outward production related investments are in the "construction" cluster. Here the two Slovenian retailer companies, Engrotus and Mercator, have expanded in neighbouring countries their sales facilities. However, these outcomes are mainly driven by pre-crisis investments in production-related activities and have been characterised by the pre-crisis values. In this period production-related activities received more than 60% of total capital invested. At the same time, the reduction in the number of greenfield investment and capital invested in the country in the past few years makes it difficult to predict if new investment will be relocated into higher valued added activities.

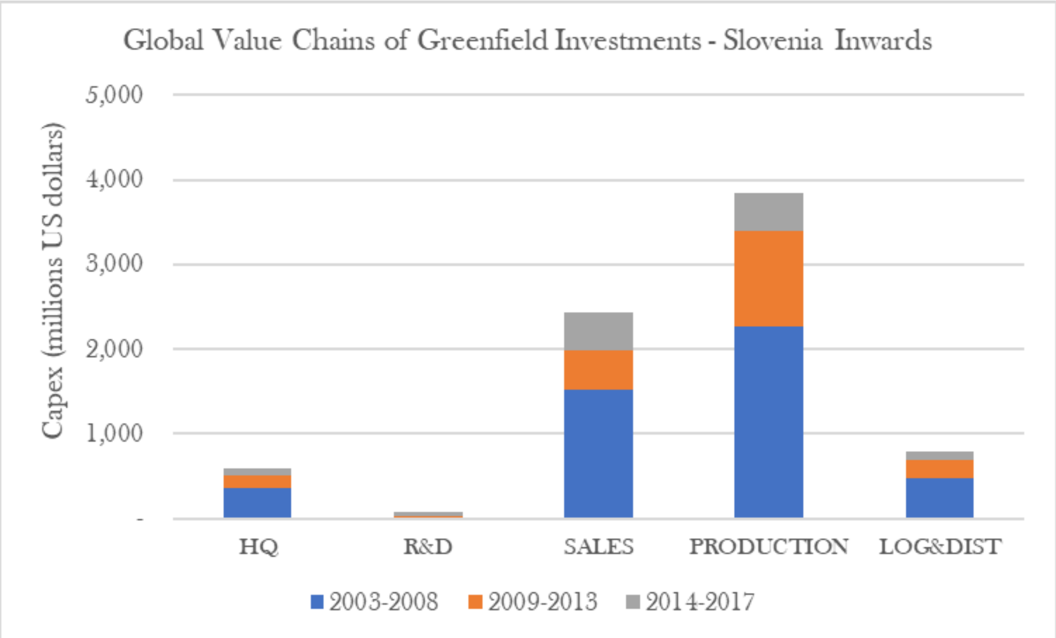

Figure 65. Greenfield investment to and from Slovenia, Value Chains of FDI, 2003-2017

163 Miškinis, A. and Reinbold, B., (2010). Investments of German MNEs into production networks in central European and Baltic states. Technological and Economic Development of Economy, 16(4), pp.717-735.

164 Ambroziak, Ł., (2012). FDI and intra-industry trade: theory and empirical evidence from the Visegrad Countries. International Journal of Economics and Business Research, 4(1-2), pp.180-198.

The presence of inward greenfield investment in production may be seen as a positive sign for the Slovenian economy. Compared to this, the high share in outward investment might unveil a process of transformation of the industrial structure. **Figure 66** shows this. This could be driven by domestic MNE active internationalisation strategies aimed at the relocation of production, mainly manufacturing, operations. It is therefore important to have a more nuanced picture of what is being produced locally and abroad, what the trends are, and what the main objectives of the strategies implemented by both foreign- and domestic-owned firm in this respect are.

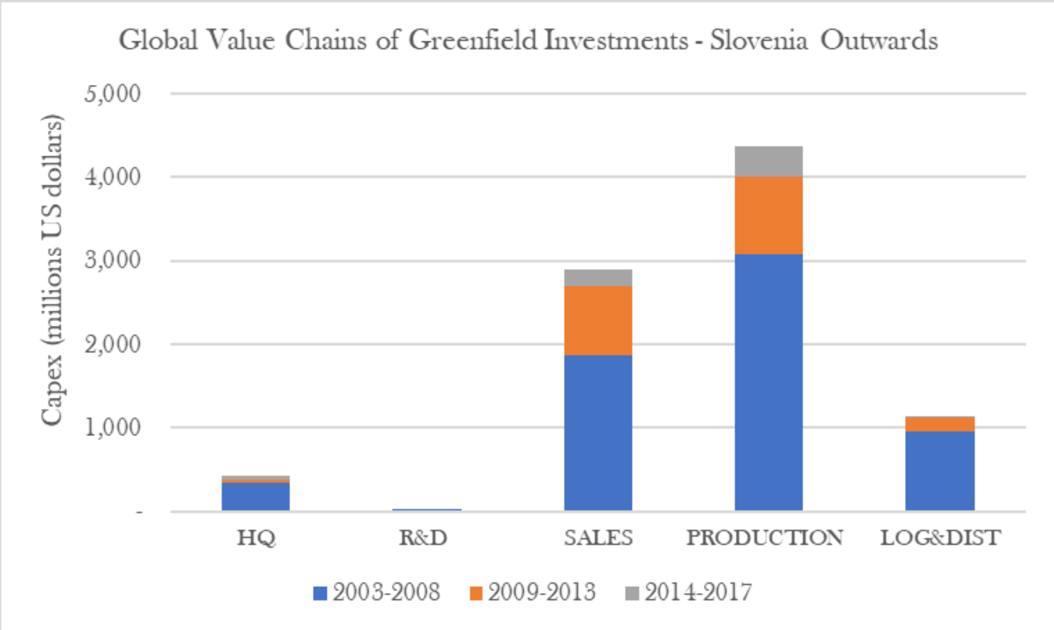

Figure 66. Greenfield investment from Slovenia, Value Chain stage of FDI, 2003-2017
Production-oriented activities received most of investment flows, but their relative importance (measured as share of capital invested by function) for both inward and outward greenfield investment is larger in neighbouring economies such as for example Austria, Lithuania and Slovakia. In Slovenia, a larger share of inward and outward greenfield investment has been allocated to 'Sales' and 'Logistics & Distribution'. Unfortunately, both inward and outward investments in the 'retail trade' cluster seem mainly directed in producing and selling goods for direct consumption, rather than in more high knowledge intense activities.
Moreover, R&D-related FDI remained limited and Slovenia seems to be underperforming with respect to similar '*comparison economies*'. Slovenia secured USD$75M in R&D-related activities over the 2003 to 2017 period. This is equivalent to less than 1% of total capital invested. As a comparison, Lithuania - the least technologically advanced in terms of FDI content among comparable economies - received more than USD$400M in R&D FDI. This further highlights the importance of a careful consideration of the linkages between internationalisation and innovation in S4 as well as in investment promotion strategies.

9.6. M&As by GVC stage

Both inward and outward M&As in Slovenia are mainly focused on production.

The functional distribution of M&A deals shown in **Figure 67** mirrors that of greenfield investment. There is a prevalence of deals in 'Production' activities in both inward and outward investment followed by 'Sales'. A large share of production-related M&A has been mainly driven by deals occurred in the post crisis period. This is particularly apparent when compared to the very limited activity in Slovenia as a source of M&A post crisis.

Post crisis more Slovenian firms have instead undertaken more outward M&A deals in HQ and Sales functions. This represents a positive step for potential firm upgrading through knowledge flows from abroad.

In the knowledge intensive area of R&D FDI, there is limited activity involving Slovenian firms. The detail of the deals targeting Slovenian firms is discussed in the following section. No acquisitions of foreign R&D targets by Slovenian companies was recorded in the period under analysis.

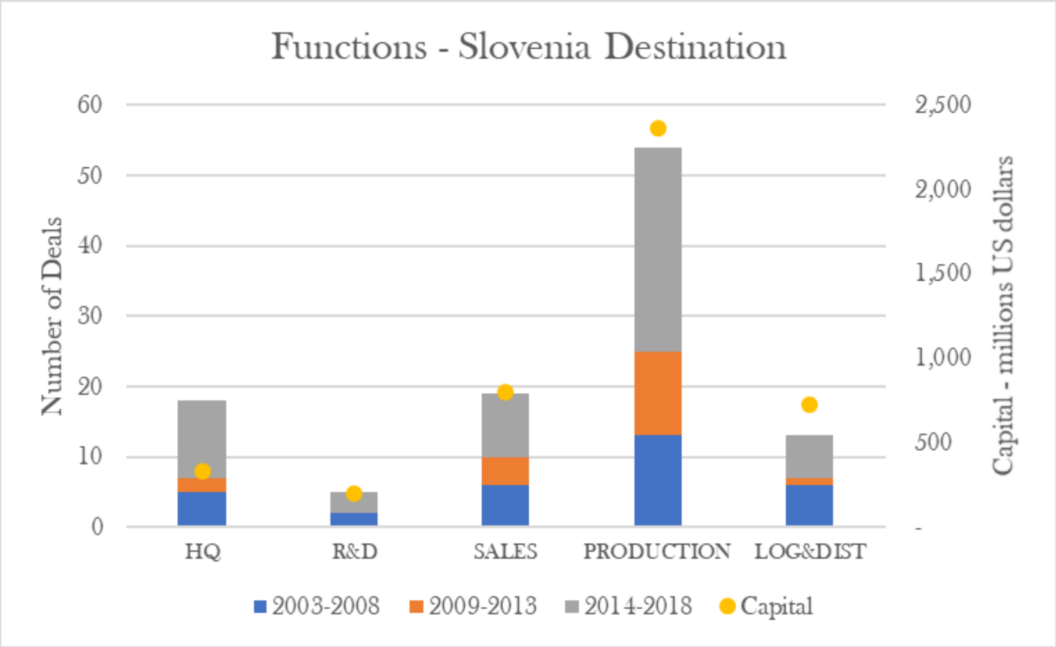

Figure 67. Foreign acquisition of domestic companies in Slovenia, Value Chain Stage of M&A, 2003 – 2018

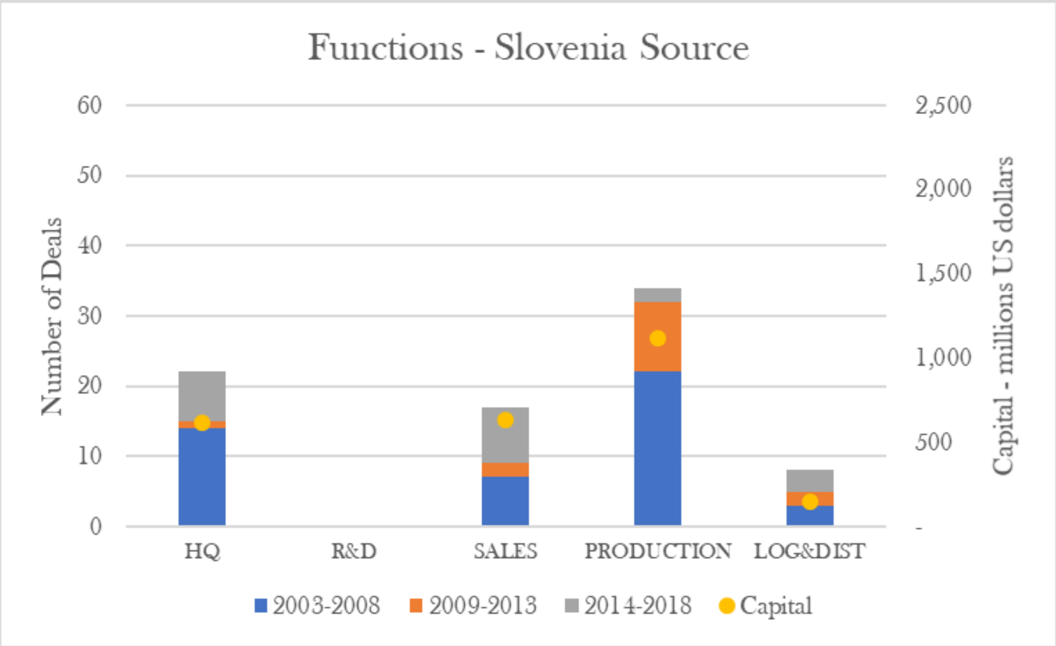

Figure 68. Acquisition of foreign companies by investing companies located in Slovenia, Value Chain Stage of M&A, 2003 – 2018

9.7. Upgrading through Research & Development

9.7.1. Greenfield investment in R&D

A total of eight foreign investment projects in R&D were recorded in Slovenia between 2003 and 2017. The first projects recorded by the Financial Times occurred in 2006 and the most recent in 2016. In total over this period an estimated total of USD$75M was invested in R&D activities by foreign companies creating over 400 jobs. Most R&D greenfield FDI arrived from Germany, followed by Switzerland, the US, Serbia and the UK.

Interestingly, two of these R&D investment projects originated from a top patenting company, the Swiss based pharmaceutical firm Novartis pursuing medical and biotechnological activities in Ljubljana and Menges respectively. The Slovenian company Lek, acquired by Novartis in 2002, invested USD$44M in manufacturing and production-related activities in 2004 before Novartis expanded its direct R&D capabilities in the country two years later with a USD$9M investment. Production and R&D capabilities by Novartis have expanded over time with further R&D projects in 2012 as well as new or expanded production-related investment in 2008, 2013, 2016 and 2017.

Geographically, although the initial R&D investment by Novartis selected Ljubljana as its centre, 'design, development and testing' investment in biological products in 2011 was located in close proximity to the production facilities established in 2004.

This dynamism confirms the importance of S4 Priority area III.2 Health-Medicine and shows the potential of R&D can co-locate with production, when the necessary supportive conditions are in place. However, in order to capitalise on upgrading through the value chain of this knowledge giant in Slovenia, policymakers should focus their attention on the key tasks that have the highest potential for spillovers and knowledge transfer in favour of domestic firms.

Similarly, Henkel's 2014 USD$4M R&D greenfield investment in the area of consumer products followed up from a 1990 Joint Venture with then state owned plant in Maribor.[165] From 2010 – 2015 Henkel invested more than EUR€40M. This is a positive result for upgrading, Maribor is now the technical competence centre for R&D, packaging, planning and microbiology for the entire company. However, it took Henkel 25 years to move from the initial production investment in Slovenia into R&D activity. This confirms that upgrading is indeed possible but it takes time and efforts to materialise. Supporting S4 policies could speed these processes up with a key role being played by investment promotion activities in reducing perceived risks of investment by addressing information asymmetries and facilitating the development of supportive investment eco-systems.

The remaining R&D investment projects span:

- Automotive components
- Software & IT services
- Industrial machinery and equipment
- Plastics

Due to the low number of R&D greenfield investments, a more systematic understanding of their drivers is problematic in absence of more qualitative information based on detailed data collection. In-depth interviews with decision makers and managers would be beneficial as part of the evidence-base for S4 strategies. Importantly, although some greenfield investment projects in production may not explicitly involve R&D facilities, they may still be undertaking some relevant product development activities. A 2016

165 See : https://www.henkel.com/spotlight/2015-05-21-25-years-of-henkel-in-slovenia-446056

survey suggests that 44% of interviewed firms undertook and claimed for R&D incentives, suggesting that the close connection between production and development might be a key feature of the innovation system in Slovenia, calling for more accurate firm-level data collections and suggesting that patents mgith be a poor metric in this context.[166] In this context, collaboration patterns between smaller innovation-oriented firms and the larger R&D performers discussed above is important for upgrading.

9.7.2. M&A in R&D

M&As involving R&D-intensive target firms have offered relevant learning experience to domestic companies.

There have been five acquisitions of R&D-intensive companies in Slovenia since 2003. Acquiring companies were headquartered in US, Czech Republic, Israel, Austria and Egypt. The trajectories of the target companies following their acquisition have been very diversified. This re-emphasises the necessity for policymakers to engage in the building, embedding and reshaping of GVCs. In the case of Coinbase Inc's 2014 acquisition of Blockr.io, it turned out to be an extractive investment where three years later the company shut down and moved to the San Francisco headquarters.[167] In contrast, the 2007 El Sewedy Group acquisition of Iskraemeco has been better embedded into the domestic economy by means of a clear set of requirements, generating value. The new parent company had to:

- invest EUR 30 million over the five years following the acquisition,
- not to reduce staffing levels
- keep the research and development activities in Kranj.[168]

Iskaremeco is still one of the largest sectoral R&D departments in Europe.[169] It is also among Slovenia's top 20 patenting firms.[170]

Other R&D-related M&A had stories that fell in-between these contrasting developments. For example Vivita was acquired to bring its parent company Frutarom advanced R&D capabilities and a top-rated management team. The intended result being a combination of both companies R&D and scientific expertise - expanding the product range. Others (the Solitea acquisition of Saop Racunalnistvo) were more passive, pursuing policies of 'non interference' in function and structure. The share of Slovenian patenting for Saop Racunalnistvo is 1/20th of that of Iskraemeco.

The above developments are useful evidence to inform future policies. Slovenia's S4 objectives can support the evolution and consolidation of Slovenia as a key R&D hub by:

- attracting foreign companies and
- strengthening R&D departments of existing companies,
- mobilizing top domestic talents, and
- attracting foreign experts and dynamic (start-up) companies

Iskaremeco and Vivita's cases highlight how acquisitions can strengthen R&D departments. This is either through the former's case of tied investment conditions or the latter's combination of parent and acquired company's R&D resources. Policymakers

166 Deloitte. (2016). Slovenia Corporation R&D Tax Report. Available at <https://www2.deloitte.com/content/dam/Deloitte/si/Documents/tax/si_RD-2016-Slovenia.pdf>

167 https://www.ccn.com/blockr-io-shuttered-by-coinbase

168 Deal information downloaded from Zephyr database

169 http://www.iskraemeco.com/en/

170 Slovenia Patent Assignees as of 3rd March 2019

can facilitate positive outcomes minimising the risl of job losses. Departments such as Spirit-Slovenia and Invest-Slovenia can play a key role in this, where actively involved in S4 strategies. Their active engagement can tie the acquiring partner to enhance and upgrade the firm and workers as part of a deal. With this active management, the key S4 objective of raising value added per employee can be achieved by leveraging Global Investment Flows.

9.8. A network analysis perspective on Slovenia's GIFs

Slovenia, although initially close to the inner core of the European Network of FDI flows, saw its centrality fall during the financial crisis. The response should be a pragmatic approach trying to absorb knowledge from the innermost core of the network.

The network analysis of Slovenia FDI flows makes it possible to study some key channels for internationalisation and upgrading. It provides a tool to understand the relationships and connectivity Slovenia has with other nations. Its empirical data driven approach makes it possible to identify three key features of internationalisation.

1. patterns of relationships between different types of locations
2. the evolutions of connections over time, and
3. illustrations of influence between the groups of countries and cities

Generally, locations in the innermost core (closer to the core of the network) have the most connections and influence. This is over and above the outermost periphery of the network. Being well connected to the core of the network becomes a critical element of being able to tap into FDI flows and to maximize the associated knowledge transfer capabilities.

9.8.1. Network composition over time

Appendix Table A2.1 outlines the overall network for both Slovenia and a set of *'comparison economies'*. This is both at country and city level[171] for both the entire period of analysis (2003 – 2017) and during the three pre, during and post crisis periods. At the national level two clear trends appear.

- Slovenia is close to the innermost core of the network, however behind all '*comparison economies'* which are all better connected with the core.
- During the financial crisis, the centrality of Slovenia in the network deteriorated substantially. This was particularly compared to '*comparison economies'*. The re-integration into the network of GIFs has been slow in post crisis years.

At a city level, these trends are more marked.

- Ljubljana is far away from the core of the global FDI network. This is particularly apparent when comparing it to '*comparison economies'* capital cities, which all appear much closer to the core of the network.
- Ljubljana's position in the global FDI network has deteriorated over time, moving Slovenian capital further away from the core.

When compared to EU28 member states, Slovenia's position should improve dramatically thanks to active internationalisation and territorial upgrading. Currently at the national level Slovenia is the outermost country in the network. Small policy changes

171 A city level analysis of the network can provide more refined results given the larger sample and detailed information related.

aimed at enhancing its centrality could have considerable effects on associated knowledge transfer. Those cities that are in the innermost core of the network and therefore potential targets for internationalisation are included in Annex 2. Strategic decision making linking S4 to some of these areas would enhance centrality.

For territorial upgrading in the framework of a S4 strategy, both at country and city level, efforts are necessary to increase Slovenia's centrality in FDI flows. A two-sided strategy approach would achieve this.

1. establish and intensify the connections with the most central nodes in the network
2. reinforce Slovenian connections with its peers' economies.

To move on up in the network hierarchy Slovenia needs to extend its connection towards a broad set of more central economies. This is rather than focusing on a small number of privileged places. The innermost core of the network is characterized by places with strong and wide connections among themselves. It is this ability to maintain a large number of connections with well-connected places that can ultimately diversify and de-risk an open economy such as Slovenia's. A diversified web of connections will help guarantee continual knowledge transfer. Encouraging inward and outward investments to core countries would be beneficial for upgrading Slovenia's economy. Particularly if these connections are embedded correctly within the GVC – deep-rooted and well spread over the core of the network. This seeking of GIFs should not be across the board. Quality matters more than quantity. There are areas of the Slovenian economy not yet fully equipped to absorb foreign investments. This pragmatic approach focusing to reinforce ties with peer economies, aiming to move upwards in the network, could also be advantageous in the long run.

The geography of greenfield investment outlined in previous sections of this chapter shows how Slovenia is well connected for inward investment with Western European countries and for outward investment Eastern European countries. At the same time the country lacked both inward and outward investments with other Macro Regions. Particularly Africa, Latin America & Caribbean and Middle East. These disconnected regions to Slovenia in fact have emerging countries located in the innermost core of the network. This allows strong and wide ties with other more developed countries composing the core. Moving closer to the core of the network is therefore crucial for Slovenia to achieve two aims:

1. Embedd and reshape GVC links with the most technologically advanced economies,
2. Build GVC links and connections to emerging economies.

The distinct lack of investment flows from emerging countries may be due to the difficulty that firms from further geographies have in understanding the Slovenian institutional context and vice versa. As discussed in Chapter IV innovation leading emerging country MNEs (EMNEs) are drawn towards regions where other similar EMNEs are located.

9.8.2. Network composition by GVC stage

In Table A2-2 in the Annex the same country and city analysis is performed looking at GVC stages. Investments in Sales, Production and Logistic & Distribution related activities have characterized the Slovenian economy for both inward and outward investments. The network analysis confirms the more central position of the country in these GVC stages with respect to Headquarter and Research & Development. However, the limited number of FDI projects in production activities to/from emerging economies does not allow Slovenia to move into the innermost core of the network. Again taking a EU28 perspective, Slovenia's production FDI connections are on a level similar to Estonia and Latvia. Slovenia seems instead able to retain a very strong position in the Sales FDI network in line with its 'comparison economies'. As seen in the previous Chapter, the presence of large Slovenian retail companies – such as Engrotus and Mercator – strongly investing in neighbouring countries can partially explain the ability of Slovenia to stay in the most central part of the network.

In developing S4 priority areas, mapping core countries active in similar areas as Slovenia's key policy targets would be useful in order to link with these knowledge networks.

Regarding a GVC stage particularly important for upgrading and innovation – that of R&D – Slovenia and Ljubljana are positioned at the periphery of the FDI network, lagging behind its '*comparison economies*' and EU28 counterparts. This is a direct consequence of the limited number of greenfield investments in R&D related activities. Successful inward and outward GIF strategies for innovation will require this to be reversed. Slovenia could achieve a better positioning in the network developing a wide range of connections with places with similar economic conditions. This is particularly true in the short run. If Slovenia looks exclusively to interact with economies characterised by highly advanced technology ecosystem short-term gains might be more limited. This would be because of the lack of technological proximity and congruence between the foreign FDI location and the domestic economy. In this sense a gradual and sufficiently diversified (in terms of foreign countries/cities) approach to FDI might offer more opportunities for upgrading in all sectors of the economy.

9.9. Conclusion and policy discussion

This integrated framework for the analysis of internationalisation and territorial upgrading has empirically and conceptually highlighted three main areas for policy change.

1. Slovenia needs to pragmatically diversify its GIFs
2. Upgrading needs to be holistic and account for territorial cohesion
3. Embedding GVCs is critical to de-risk the internationalised economy

Slovenia needs to pragmatically diversify its GIFs

A key takeaway from this report is the need for Slovenia's inward and outward investment to seek new knowledge. Post-crisis much of Slovenia's GIFs have not returned in scale to their previous levels. This combined with a small geographical connectivity results in limited opportunity for firm and worker upgrading. Decision makers should champion investment with a wider macro-regional base – particularly EMNEs. In 2017 signs started showing this, it cannot fall away. Pragmatic diversification will see Slovenia integrate into new knowledge networks and learn from peers. This will help increase S4's value-added per worker. Chapter IV.B outlines potential geographies of interest.

Size of investment does matter, but more important is its direction. Certain types of GIF will allow Slovenia to gain centrality, learning from a better connected knowledge core. Re-enforcing this connectivity is key. Yet, it is not just the technological frontier from which S4 can gain. Learning from peers is as critical as learning from leaders. Internationalisation can ensure knowledge transfer from all.
It is the channel and linkages which needs to be understood. This channel corresponds to the position Slovenia is in and what potential there is to learn. Pragmatism is key. Some channels are Slovenian sectors that are seeing increased GIFs. Some channels are value chain function than Slovenia wants to upgrade into. These areas of potential pursuit are outlined in Chapter IV.C.

Upgrading needs to be holistic and account for territorial cohesion

Upgrading is a powerful tool for enhancing innovation. It underpins the target of S4 enabling a shift to a high productive economy through boosting innovation potential. Technological advancement does not solely have to be driven by patenting. Process, product, functional, chain and other upgrading methods show firms and workers can indeed become more innovative. Some of the production investments leading to R&D investments highlighted in Chapter IV.E highlight this. Building and embedding appropriate GIFs can therefore be an effective way of supporting growth of new and fast growing companies no matter their size or technological scale.

A holistic and integrated approach must be taken. Cities and regions cannot all internationalise in the same sectors or functions. Policymakers must understand what position areas are in and what policy space is available. Regions must work in collaboration not in competition. This necessary holistic and integrated approach could also be championed by Slovenia's new investment promotion agency within the overarching framework of the S-4 strategy. They must play an active role. Ensuring MNEs are coordinated and benefits from internationalisation in terms of upgrading are distributed in a territorially and socially cohesive manner. GIFs are not a matter of quantity, but quality. They should be directed as such – linked suitably for region and for the firm.

Embedding GVCs is critical to de-risk the internationalised economy

Slovenia's size will restrict its ability to diversify like other EU28 counterparts. There is only a certain level of scale that can be achieved. Yet through mapping, Slovenia can develop the 'right' specialisation and functional profile. Building and embedding linkages between the GVC and the local economy. These don't necessarily have to be high-tech, evidence suggests research and innovation smart specialisation strategies might respond better in traditional sectors or activities [172]. Attention for technologically advanced industries should not overshadow the potential benefit to be derived from more traditional activities.

Embedding will be able to diversify the industrial makeup and alleviate future risk. Despite being quite internationalised prior to the crisis Slovenia has seen its position fall relative to its peers. There are economic consequences to the loss of knowledge flows through connected firms. Limited greenfield and M&A investment is correlated with the GDP retraction. In diversifying its approach and re-establishing an outward looking global network of firms S4 can bring innovative activities from overseas. With this there is risk in being over reliant on some specific value chains. This can result in occurring shocks being reverberated heavily as they run down the chain. To mitigate future difficulty, from potential future downturns, not being over reliant on some specific MNEs, but instead a wider range would help cushion global economic changes. This ties back in with the first policy conclusion – pragmatic diversification.

Championing internationalisation

Of S4 public incentives, 8% of allocation was planned for industrialisation, however to date 3% of total key S4 incentives have been delivered in this way.[173] S4's larger allocation to RTDI is important, however if Slovenia is to reverse the trend of GIFs then looking to the connected MNEs, their knowledge flows with respect to both outward and inward investment is critical.

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172 Crescenzi R., De Blasio G. and Giua M. "Cohesion Policy Incentives for Collaborative Industrial Research. The Evaluation of a Smart Specialisation Forerunner Programme", Regional Studies, 2019, forthcoming [OPEN ACCESS] Read also the VoxEu column : What works (and what doesn't) for smart specialisation strategies in Italy's Mezzogiorno: https://voxeu.org/article/smart-specialisation-strategies-italy-s-mezzogiorno

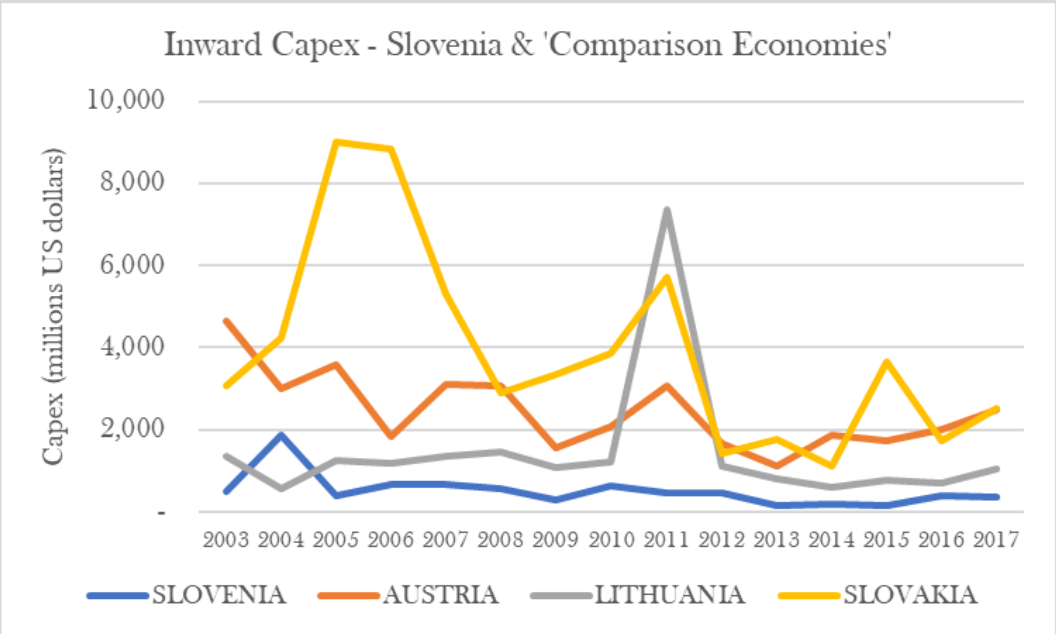
173 See http://www.svrk.gov.si/fileadmin/svrk.gov.si/pageuploads/KP_2014-2020/Strategija_pametne_specializacije/Angleska_stran/S4_incentives.pdf

The public policy space for empirically led internationalisation requires active engagement. With this integrated framework utilised, S4 will further enhance shifting Slovenia to a high productivity economy.

10. Annexes

Annex 1 - Greenfield Investment Comparison with EU 'Comparison Economies'

Figure A1- 1. Greenfield investments to and from Slovenia & 'Comparison Economies', 2003-2017 – Total Capital Invested and GDP shares



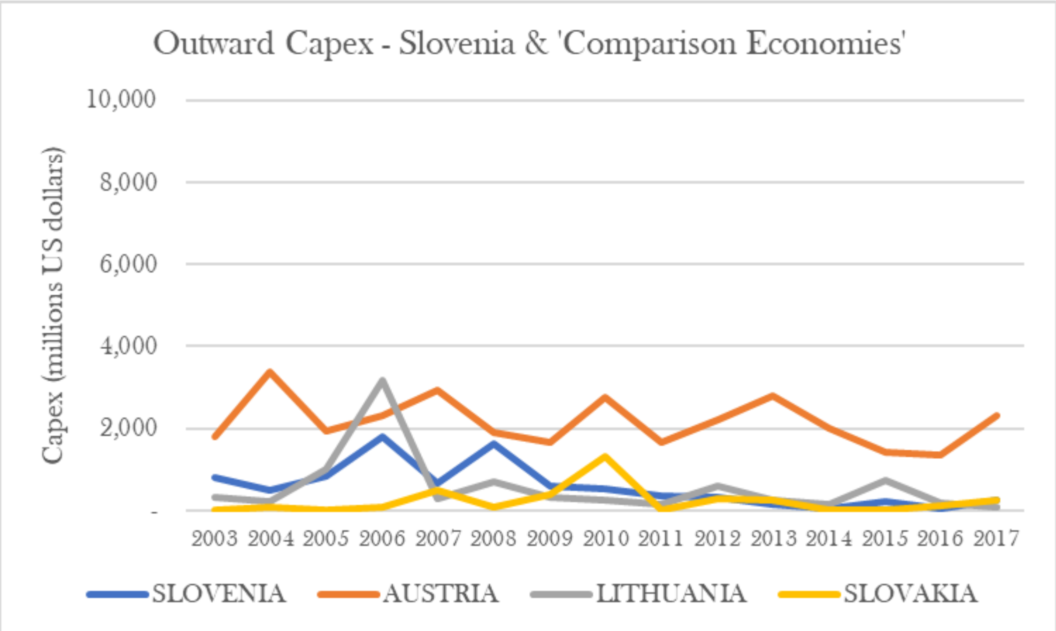


Chart Appendix 1.b Greenfield investment to and from Slovenia & *'Comparison Economies'*, 2003-2017 – GDP shares

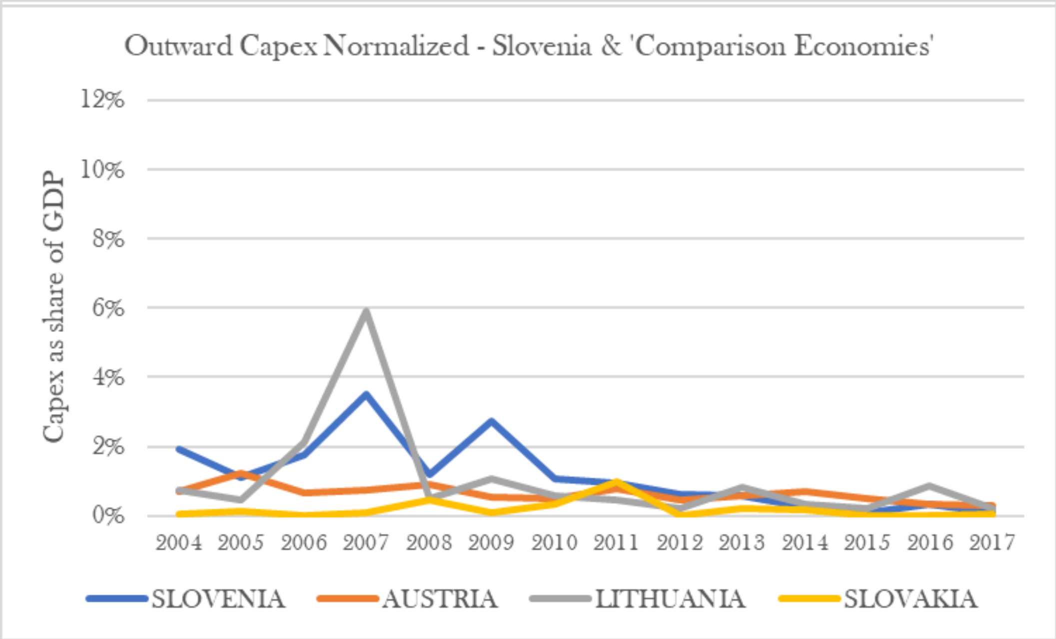
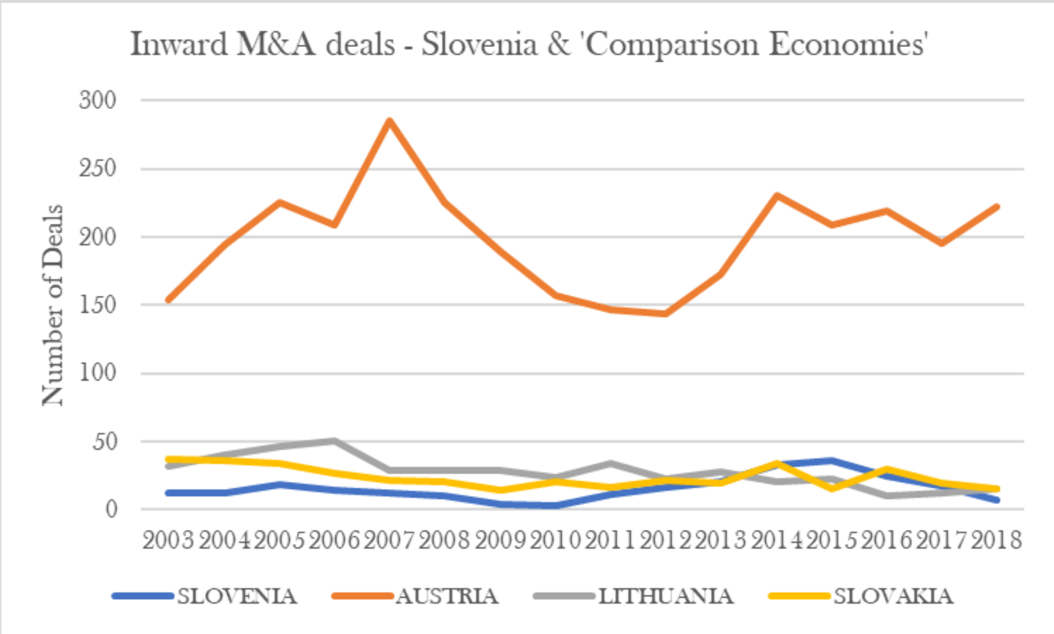
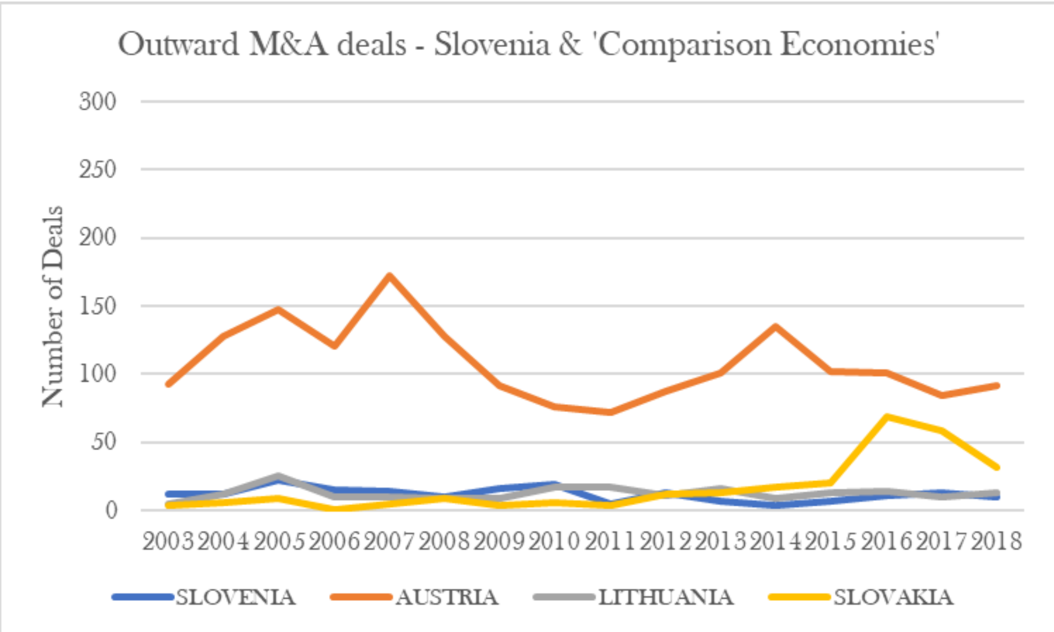
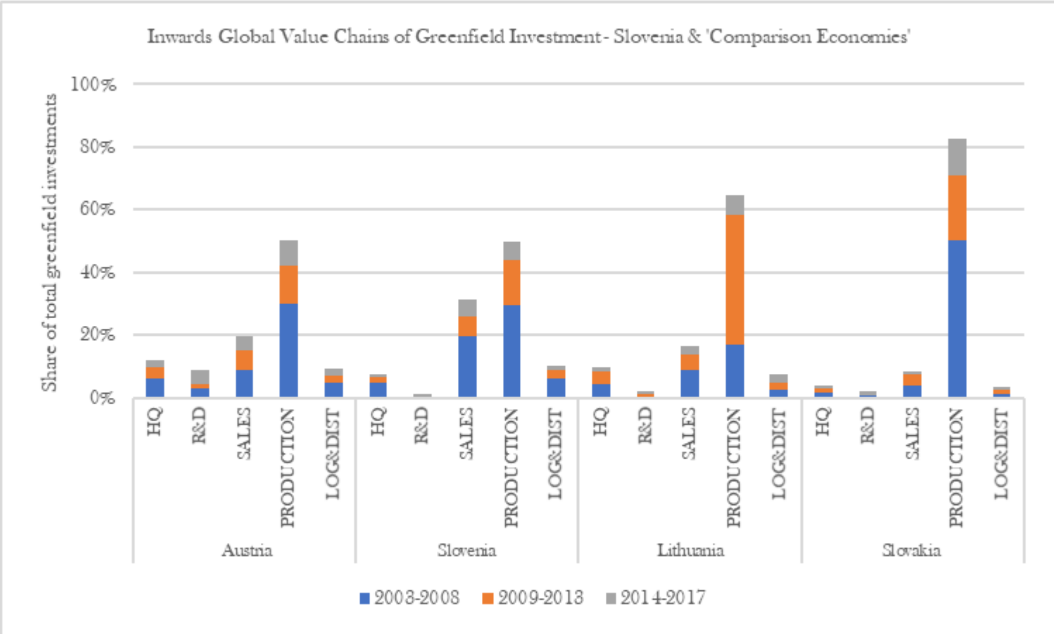


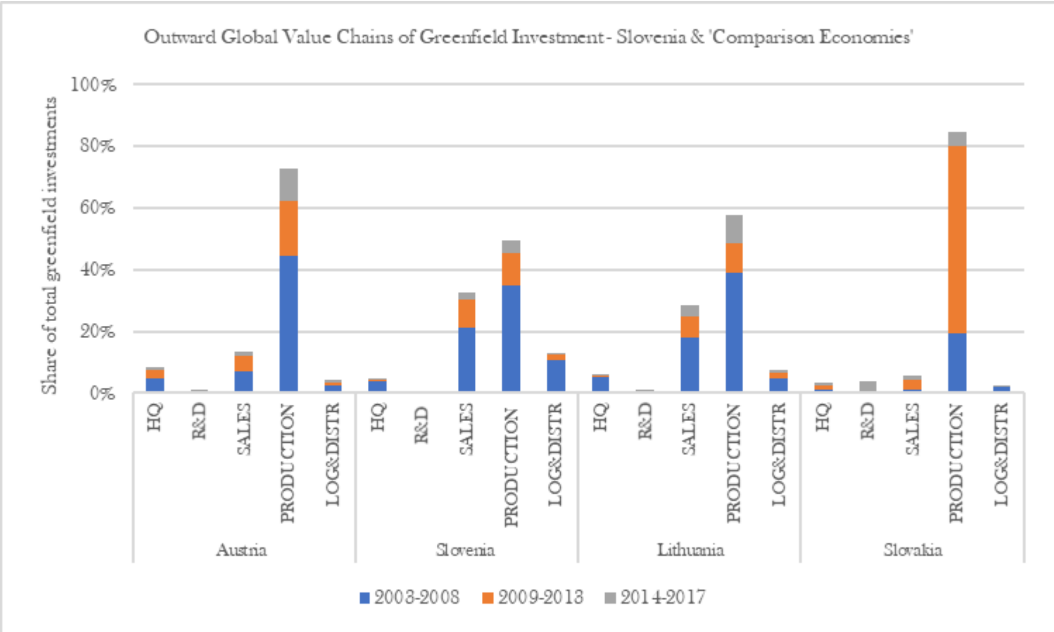
Figure A1- 2: Inward and outward M&A deals to 'Comparison Economies', 2003 – 2018





FigureA1- 3. Greenfield investment to 'Comparison Economies', Value Chains of FDI, pre/during/post crisis





Annex 2 - Network Analysis of FDI

To provide further information about Slovenian global connectivity, a network analysis based on the "*k-shell decomposition*" method is performed[174]

Using data related to greenfield foreign direct investments from fDI-Market database for the years 2003-2017, the *k*-core decomposition method partitions a network into sub-structures that are directly linked to centrality.

This method assigns an integer index, k_s, to each node that is representative of the location of the node in the network, according to its connectivity pattern: the number *k* of any *k*-shell identifies the minimum number of connections to other locations within that *k*-shell accruing to every location within that same *k*-shell, regardless of the number of connections to peripheral locations outside that *k*-shell. Nodes with high (low) values of k_s are located at the centre (periphery) of the network. For example, every location within the 30th *k*-shell of a network has *at least* 30 connections to other locations within the 30th *k*-shell, while a nested *k*-shell where $k = 45$ signals that every location within that *k*-shell has *at least* 45 connections to other locations within that 45th *k*-shell.

This way, the network is described by a layered structure (similar to the structure of an onion), revealing the full hierarchy of its nodes.[175]

174 Seidman, S. (1983) Network structure and minimum degree. *Social networks*, *5*(3), pp.269-287. Kitsak, M., Gallos, L.K., Havlin, S., Liljeros, F., Muchnik, L., Stanley, H.E. and Makse, H.A. (2010). Identification of influential spreaders in complex networks. *Nature physics*, *6*(11), p.888

175 As shown by Seidman (1983) in its work nodes with $k<3$ are too degenerate to be analyzed in much deep, and so discarded from the analysis. This provides a clear cut-off for core and periphery in a given network: any nodes with $k>3$ are considered cores of the network, while $k=1$ and $k=2$ are peripheral locations.

Table A2-1: FDI Network composition for Slovenia and 'Comparison Economies' – all years and pre/during/post crisis periods

		Years: 2003-2017	*Years: 2003-2008*	*Years: 2009-2013*	*Years: 2014-2017*
		innermost core=45	innermost core=35	innermost core=37	innermost core=34
	Slovenia	43	33	29	29
Comparison Regions	Austria Lithuania Slovakia	45 44 45	35 33 35	37 35 37	34 33 33
		innermost core=73	innermost core=35	innermost core=46	innermost core=44
	Ljubljana	44	23	20	19
Comparison Capitals	Vienna Vilnius Bratislava	73 67 66	35 31 31	46 31 37	44 37 33

Table A2-2: FDI network composition for Slovenia and 'Comparison Economies' – by GVC, all years

		HQ	***R&D***	***SALES***	***PRODUCTION***	***LOG&DIST***
		innermost core=30	innermost core=21	innermost core=37	innermost core=35	innermost core=22
	Slovenia	19	6	35	29	18
Comparison Regions	Austria Lithuania Slovakia	30 26 23	21 17 11	37 35 35	35 30 35	22 18 19
		innermost core=39	innermost core=20	innermost core=47	innermost core=23	innermost core=12
	Ljubljana	15	4	30	10	6
Comparison Capitals	Vienna Vilnius Bratislava	39 27 27	18 14 9	47 45 42	23 16 18	12 9 12

Table A2-3: FDI network composition for Slovenia and 'Comparison Economies' - Sectors, all years

		Goods Producing Industries	***Services Producing Industries***
		innermost core=40	innermost core=39
	Slovenia	36	31
Comparison Regions	Austria Lithuania Slovakia	40 38 40	39 35 36
		innermost core=47	innermost core=55
	Ljubljana	27	30
Comparison Capitals	Vienna Vilnius Bratislava	47 42 44	55 45 42

Table A2-4: Sectoral classification: Goods production vs service producing industries

Goods-Producing Industries	**Service-Providing Industries**
Aerospace – Alternative/Renewable energy – Automotive Components – Automotive OEM – Beverages – Biotechnology – Building & Construction Materials – Business Machines & Equipment – Ceramics & Glass – Chemicals Coal, Oil and Natural Gas – Consumer Electronics – Consumer Products – Electronic Components – Engines & Turbines – Food & Tobacco – Industrial Machinery, Equipment & Tools – Medical Devices – Metals – Minerals – Non-Automotive Transport OEM – Paper, Printing & Packaging – Pharmaceuticals – Plastics – Real Estate– Rubber – Semiconductors – Space & Defence – Textiles – Wood Products	Business Services – Communications – Financial Services – Leisure & Entertainment – Software & IT services – Transportation – Warehousing & Storage

Table A2-5: Core FDI Cities

City	Country
Paris	France
London	UK
Munich	Germany
Stockholm	Sweden
Amsterdam	Netherlands
Madrid	Spain
Dusseldorf	Germany
Vienna	Austria
Helsinki	Finland
Luxembourg	Luxembourg
Barcelona	Spain
Zurich	Switzerland
Dublin	Ireland
Milan	Italy
Stuttgart	Germany
Brussels	Belgium
Istanbul	Turkey
Berlin	Germany
Hamburg	Germany
Copenhagen	Denmark
Frankfurt	Germany
Bonn	Germany
Oslo	Norway
Koln	Germany
Antwerp	Belgium
Athens	Greece
Prague	Czech Republic
Basel	Switzerland
Budapest	Hungary
Espoo	Finland
Geneva	Switzerland
Warsaw	Poland
Cambridge	UK
Bucharest	Romania
Rotterdam	Netherlands
Rome	Italy
Gothenburg	Sweden
Manchester	UK
Lisbon	Portugal
Sofiya	Bulgaria
Lyon	France
A Coruña	Spain
Birmingham	UK
Glasgow	UK
Edinburgh	UK

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