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Evolution of ICT and Software Industry: Crisis, Resilience and the Role of Emerging Clusters

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I. Introduction

Knowledge intensive industries tend to flourish in a population of clusters in the world. This cluster population has strong dynamics of change, and clusters of different characteristics survive or decline during different episodes of technological lifecycle. Software Industry (SI), with its sister hardware industry, is a very interesting case for studying clusters as now the technology has become part of almost every industrial process and services. The strong dynamics of global geographical organization of the software industry makes it particularly interesting as a case to study resilience against crises. As well known, important SI clusters exist in both developed countries as well as a number of emerging market economies, namely India, China, Brazil, and Turkey. To name others, Ireland and Israel as well provide interesting cluster cases regarding embeddedness to local and global industrial networks, and how they mutually influence the evolution of the industry.

A brief look at the industrial history of information and communication technologies reveal that development is highly path-dependent and since the technological revolution of the transistors in 1960s the industry has been mostly influenced by an ever-changing relationship between multinational (later transnational) companies, governments and inter-governmental organizations. By the second revolution of microprocessors and official unbundling of software from hardware, local SMEs have become a powerful driver of the innovation processes and influencers of regional/national innovation policies starting by 1980s. The long-discussed off-shoring stories are only part of the story, as the industry meanwhile have shown many counter geographical moves including re-shoring of developed country MNCs as well as off-shoring of emerging country company plants. In a broader perspective, software and hardware industry has a very interesting dual character. In one way this large industry has transformed all other industries, and together with transportation systems it has enabled a time-space convergence of other industries globally. Yet, the software and hardware industries have themselves also experienced such convergence as production systems became global and embedded to different time zones. During this transformation, many clusters have emerged and some have either declined or vanished during periods of significant change: crises.

This paper evaluates resilience of software clusters in the case of Turkey, with respect to global industrial dynamics. Establishing first a resilience framework focusing on knowledge intensive industries, the paper continues by evaluation of adaptive cycles of global software industry and local cluster resilience. In particular, the paper discusses Turkey's software clusters and their resilience in line with other examples from the world. The study depends both on a survey of the specific literature, secondary data, a personal communications of the author by industry experts and personal evaluation of 250 software company profiles from Turkey that were established in the post 1970 period.

II. Global Industry and Local Clusters: Where Does Resilience Fit In?

There is now a substantial literature on resilience of industries and some of this literature refers particularly to knowledge intensive sectors (KIS). Yet resilience is discussed at particularly different abstraction levels, i.e. that of the global industrial resilience or the resilience of a regional cluster. The complete story incorporates both dynamics as global industrial resilience may require sacrifice of particular clusters, while at the same time let some others grow beyond their original regions and increase their influence through industrial networks. And of course, there is the birth of new clusters in new regions.

II.I. Alternative Approaches to Resilience

Resilience studies focus on three concepts, with different coverage and abstraction levels which could be useful in studying different cases or different dimensions of resilience and crises. In addition, slow-burn events which lead to crises at some point in time are harder to detect but often what shows “resilience” against a crisis is related to what is “emerging” through increasing variations of industrial and business routines. “Engineering resilience” as an example, addresses the ability of a system to return to its assumed stable equilibrium state following a shock (Martin, 2012b). By definition, this approach does not consider a change in the components of the system but rather on how the system continues its productivity and return to its ceiling output level (Simmie, 2014). Thus, applicability of this concept in studying more complex events is limited.

“Ecological resilience” refers to a more complex process where the system is thought to be elastic by the relationships it can establish between its components by employing alternative technologies and switch different equilibriums as a response to shocks (Martin, 2012b, Modica and Reggiani, 2015). This approach should be thought as a discussion in line with whether specialization or diversification in a region works for or against resilience. It is generally thought that diversity introduces a more flexible carrying capacity and enhances learning and adaptability to new configurations and thus is crucial for resilience in a region (Folke, 2006). Yet in evolutionary terms, such variation and adaptability does not seem to automatically ensure resilience of a cluster in a particular region as the variation created is an innovation and characteristically there is no guarantee that the innovation will be best applied in favor of the early innovators. The technology s-curve rather points that it is often not the original innovator who benefits the most from the innovation but rather those that are able to increase scale and scope of the new productive system. This might have particularly different impacts on different regions.

The third approach is the “Adaptive resilience”. It addresses the ability of a complex system to undergo anticipatory or reactionary reorganization of form and function to minimize the impact of a destabilizing shock (Martin, 2012b). By definition, this approach seems to fit better to study a population of clusters rather than a single cluster which may limit our understanding of how variation and adaptability are interwoven with slow-burn events and crises. Holling (2001) addresses that a system’s capacity to create, test and maintain adaptive capabilities determines its sustainability. From this perspective, a population of actors with varying powers of scale, innovativeness, sunk costs and ability to detent and retain variations, create some major trends in the sector which introduce opportunities but also simultaneously impose significant limitations on clusters.

A major issue here is then whether if the resilience of a local cluster is dependent on its ability to generate variety and potential for innovations? It is apparent that in a global industry variety is created in a large system and most clusters do only create small parts of the variation. The detection, retention and application of such variations require network relationships. In general these are roughly called as knowledge spillovers but the knowledge spilled and how actors respond to this knowledge is at the very heart of evolutionary processes in an industry. On the other hand general mainstream theories like New Economic Geography often assume that knowledge spillovers are solely useful for increasing productivity in a region and often adopt a simple linear thinking of cause and effect. These mainstream approaches often ignore the fact that increased variation builds into two things simultaneously: while each local cluster develops new variations, (or routines) these create new opportunities for actors which are able to invest globally and to increase scale of production. Innovations require cross-sector information exchange and diversity is thought to provide more resources that can be shared. In turn, this creates opportunities for the emergence of new activities (Holm and Østergaard, 2015) . In time, these dynamics can reach to a new situation of crisis where older technological systems in many clusters may not cope and new systems may emerge. Clusters which can overcome sunk costs and adopt newer systems will apparently not be common. The resilience of a cluster under these processes depends on both being able to take part

in newly emerging higher hierarchy structures while retaining its own integrity (Holling, 2001). The impact of such change in cluster and intra-cluster firm populations will then be significant on regional economies. That is why when studying resilience, a cluster approach seems to be better fit as it enables us to incorporate global industrial dynamics and assess how innovation dynamics and adaptive mechanisms lead to restructuring and geographic reorganization of the global industry.

(Fromhold-Eisebith, 2015) provide a theoretical framework in which actors constituting a global economic sector flexibly act and interact across different regions and scales, determining sectoral resilience. Regional resilience in this framework addresses the situation where in a regional arena flexibly acting actors are influenced by external factors or events. Both global and local actors may from time to time be aware of emerging situations and alternative development paths, anticipatively reconfigure these structures and sources and try to enhance their adaptability against a changing environment. They also adapt post shock collective responses to shocks such as market re-orientation, value-chain optimization, strategic corporate re-organization, focus on innovation and upgrading, relocation of production, and ecosystem dynamics of firm demography. According to (Simmie, 2014) actors try to increase their adaptability against anticipated shocks. But from a global perspective, actors do not only anticipate shocks but also are organizers of slow burn events that lead to shocks, and the challenge of survival is a continuous process, where new species always emerge through mergers and acquisitions (Filippov & Kalotay, 2011) or new routine spin-off dynamics (Frenken and Boschma, 2007).

While in the literature, collaboration between smaller firms in a local cluster is believed to be another behavior which reduces influence of the shock ((Fuchs and Kempermann, 2012) in (Fromhold-Eisebith, 2015)), in reality it is not uncommon that higher hierarchy actors establish, remote-coordinate and acquire or merge smaller firms in anticipation of shocks. As a result, the shock may lead to closing down of unproductive units and concentration on fewer units or off-shoring or re-shoring activities (Schamp, 2005) at the expense of some local components with significant impacts on spatial organization of industry, and on regional economies (Schamp, 2005).

The role of national and regional governance can not be thought in isolation from all these dynamics. Providing resources necessary for R&D, scaling up production, provision of public utilities such as communication and transportation, and establishing competitive regulations, governments are critical actors that play key roles also in evolutionary dynamics. Anticipatory regulations and inter-governmental or government-private sector alliances may play critical roles and lead to slow-burn events and crises having strong impact on global reorganization of industries. The power, capabilities and choices of national and regional governments in this context may be crucial in the emergence, growth and survival of clusters accommodated in the respective administrative boundaries (Todd, 2008, Simmie and Martin, 2010).

Clusters thus emerge, grow and decline as a spatial result of the complex interplay between global and local actors and innovation dynamics. The specific issue with the ICT technologies is that it has been one of the most innovative industries since 100 years, and from the onset of 1960s technological revolution has become a multinational and from the onset of 1980s microprocessor revolution a transnational industry. As place-bound and context specific institutional and actor constellations may lead to emergence of qualities of adaptability (resilience) in some localities (Bristow, 2010, Pike et al., 2010, Martin, 2012a, Boschma, 2014, Martin and Sunley, 2015), they may also be source of vulnerabilities of economic clusters.

Knowledge intensive sectors like ICT and software industries provide numerous examples of such dynamics. Value in knowledge driven industries are created by new knowledge and unique products and services whose major input is the product of R&D activities. Both legally defensible rights and inimitable organizational forms create high returns in knowledge intensive sectors (Mudambi, 2008). In this competitive environment, firms draw upon technological and knowledge externalities for enhancing their competitiveness. The supply base of these externalities are provided

by national innovation systems according to (Amin and Cohendet, 2004), but nevertheless regional (Asheim et al., 2011), cross-border (Lundquist and Trippel, 2011) or transnational (Yeung, 2009) innovation systems have become important. In knowledge intensive industries, alliances with governments, the disaggregation of value chain, retention of activities where it can create and appropriate the highest value, and outsourcing of operations that create less value date back to as early as 1930s, when IBM has disaggregated its activities to remote locations in the USA while also established strong ties with European companies before the WWII.

To create highest value, firms choose between alternative vertical integration vs. specialization strategies and concentrated or dispersed geographical location strategies (Mudambi, 2008). In knowledge intensive sectors, competitive advantages are best enhanced by dispersing MNC activities to benefit different regional and national innovation systems and by establishment of a unique coordination system (Lorenzen, 2005). The economic interplay between costs of coordination vs. growing up scale in narrow specializations create opportunities and vulnerabilities at different episodes of technology lifecycle whether before, during or after a crisis.

Table 1. Strategic choices of location and control for MNCs

		Geographical Location Strategy	
		Concentrated	Dispersed
Control Strategy	Vertical Integration	1.Onshore in-house	3.Captive offshore
	Specialization	2.Onshore outsourced	4.Offshore outsource

Note: Redrawn from (Mudambi, 2008)

II.II. Clusters in Knowledge Driven Industries

The four “ideal” cluster types as offered by (Markusen, 1996) Marshallian, hub-spoke, satellite-platform, and state-centered clusters exist in the knowledge intensive sectors. The global software industry is often embedded with the ICT industry in hub or state-platform type clusters. In real life conditions, a cluster’s structure varies between these different states (He and Fallah, 2011). Some clusters may be previously state dominated while may transform into a hub-spoke character due to government interventions or growth in the private sector. Some interventions may also aim at making use of different aspects of such clusters, i.e. by supporting SMEs in different periods. Adapting selective policies at various stages of a cluster’s life cycle might be useful to militate against decline and facilitate new development paths (Menzel and Fornahl, 2009). On the other hand the decision-making power of the cluster in the global industry also varies regarding the ownership of the hub company, power of the state and power of industrial alliances. Satellite platforms are accepted to be highly vulnerable as decisions are made externally and there is almost no local ability to develop new variations. Yet, many emerging country clusters in software industry have started initially as satellite platforms, but then turned into different clusters through state policies that depend on international alliances.

A more realistic cluster approach taking into account the global industrial dynamics and power relations is provided by (Suire and Vicente, 2014). Dominancy in exploiting global markets, having a mix of related and unrelated variety, a mixed pattern of core/periphery features, connectedness to periphery and having geographical bridges elevates the resilience of a cluster beyond the lifecycle of the technology. Clusters in scale-free networks benefit from variety created by core-periphery relations, and resist random shocks. Yet such clusters are more prone to crises associated with targeted interventions such as re-location of an MNC subsidiary as they get disconnected from higher degree knowledge flows (Albert and Barabási, 2002).

In the case of Munich, Germany, (Evans and Karecha, 2014) variety, local government leadership, pro-active learning, impact of hub companies and state were important on creating a strategic direction; high levels of entrepreneurship, and mechanism to create collaborations between smaller and larger enterprises were also effective for resilience of the knowledge intensive industrial cluster. (Mayer, 2013) finds that in Seattle case, both large company spin-offs and new start-ups contributed to diversification or branching out to new paths. As an example of ecological resilience, (Simmie and Martin, 2010) demonstrate that Cambridge, UK initially became a high-tech center in the 1960’s by university-led clustering efforts of small and medium sized high-technology enterprises, and after weathering the storm of 1980’s, and a new path of development was created through branching out into other fields. Cambridge’s continuous ability to de-lock and branch out to specialized high-tech industries helped it to quickly recover in times of economic recessions while Swansea could not cope. The adaptation of Cambridge seems to be starting with the phase of innovation and restructuring, and then by growth through seizure of opportunities, reaching to stability and rigidity, and a release phase. Then the new cycle begins, similar to adaptive cycle concept offered by (Holling, 2001). Swansea was not successful because of its satellite platform character which depended on external upstream activities of multi-national companies which relocated to Spain and Eastern Europe during 1990’s causing the emergence of new clusters there.

III. Software Industry Clusters and Resilience

The software industry is shaped by basically five periods ending with major technological changes accompanied by either economic crises and political changes, and geographical re-organization of the global hardware and software industries.

The first period: The first can be seen as the post-great depression period until 1960s. State supports to companies like IBM in the US and their anticipatory innovative and organizational movements have led to investments in more remote parts of the US, and European countries. These lead to counter-reactions from other countries like the UK and France, but also collaboration of companies from these countries with US companies. In this period of electro-mechanical ICT industry, IBM started a subsidiary as early as 1934 in Turkey's capital, Ankara, which would later become an important actor up to day.

The Second Period: This period was followed by specialization and stronger control processes, promoting bundled software services with mainframe computer systems, forcing other competitors in business machines to follow the course. As new governmental control structures emerged at higher hierarchies, like the NATO and the OECD, companies started to distribute more activities into developing countries, such as Brazil, Southern Korea, Argentine, and Turkey during 1960s (Göker, 2004, Arora and Gambardella, 2006, Botelho et al., 2005). In 1970's India started to export software coding and testing services to US public and private institutes in collaboration with a US hardware producer, Burroughs. India then started to provide more sophisticated on-site services. Indian policy started promoting local ICT industries in key locations like Bangalore in 1970s (Aspray et al., 2006) (Tiryakioglu et al., 2014). Israel, in response to the embargo of France in 1967, followed a public policy favoring foreign direct investments and specialization in certain fields, leading to strong development of software and ICT industries (Breznitz, 2005) (Tiryakioglu et al., 2014). Turkey's local software clusters were seeded during the import-substitution industrialization model which was effective until 1980s, similar to other emerging countries like Brazil or Argentina (Chudnovsky and Lopez, 2005, Botelho et al., 2005). Ankara and Istanbul became first locations for first computers in Turkey, installed by IBM during 1960-1965. The focus was more on development of highway system, banking and telecommunications in the post-coup country where local technological efforts were mostly abandoned and production under US licenses were promoted for local consumption. In this period, IBM moved its headquarters to Istanbul, which started to attract subsidiaries of MNCs.

The third period starts from 1970s. Companies in local clusters like those in Japan started to gain competitive advantages. In anticipation of state intervention in 1982, and shifting away from the maturing mainframe computer technology, IBM unbundled its products and services. A new industrial structure emerged, and US based companies repeated the adaptive cycle in 1980s and 1990s. New start-ups like Microsoft in on-shore (US) locations were used as outsourcers to provide competitive advantage globally especially against Europe which suffered from longer periods of commercialization of innovations (Cooke, 2001). Resilience of Silicon Valley was due to building new connections between established core companies and growing peripheral start-ups (Saxenian, 1990). US based start-ups then became strong MNCs by off-shoring their activities with new control mechanisms, introduced standardization and gained competitive advantage against off-shore competitors, as in the case of Japan (Metiu and Kogut, 2001) (Anchordoguy, 2000). Despite the fact that in off-shore locations, many new start-ups were also opening due to more liberal policies that replaced import substitution policies, only few countries; Israel, Ireland and India became important software exporters, and Brazil, Argentina, Turkey and China remained focused in customized software development for domestic markets, rather than exports (Arora and Gambardella, 2006, Botelho et al., 2005, Chudnovsky and Lopez, 2005). The decisions of MNCs to outsource elsewhere, in regions within relatively newer EU member states (like Madrid in Spain) had strong impacts on the resilience or failure of clusters in the UK (Cooke, 2001). During this period, state-sponsored clusters could grow and remain resilient in Europe (Nohara and Verdier, 2001, Sotarauta and Kautonen, 2007).

In the case of Turkey In 1970s, evaluation of company profiles reveal that new spin-offs started either from large local non-ICT companies or public institutions which were computerized during the previous decade. The objective of spin-offs was to outsource large manufacturers and banks. A new state-sponsored research cluster was established in Kocaeli, at the border of Istanbul, seeding the successful state-anchored cluster in Gebze. While 1970s is too early to speak about presence of a software cluster in Turkey, yet it is a period of aligning technology with NATO-OECD structures. After a military coup in 1980, import-substitution policy was abolished for the sake of an export oriented growth model similar to other emerging countries in line with the neo-liberal agenda. The author's investigation of software company histories reveal that initial software start-ups during 1980s started around 1984 and accelerated in the very initial core locations in Ankara and Istanbul, but also in downtown Izmir which became an advantageous port with access to Europe. The unbundling of software and hardware in the US and the new reorganization of the industry created suitable conditions for both MNCs and local companies in software and hardware industries to invest in these clusters in Turkey, similar to Brazil, China and India. Yet there were also problems: Due to underdeveloped national innovation system, lack of risk capital and other capabilities, some upstream activities in Istanbul re-located to original on-shore locations in more advanced Western countries (Göker, 2004). During this period, state-anchored projects and strong growth of local demand likely prevented full disintegration of established local clusters in Turkey. Another advantage was that Turkey has not invested heavily in mainframe computer technologies thus avoided sunk costs and technological lock-in situations. This advantage extended beyond 1980 well until 2000s. Turkey followed a similar path with Argentina and Brasil until 2000s with strong growth of ICT clusters during 1990s, due to liberations and state supports to SMEs (Chudnovsky and Lopez, 2005, Botelho et al., 2005). Author's investigation of company histories reveal that new spin-offs were opened in more peripheral locations near global gateways In the 1990s, like Kocaeli, Bursa and Kayseri, but they were limited in number. Growth was mostly due to new start-ups enjoying state supports in global gateway cities of Istanbul, Izmir and Ankara. MNCs like IBM had a stake in all these clusters: The private sector anchored and SME rich Istanbul cluster, The state-anchored cluster of Ankara, mixed cluster of the Gebze Cluster in Kocaeli-Istanbul border, and private sector SME dominated Izmir cluster which enjoyed a major network connection between Italy and Israel. Thus, each cluster were able to connect and benefit from global information networks, while the general atmosphere of low intellectual property rights and rich SME supports helped in rapid growth of local clusters beyond their original regions and extend to more peripheral areas.

The fourth period starts from mid 1990s and extends until 2007-2008 crisis. The number of global software companies grew until 1997. Increasing coordination costs forced companies to upscale on-shore overseas development capacity and work with fewer off-shore outsourcers. The number of large software producers then started to decline sharply by accelerating acquisitions and mergers before and after Dot.com crisis in 2000. During this period local clusters in off-shore locations had varying responses, but the composition of the global industry remained dominated by North American companies. The dominant companies shifted to service revenues from pre-packaged software sales revenues (Aspray et al., 2006) followed by few companies in emerging countries (Fois and Lysonick, 2012). In the post-dot.com period, more sophisticated parts of ICT and software services started to be offshored. (Aspray et al., 2006).

Silicon Valley's success in this period is claimed to depend on its capability in establishing intra-cluster collaborations (Pria and Vicente, 2006) and later dominating world markets, while resilience of the Waterloo cluster in Canada, (Bramwell et al., 2008), was due to the presence of a diversity of activities, and presence of non-local linkages and external knowledge flows. In Europe, MNCs preferred to adjust by nearshoring to new members and off-shoring to culturally connected countries

(Aspray et al., 2006). French Silicon Sentier's inability to engage in local interactions and its lock-in to specialized segments are claimed to be the causes of its crash after the Dot.com Bubble in 2001 (Pria and Vicente, 2006). Japanese software industry used a similar strategy of near-shore and off-shore outsourcing, similar to EU based MNCs, fueling growth of Indian and Chinese clusters. (Aspray et al., 2006).

In line with the global industry, company history analysis and expert interviews reveal that the software industry in Turkey went into consolidation in line with the global industry, leading to vanishing start-ups in peripheral areas and consolidation of power especially in Istanbul and Ankara. Yet Izmir remained resilient, by local anchor companies extending subsidiaries in Istanbul and Ankara and by further investment of MNCs. State sponsored projects continued especially flourishing all clusters but particularly Gebze and Ankara, where MNCs also enjoyed important R&D resources and infrastructure advantages. Istanbul's elevation as a global city by in migration of non-ICT MNCs regional offices boosted local demand. The opening of a Microsoft Regional Office addressing the Middle East and Africa markets was a crucial event, reflecting importance of resources provided by national innovation systems as well as importance of growing local demand from the financial industry. The anticipatory move of government on open source systems may be seen as a key source of resilience of Turkey's clusters during this period (Tiryakioglu et al., 2014). Another factor is the rapid government interventions and realization of techno-park projects in major universities in these clusters during early 2000s (Lenger, 2008). This increased production of related and unrelated variety and extended capabilities of local clusters to establish strategic alliances and focus on specialized markets beyond Turkey's borders. Company histories often address continuing spin-offs at a lower rate and mergers and acquisitions similar to that in the global industry. In this period, Istanbul was elevated as an upstream research center by MNC promotions and state-sponsored supports.

The fifth period: The global financial crisis of 2007-2008 first originated in the USA and the UK, and then affected Europe in the second half of 2008 (Di Caro, 2014). Although emerged from the financial industry, the crisis coincided with important technological shifts mostly originating from US based MNCs: a packaged software producer, Microsoft, started to produce hardware, while strong competitors like Apple, a hardware producer, and Google, a services provider, entered to the mobile sector. These events had diverse effects on different local ICT-software clusters (Østergaard and Park, 2015). Worldwide IT spending quickly recovered to pre-crisis levels by 2011 (Fois and Lysonick, 2012) but without a great change in the position of dominant actors and their dominant clusters in the world. New services started to create most of the revenues for software companies in this period, rather than packaged software, i.e. cloud computing services (PwC Global 100 Software Leaders [www.pwc.com/globalsoftware100]).

During 2009-2011, the number of creative employees dropped sharply and number of self-employed creative software professionals increased in contrast in the UK software industry, with negligible drops in productivity levels (De Propriis, 2013). This reveals a more ecological resilience type of reorganization in UK industry. The French software industry weathered the 2008 financial crisis well -except some individual clusters- by mergers and acquisitions and diversification into services (Syntec and Ernst & Young). In the wireless communication cluster in Denmark, software activities increased, while some major MNCs that generated spin-offs exited. In reaction a diversity of spin-off firms was established from existing companies within the cluster, and the university focused on the new generation 4G technology. These helped to stabilize employment loss (Østergaard and Park, 2015). The geographic dispersion of the software industry though, continued widely globally (Jiménez et al., 2009), promoting other locations.

In the case of Turkey ICT expenditures were hit in 2008, only to recover in 2013. The software industry recovered faster according to new TURKSTAT data. The production value in nominal Turkish Lira terms increased about 9% in 2009. Employment in software industry went down to 39.404 in 2009, from 48.454 persons in 2008. Similar to the UK case, number of workplaces increased rapidly to 3950. Average workplace size thus decreased from 15,75 to 9,98 persons. Employment in the industry recovered quickly and by 2011 it surpassed 2008's employment, but workplace size did not grow and continued to drop, reaching to 7,59 persons per company by 2013. The statistics reveal a booming number of micro-workplaces with less than 20 workers, reaching to 7.904 workplaces in 2013 from 3767 in 2009. Number of workplaces with 20-99 workers also increased rapidly from 127 to 418. Medium sized units with 100-249 workers increased from 33 to 56, while, number of larger workplaces was rather stable around 27. The data recovery (NACE Rev.2. J62.09) and computer facility management (NACE Rev.2. J62.08) segments did not see increased employment. Number of units in both computer programming (NACE Rev.2. J62.01) and computer consultancy services (NACE Rev.2. J62.02) rapidly grew. The data processing services segment contrarily registered a declining number of companies in the post 2008 period from 520 to 392.

(Sökmen, 2010) provides interesting findings on the post-crisis industrial structure of the software industry in Turkey. Outsourcing was similar to UK by 2010, where 34,1% did neither use outsourcing, nor serve for outsourcing, 46.6% used outsourcing but did not serve for outsourcing. Yet, other indicators represented structural similarities to Brazil or China. Of (Sökmen, 2010)'s sample of 439 companies in Turkey, only 19% of software companies were developing pre-packaged software while the majority worked on customized projects. Half of the companies produced both packaged and customized software. The market was dominated by large actors, generating 90% of revenues and 90% of exports. Unfortunately the export data is not very consistent in different resources. According to (Sökmen, 2010), software and services exports reached to 732.5 million USD, while (Tirpançeker, 2011)'s study on the whole population of software companies in Turkey indicate that exports were barely 100 million USD by 2011. A more recent statistic is provided by YASAD, indicating that 2013 exports were 680 million USD, while the domestic market size reached to 6.8 billion USD (YASAD, 2014).

(Akman and Yilmaz, 2008)'s empirical study on the sources of pre-crisis resilience of software companies in Turkey claims that resilience was due to high level of innovativeness. Innovative capacity was due to future awareness, customer orientation, mild competition environment favoring me-too products and shorter launch times.

The author of this paper's own evaluation of company histories reveal that anticipatory moves of software companies and IT services providers due to competition have become one of the factors which has elevated role of Istanbul software cluster before and after the 2007-2008 crisis years. As Istanbul became a regional hub of MNCs' targeting Africa and Middle East, and as earlier actors like IBM strengthened local ties, the level of intra-cluster and inter-cluster connectivity and the level of connectivity to international industrial system seem to have increased. The local companies responded as they followed a similar strategy by gradually branching into other local clusters through government supports provided for techno-parks and technology development zones in the pre-2008 period. These companies likely benefit local knowledge externalities and smoother production cycles, flexibility and customer orientation advantages due to multi-cluster locational strategies, while at the same time enjoy prolonged tax benefits arising from policy regulations. Some companies became successful exporters during this period, like Logo-NETSIS or Peak Games INC.

Ankara's elevation as the most important software cluster (Tiryakioglu et al., 2014) and Kocaeli's associated growth can be more attributable to Turkey's general elevation as a critical actor in international defense programs, Turkey's EU Accession process which initiates significant efforts for increasing government capacity for central and local governments, and paradoxically the stall of the EU Accession process by 2006. The stall extended protection for local companies and MNC subsidiaries against foreign competitors in public procurements, and likely prevented spread of

negative impacts of the crisis from the EU. In general, the companies in Turkey weathered the quasi-EU membership period well through state-anchored project supports at varying levels to all clusters.

The local restructuring of software and IT services industries point to some other dynamics in firm ecosystem. According to TURKSTAT data average productivity in the software industry decreased strongly in Istanbul from 108.939 USD per workplace to 75.559 USD in 2010, but then recovered 99.492USD. In Ankara average productivity was 75.574 USD in 2009, which slightly increased but fall back to same levels by 2013. İzmir with low levels of productivity, 25.142USD per company at year 2009, doubled its productivity reaching to 55.262USD by 2013. Bursa also increased its productivity from 42.795 USD to 60.303, and Kocaeli first registered strong gains and then strong drops in productivity, finally reaching to 56.427 USD per company in 2013. Temporary productivity gains due to large public projects seem to have been important in state-anchored clusters like Ankara and Kocaeli. In general, the above processes seem to have decreased inequalities of productivity levels across clusters.

Interviews and field observations in Istanbul hint that the software industry in Turkey employed a similar model that was employed by US venture capitalists before the Dot.com crisis (as addressed by (Cooke, 2001)). Many start-ups are opened and are encouraged to trade with each other in small geographies. Yet, the old problem of difficulties in control and maintaining quality with micro-firms still continues (Iyidogan, 2014).

Author's interviews in Bursa and Izmir demonstrate that increasing participatory planning practices at local level promoted local network development, while a strategy document by Ankara Regional Development Agency indicates that it is more likely for the capital city to establish stronger ties with higher hierarchy industrial structures like the Silicon Valley (Tiryakioglu et al., 2014).

IV. Conclusion

The global software industry seems to be following adaptive cycles. As variety increases and production becomes complex and cumbersome and returns start to diminish due to increased communication and control costs, private and public actors collaborate and introduce new models of growth anticipating potentials elsewhere. In the early stages of the model uncertainties are high so these actors try to spatially concentrate their new activities. As the model succeeds, a global expansion takes place, often finding its way through a mix of existing and emerging clusters in a selective manner. While some clusters are key initiators and these are often dominant clusters, other clusters are rather reactionary and try to associate themselves with current technology leaders. Having established geographical bridges, and accommodating some level of variety that is associated with the new reorganization of the global industry are key issues in the resilience of less dominant clusters. Over extension of spatial configuration and specialization and standardization in time creates increasing costs and limit further growth of participating clusters, opening up new opportunities for alternative technological pathways. Crises in this sense can be called as peak points for new opportunities and bottom line for those matured industrial organizations. Crises lead to significant changes in cluster and firm populations and their interrelationships globally. The role of national and regional innovation systems for local cluster adaptability and resilience lies in their competence in balancing supports to local companies and MNC participation, and their ability to shift between different cluster structures.

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