# Mid-tech trap: The case of Automotive Industry in Turkey

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**Abstract**

This paper uses a novel methodology to argue that Turkey has fallen to a mid-tech trap on the borders of a weak innovation system (IS) and a strong global value chain (GVC). We use detailed information from one of the main R&D and innovation funding agency (TTGV) to show that the technological sophistication of the funded automotive R&D and innovation projects remained fairly stable over the 1990-2010 period. For the robustness of this finding we designed two case studies. We first selected a group of beneficiary firms, then a selected a group experts on automotive industry in Turkey and conducted semi-structured interviews. The findings of the TTGV project level data are cross-validated by findings in the firm and expert interviews. Analysis at the project, firm and expert level indicate that despite extensive learning and technological upgrading in manufacturing Turkish automotive industry cannot build innovation capabilities that demand sophisticated technologies. Turkey's delegated position in the well-defined GVC and the joint venture (JV) structure seems to impede further technological development.

Keywords: automotive industry, technology, innovation, Turkey
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## 1. Introduction

The first attempts of producing automobiles in Turkey dates back to 1960s. A selected group of engineers were given the task of manufacturing the first domestic car in Turkey. Through reverse engineering three functioning prototypes were produced in 1961 by the name of *Devrim* (in English "Revolution"). Despite the heroic efforts the project deemed unsuccessful. Turkish automotive industry has come a long way since then to be considered as an excellent manufacturing base with about 10 global companies and a large supplier network manufacturing about 1.2 million vehicles per year (KPMG, 2013). However to set a sustainable development path of catching-up and leapfrogging the capabilities and learning in manufacturing have to be accompanied by R&D and innovation efforts (e.g., Kim, 1999; Lee and Lim, 2001; Bell, 2006; Lema, Qaudros and Schimtz, 2015).

Today's world creates various opportunities for the developing countries (DC) many of which are constrained by a weak Innovation System (IS) and strong Global Value Chains (GVC). Technological learning occurs in a local "natural" interactive process where knowledge diffuse and actors learn. In an IS where innovation is by and large incremental, capabilities are weak and interaction is low external knowledge may enhance the system (e.g., Viotti, 2002; Alcorta and Peres, 1998; Pietrobelli and Rabellotti, 2011). GVCs become handy at this point by providing an "artificial" global environment where local firms can learn (e.g., Gereffi and Kaplinsky, 2001; Gereffi, Humphrey, and Sturgeon, 2005; Morrison, Pietrobelli and Rabellotti, 2008). But in the process of technological upgrading DCs may find themselves stuck in a mid-tech trap between a "natural" weak IS and "artificial" strong GVCs.

The main aim of this article is to investigate the extent of mid-tech trap in the Turkish automotive industry. Turkey has achieved manufacturing excellence and technological upgrading however a similar argument cannot be put forward for innovation capabilities that would enable technologically sustainable development. Initial impetus led by the Joint-Venture (JV) and Foreign Affiliate (FA) structure and extensive support on production (and to a certain extent R&D and innovation) were instrumental in supporting learning in manufacturing which also was compatible with the export-led growth strategy. This research shows that learning in manufacturing has not been successfully transferred to capability building in R&D and innovation. Turkish automotive industry has reached a level of technological sophistication which is not sufficient for a forward leap. We argue that on the borders of a weak IS and a well-structured GVC Turkish automotive industry has fallen in to a mid-tech trap.

Our arguments can best be understood in a brief historical framework. In the closed economy of the 1960s infrastructure shortages, political and bureaucratic problems as well as shortage of physical, human and intellectual capital prevented industry formation. The government supported the industry by subsidizing business groups such as *Koç Holding* to foster (automotive specific) capital accumulation. Backed by the import substitution policies this process led to first organized attempts of production and the emergence of JVs such as *Tofaş-Fiat* and *Oyak-Renault* at the end of the 1960s. The industry reached a certain level of capital accumulation in the 1990s as new investments in manufacturing capacity were made. With the help of assembly production the industry reached a certain level of expertise in manufacturing of automobiles. As such by accumulating financial capital and investing in human and intellectual capital the import substitution period from 1960s to 1980s was an attempt to build capabilities. By mid-1980s Turkey started to implement export-oriented policies aiming to establish a fully functioning market economy. The customs union with the European Union in 1996 was a major test of surviving in global competition. The industry passed this test by obtaining licenses from foreigners to produce cars that can sell in large quantities in the domestic market (e.g., *Fiat-Tempra* produced by *Tofaş-Fiat*). In the past 30 years Turkish share in global vehicle production rose from a mere %0.1 to about %1.5.

The development briefly described above is of course not disparate from how technology shaped the world automotive industry. Automotive industry is governed by GVCs with strong entry-exit barriers and pre-determined profit margins (Sturgeon, Van Biesebroeck and Gereffi, 2008). The lead firms can decide on the part of the manufacturing process that is allocated to the sub-tiers of the procurer countries. Thus most procurer countries have a delegated role. What makes us argue that Turkey is in a mid-tech trap is the finding that the Turkish automotive industry has accepted the delegated role of being a mere manufacturing center.

To investigate the extent of mid-tech trap in Turkish automotive industry we follow a mixed research design where quantitative and qualitative analyses are in tandem. Data is collected on the automotive sector specific technology development projects from 1995 to 2011 using the Turkish Technology Development Agency (TTGV) database. This unique longitudinal data enables us to compare certain characteristics of the R&D projects through time. The quantitative part was complemented by two case study designs based on the beneficiary firms and the industry experts. The former involves detailed face-to-face interviews with 13 firms on the specifics of R&D and innovation process. The latter involves interviews with 14 experts consisting of R&D managers, CEOs of automotive firms and industry professionals. The experts are instrumental in presenting a micro to macro framework of the automotive industry. The expert interviews that present information at the macro level are complementary to the interviews at the firm level and the TTGV data at the project level. This novel research design provides internal and as well as external validity and robustness to our findings.

This paper is structured as follows. Section 2 briefly discusses the IS and the GVC literature. The following section describes the methodology with particular details of TTGV data, firm and expert interviews. Section 4 starts by presenting the results of the quantitative analysis of the TTGV data. The main findings are analyzed under three subtitles: manufacturing abilities, R&D and innovation process and foreign dependence. Section 5 includes a synthesis of the results with some policy recommendations. Section 6 concludes.

## 2. Literature: learning in innovation systems and global value chains

Technological learning and industrial upgrading is important for development (Kim; 1999; Lee and Kim, 2001; Giuliani, Pietrobelli and Rabellotti, 2005; Bell, 2006; Altenburg, Schmitz and Stamm, 2008; Lema, Qaudros and Schimtz, 2015). While today's technological, economic and geographic state creates many opportunities for the developing world it also generates local and global barriers for learning (Archibugi and Pietrobelli, 2003).

On one hand technological learning occurs in an innovation system (IS) where actors and interaction between actors matter. IS provides a “natural” interactive process of learning where firms and formal and informal institutions blend (e.g., Lundvall, 1992). The locality inherit in the system is conducive to technological learning but may also create lock-in situations (Narula, 2002; Bathelt, Malmberg and Maskell, 2004). On the other hand it is also possible to learn from the foreigners in an organized setup such as the global value chains (GVC) that provide an “artificial” global environment where local firms can learn from their foreign counterparts. However GVCs may also hinder technological learning depending on how much knowledge the leaders of GVC willing to transfer and how capable the local firms are. Thus a less developed country (LDC) may face a mid-tech trap on the borders of local natural systems such as the IS and global artificial organizations such as the GVC.

### 2.1. Learning in IS

That innovation occurs in a socially embedded learning system where actors interact is widely accepted by now (Lundvall, 1992; Freeman, 1995; Edquist, 1997). Within the wide literature of IS there is an emerging part that looks specifically at IS in developing countries (Arocena and Sutz, 1999; Edquist, 2001; Lundvall et al, 2009). While the concept is beneficial to understand innovation and technological learning in developing countries it needs fine-tuning to address the problem of development.

Pietrobelli and Rabellotti (2011) argue that innovation in developing countries is mostly incremental that occurs in a weak IS where external knowledge is important. In most developing countries even to achieve a certain level of technological maturity, firms have to learn and absorb new knowledge. This process involves a high degree of new to the firm learning and is by and large incremental (Bell, 1984; Ernst, 1998). Countries that govern learning-by-doing and learning-by-using phase successfully can in fact move to more active learning where transition to truly innovative environment is possible (Viotti, 2002; Chiarini, Rapini and Silva, 2017).

Technological learning in developing countries occurs in weak innovation system. Most of the time either the actors or the interactions are missing in the IS which creates barriers for successful firms. Comparing India and Brazil Guennif and Ramani (2012) argue that how divergence forms is very much related with how actors in an IS perceive windows of opportunity which boils down to capabilities. In another comparative study on Brazil, China and India McMahon and Thorsteinsdottir (2013) find that capabilities of local actors are of utmost importance for learning. The capabilities of the actors also affect network formation and being in networks as Dantas and Bell (2011) argue. There are various studies that show that actors lack capability and interaction is low (Alcorta and Peres, 1998; Dantas and Bell, 2011; Crespi and Zuniga, 2012). A weak IS is an important caveat for technological learning that demands a more active government policy. In developed countries the role of the government is to fix systemic failures, whereas in most developing and less developed countries government has to play active role in creating the system.

One of the most important differences in IS between the developed and developing world is the quantity and the quality of knowledge in the system. When technological knowledge of actors in the system is limited and interactions are non-existent or weak the process of diffusion of knowledge is interrupted. An important mechanism to alleviate the knowledge diffusion process so to enhance learning and technological upgrading is bringing external knowledge to the system (Carlsson, 2006; Fromhold-Eisebith, 2007; Iammarino, Padilla-Perez and Von Tunzelmann, 2008).

Part of the capability building in less developed countries is due to interaction with foreign firms. GVC is viewed as a form of learning by interacting with foreigners (Lundvall et al. 2009; Pietrobelli and Rabellotti, 2011) next to others such as learning from exporting (e.g., Wagner, 2007) and learning from spillovers as a result of Foreign Direct Investment (FDI) (e.g., Navaretti and Venables, 2004). By participating in the GVC domestic firms can learn from foreign firms and upgrade their technologies, which would enhance the variety and quality of knowledge in IS. When government is active in enabling interactions and/or when domestic firms demand such soft policies one can even talk about upgrading of the IS.

## 2.2. Learning in GVC

In essence the concept of GVC is related with how global production is organized. Technological advances and the favorable political climate enabled large firms to divide the production process and distribute the pieces to the geography on the basis of cost and quality restrictions. Multinational Corporations (MNC) view this vertically integrated fragmented production as a value chain where stages of production is carried out in a network of firms on a global scale (Gereffi and Kaplinsky, 2001; Gereffi, Humphrey, and Sturgeon, 2005; Pietrobelli and Rabellotti, 2007). This governance of global production provides various technological learning opportunities for the LDCs (Morrison, Pietrobelli and Rabellotti, 2008).

LDCs can benefit from the GVCs in several ways. LDCs can access to global markets via GVC so to leverage the learning effects from exporting. But more importantly GVC may transfer technical and managerial knowledge to firms in the LDCs. When such knowledge is combined with local capabilities in an IS LDCs can so to say move up the value ladder (Pietrobelli and Rabellotti, 2007). This moving up the value ladder may entail significant amount of technological learning and capability building. The firms in the LDCs can upgrade their technology in terms of learning and applying new processes and producing higher value-added products. However when GVC meets a fairly developed IS firms can obtain new higher value-added skills such as design and R&D and can even learn to tap in to new value chains (Humphrey and Schmitz, 2002; Pietrobelli and Rabellotti, 2011).

Gereffi et al. (2005) lists various forms of learning mechanisms with GVC. In the first place meeting standards, regulations and technical specification of the lead firms is in itself a learning mechanism that forces firms adopt certain skills just to tap in the value chain. Second form of learning is via technical and managerial knowledge transfer. This form of learning can be a by-product of interaction or can be deliberately organized by the lead firm. Training and turnover of key employees may also help local firms to learn from the lead firms in the GVC. For instance, Contreras and Carrillo (2011) show that spin-off process of the locally established lead firm in Mexico can in fact result in the emergence of knowledge-intensive firms within the automotive supply chain. By transferring complex manufacturing, managerial and to an extent knowledge related tasks GVCs can help the development process of the

LDCs under the assumption that firms learn from and/or imitate the lead firms in the GVC and through spillovers and further imitation knowledge spreads to local firms (Dutrenit and Vera-Cruz, 2005; Henderson et al., 2002). The idea of development enhancing GVC rest on the assumption that local firms in LDCs learn from the suppliers to the extent of the presence of backward and forward linkages.

Automotive industry is an example of GVCs with complex and dynamic interactions. Sturgeon, Van Biesebroeck and Gereffi (2008) defines the industry as global in codified knowledge (i.e., production) but local in tacit knowledge (i.e., design and R&D). Though there are technical (and even R&D) centers of lead firms in LDCs like China the conceptual design and heavy engineering remain centralized. Once conceptual design and modularization is complete suppliers that met stringent technical specifications and standards are integrated to the value chain. In a similar manner Pietrobelli and Rabellotti (2011) refer GVCs in the automotive sector as "modular chains" where capable suppliers produce technical modular parts under highly complex codified transactions. In most of the cases lead firms provide ready designs and specs and force the suppliers to commit certain technical specifications and standards. To fulfill the standards suppliers have to learn and innovate to acquire certain technological and managerial skills. Automotive GVCs can also be considered as captive and quasi-hierarchy value chains in which lead firms drive the value chain and decide who to produce and what to be produced (Gereffi et al, 2005; Pavlinek and Zenka, 2011). All such conceptualizations define a well-structured value chain driven by lead firms where tacit knowledge reside in the lead firms and codified production knowledge is transferred to suppliers elsewhere only if they can met certain standards.

In such a well-structured value-chain it is hard to move up the value ladder. The process of learning and technological upgrading that would enable this seldom includes the active involvement of the lead firms. As in the examples of Argentina (Albornoz and Yuguel, 2004), Brazil (Quadros, 2004) and South Africa (Barnes and Morris, 2004; Lorentzen, 2005), Turkey (Özatağan, 2011) and even in the International Joint Venture (IJV) case of China (Nam, 2011) suppliers and local firms do upgrade but mostly toward a particular direction so to become a "technology colony" as Barnes and Morris (2004) refer it neatly. Learning and technological upgrading at such a stage is of course possible depending on the capability of firms in the LDC, the state of IS in the LDC (Pietrobelli and Rabellotti, 2011), the active government policy such as the case of China (Liu and Dicken, 2006; Chu, 2011) and ownership of the technology (Lorentzen, 2005).

### 2.3. Mid-tech trap

We conceptualize mid-tech trap in a narrative where IS meets GVC (Pietrobelli and Rabellotti, 2011). To our knowledge the term has once appeared in a paper by Robert Wade as "middle-technology trap" to refer to situations where firms in middle-income countries stuck in low-value added segments of the global production chain (Wade, 2010).

In DCs a weak IS with capability and interaction problems limits learning and technological upgrading. Only capable local firms engage in GVC to create new learning opportunities but face a strong reluctance from the foreign lead. Thus capable firms of the DCs are pulled by the weak IS and pushed by the lead firms of the GVC.

Thus on the borders of IS and GVC there exist a strong mid-tech trap where both the IS and GVCs restricts technological learning opportunities. The concept of mid-tech trap is related to transition from a passive by-product of production type "doing-based" learning to a more active "non-doing-based" learning where firms deliberately invest in technological upgrading (Bell, 1984). A similar transition occurs from this active type of learning to building innovation capabilities (Viotti, 2002). Most DCs are trapped between "active" learning phase and innovation.

## 3. Methodology

One of the novelties in this article is the methodological approach. We employ a mixed approach that includes both quantitative and qualitative analyses (e.g., Teddlie and Tashakkori, 2009). The quantitative part is based on the TTGV data and provides information at the project level. Then we obtain detailed information on technology development at the firm level by conducting face-to-face semi-structured interviews. Finally expert interviews are conducted to assess the position of Turkish automotive industry in a global setting. We follow an explanatory sequential design in such a way that the qualitative part is employed to further interpret and contextualize the findings of the quantitative part (Creswell and Plano Clark, 2011). Figure 1 depicts our research design.

<FIGURE 1>

There are two main advantages of using mixed research designs. First of all, mixed designs provide complementarity (e.g., Morse 1991). In our setting neither of the research design stand-alone would convincingly address the research problem. TTGV data provide hard evidence which was instrumental to reach interim findings on the level of sophistication of the R&D projects conducted in the automotive industry. But it also left open doors for further analysis. The two case study designs on firms and experts were complementary in nature. They provide detailed information on some of the aspects that TTGV data could not verify. Second advantage of using mixed design is triangulation (e.g., Denzin, 1978). The findings from the TTGV data are cross-validated by two case study designs.

### 3.1 TTGV data

Technology Development Foundation (TTGV as the Turkish acronym) was founded as a non-profit organization in 1991 to support technology development in Turkey. TTGV aimed at increasing competitiveness by providing seed capital and R&D funds to Turkish industrial firms.

What makes the TTGV data interesting is that it is the antecedent of all R&D support mechanisms in Turkey. The data set covers the whole R&D support period of Turkey starting from the beginning of the 1990s. The longitudinal character of the data enables comparisons over time. Our data for the automotive projects come from the Technology Development Support Program of TTGV. Each project has a fact sheet and a full evaluation report (including interim evaluations). The data set was constructed by examining the fact sheets and the reports first to determine that the project is in fact related to automotive.[1] The first project initiated was in 1996 and

[1] Initially we selected about 500 projects that may be classified as an automotive sector project. Then these projects are carefully examined to determine whether the project is indeed an automotive project.

there were in total 86 projects in automotive till 2011. Our data set comprise information on firm characteristics (size, capital structure, location, R&D experience, etc.) and the characteristics of the project (budget, involvement in design, type and level of innovation, the technology field, target markets, type of customer, which component of a car that the project aims at etc.). Summary data for these projects are presented in Table 1.

<TABLE 1>

Table 1 shows that about 60% of the automotive projects are initiated by SMEs. Although the main aim of the program is to increase the capability of the SMEs big firms, OEMs and JVs commonly benefitted from the R&D supports. Most of the firms are domestic (the rest is either foreign affiliates or domestic-foreign partnership, i.e., the JVs), have quality certificates such as the ISO9001, ISO16949, Ford Q1 etc., and are involved in R&D activities before applying to TTGV. The beneficiaries are generally located in the Doğu Marmara Region (Bursa, Istanbul, Gebze and Izmit), which is the heart of the automotive industry in Turkey. When we look at the core activities of the firms we see that most applicants are suppliers. However OEMs and JVs constitute one-fourth of the project applicants.

One of the arguments in the paper is the technological sophistication levels of the R&D content were fairly stable over the years. To at least have an idea of what the projects are about we matched the R&D project to an automobile component.[2] Our intention behind this was to see whether through time there is an inclination towards more contemporary technologies (such as safety technologies, electronics component, engine etc.) rather than traditional technologies (such as body and body equipment). Table 1 shows that over the years most project applications involved traditional technologies. About one-third of all project applications were on body and body equipment. Only 8 projects (which is about one-tenth of all applications) in the whole period were on electronics, safety component and engines. This is a very subtle indicator that shows the technological sophistication level of the Turkish automotive industry.

### 3.2 Firm and expert interviews

We designed two case studies on firms and experts to cross-validate the findings of the TTGV data. Variety within the selected firms and experts is an important aspect of our case study design. In this way the findings are more compelling and robust (e.g., Yin, 2003). In both case studies we presented the interviewee brief information about the research but we specifically did not mention about the interim results we obtained from the TTGV data.

The first case study on firms aims to collect detailed information regarding the R&D context (content of R&D, novelty and OEM presence in decision making etc.), R&D output (customers, decision making in commercialization and the returns to R&D etc.) and firm strategy on R&D and innovation. The main objective behind this setup

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We end up with 102 projects however due to missing information 86 projects that have the full data were analysed.

[2] We used an unpublished study conducted by a group of acedemics that divides an automobile to detailed components (6 major) and sub-components (70 parts).

is to understand whether firms perform R&D in contemporary technological areas and whether firms are inclined towards more sophisticated R&D activities over time. We initially selected 15 firms among the firms that applied to TTGV Technology Development Projects Support mechanism on the basis of size, location, capital structure (domestic, joint venture, foreign affiliate) and core competences (suppliers, design and engineering firms, raw material manufacturer etc.). 13 of these firms responded (5 SMEs, 6 big firms, one joint venture and a foreign affiliate). The face-to-face semi-structured interviews with the R&D managers (or top-level managers) lasted on average one hour. The selected firms operate in diverse areas such as design and engineering, automotive component producers, raw material producers etc. The firms also vary in terms of type of end-product in the automotive sector (i.e., automobile, heavy vehicle, bus and tractor). Summary information regarding the selected firms is presented in Table A.2 in the appendix.

TTGV data analysis and firm interviews present complementary information at the project and firm level. Despite the rich information that project and firm level analyses provide we still lack a macro perspective. For this reason the second case study aims to collect information on the development of the automotive industry in Turkey, its position in the GVC in terms of manufacturing and technology production, and the future of the industry with specific reference to R&D and innovation activities. 20 names were initially drafted of which 14 responded. The general characteristics of the selected 14 experts are presented in Table A.3 in the appendix. Interviews took on average 45 minutes. Interviewees are mostly from the automotive industry. They have either previously worked in automotive firms or automotive related NGOs or are still actively working in automotive related firms or bodies. The backgrounds of the experts varies in terms of status (managerial positions in firms and NGOs), past and current work experience (from production, engineering and design activities to more top-level management) and background (policy-makers, consultants, R&D managers etc.).

In the qualitative research design three aspects are in focus. First we ask firms to evaluate their last five R&D projects in order to have an idea on the evolution of the content of R&D efforts. The interviews are tailored to investigate whether R&D activities of firms are in more design oriented contemporary automotive technologies (electronics, safety, engine, niche technologies). Second we focus on the content of innovation and decision making in commercialization activities. Finally we look at the foreign presence how this affect decision of domestic firms. If firms involve in design oriented R&D activities in contemporary technologies and has decision making power on commercialization and innovation we take this as a sign of increased technological sophistication in the Turkish automotive industry.

The three designs -TTGV data, firm interviews and expert interviews provide complementary information at different levels. TTGV data provide information at the project level, firm interviews at the micro level and expert interviews at the macro level. The main findings of this research are mostly validated at all three levels of the research design which we think is a unique characteristic of this research.

## 4. Results

### 4.1. What do the TTGV data tell?

In this section we analyze the automotive projects by investigating six indicators that reflect the quality of the R&D projects. These are *(i)* R&D content (i.e., whether the R&D involves modeling and design activities), *(ii)* type of intended innovative activity (process, product or both), *(iii)* intended level of innovation (new to the firm, country, world), *(iv)* auto-component the R&D address (traditional vs. contemporary technology), *(v)* intended benefiters of R&D (who uses the results of the R&D: OEMs & JVs or other parties) and finally *(vi)* market orientation of the projects (domestic vs. abroad). To analyze the development through time we divide the 16-year period in to two sub-periods of 8 years, one from 1996-2003 and the other from 2004-2011. The first period characterizes the deepening of the manufacturing capabilities of the automotive industry when first examples of industrial R&D start to emerge. In this period TTGV supports were instrumental in not only funding the industrial automotive R&D but also improving the image of the program participants (being funded by TTGV was used as a signal of capability). The latter characterizes a period where number of automotive R&D performers increase and funding opportunities expand. To convincingly talk about technological upgrading and innovation in the automotive industry we expect that in the second period the R&D projects aim at more design oriented product innovations that are at the world frontier. We also expect to find less presence of foreign JVs and OEMs which would mean that the firms have more decision power in commercialization activities.

<TABLE 2>

The results of this exercise are presented in Table 2. Since there are more projects in the second period looking at the absolute numbers would not mean that much for this reason we present the column percentages. Table 2 shows that intended level of innovation that reflects novelty do not display a clear pattern. In the whole 16 year period there are only 5 projects that can be classified as new to the world of which 3 belong to foreign OEMs and JVs. When we look at the type of innovations we see that in the first period the R&D projects predominantly aimed at product innovation while in the second period process as well as product innovations were at the focus. Process innovations are considered as a trigger of productivity increase whereas product innovations reflect increased market share. In this manner we can say that Turkish automotive R&D projects are more inclined towards augmenting productivity at the expense of increasing product variety.

The second set of indicators relate to the content of R&D projects.[3] We specifically look for design oriented R&D activities not dependent upon OEMs or JVs. Design and design confirmation processes are considered as a significant determinant of quality and technological sophistication. The project may involve modeling, design and design verification activities that are mostly conducted by the domestic firm or may be in the form of ready specs, know-how and technology transfer from abroad (from the foreign affiliate or a third party). Table 4 shows that almost all projects have

[3] From the project reports we were able to determine the activities of the R&D projects in detail. This information is provided in detail by the performer firm and it has to be approved by the field committee members who evaluate the projects.

design component however there is a difference between the two periods in terms of the source of such activities. Performers are more inclined to obtain know-how from abroad in the second period compared to the first period. If we consider the period after the economic crises (2008-2011) the pattern becomes even more apparent: in recent years more than 40% of the R&D projects use ready specs and know-how sourced from OEMs and JVs. The intended use of the R&D output numbers further supports this finding. About 60% of the automotive R&D projects are intended for foreign OEMs and JVs. This is a sign of foreign dependency which may affect R&D, innovation and commercialization decisions of domestic firms.

Finally from the project files we gathered information regarding which automotive component the R&D project address to. As explained in section 3 we first matched each project to 70 automotive sub-component; 6 groups and two main groups: *(i)* contemporary: electric and electronic component, safety component, engine and emerging engine technologies such as recyclability and telematics, *(ii)* traditional: body, body equipment and power transmission technologies. As Table 2 shows almost 70% of the automotive R&D projects are in traditional components and there is almost no change between the two periods.[4] It seems that the project portfolio in terms of technological areas did not change in the past 15 years.

Three important findings emerge from the TTGV data. First technological sophistication level of the R&D projects has not increased over time. Table 2 shows that there is no significant difference in the projects between two time periods regarding R&D content and output, auto-component technology and innovation type and level. TTGV's current project portfolio (around 2010) qualitatively resembles to its past at the end of the 90s. Second, Turkish automotive suppliers and manufacturers depend on global OEMs on strategic issues concerning R&D and innovation. Automotive R&D in Turkey is usually sustained with the provision of specs from the foreigners. This situation may restrict domestic R&D efforts to traditional technologies with less value-added. Finally though we do not report any finding towards an increased technological sophistication over time we can look at the bright side and argue that Turkish automotive industry has become an excellent manufacturing center and that the automotive firms are still learning.

### 4.2. Manufacturing abilities

Current global automotive industry has a well-organized structure with high entry/exit barriers and pre-determined profit margins that are consolidated by big players allowing little space for the latecomers such as Turkey. *INT1* specifically describes this current state as "*A branded car is manufactured at a cost of 75 percent of its sale price. JV has rights to sell it to a dealer or export it with 3-5 percent margin. Main branch of the JV is determining what part of the production is sold abroad and what part will remain inside. JV has rights to sell the part that is left for the domestic market with a margin of extra 12 percent. For a car sold in domestic market, the profit margin for JV is reaching nearly to 17 percent. The last 8 percent is acquired by the dealer. The growth of domestic market refers more value-added for JVs.*" In

[4] Interviewees also mentioned this point. For instance, INT5 argue that Turkey is capable of designing a whole vehicle but not succeed in designing components. Generally, engines, transmission components and axes are being imported from the global producers. Turkey focuses on body, body equipment, seats, interior trims and plastics parts.

such a well-organized scheme foreign firms establish branches in developing countries mainly for manufacturing and domestic market exploitation reasons. Most firms and experts agree that Turkey gained competence in manufacturing over the years. For instance *INT3* argue that "*with about 50 years of experience, we learned how to produce efficiently in good quality, how to implement production methods and produce a ready-made product*". In a similar manner *INT7* argues that "*Reaching a certain level of intellectual capital has been an accumulated process during the past 50 years. Turkey has reached this level by manufacturing. Now, manufacturing has reached a certain level of maturity. On tier 2 (supplier industry), quality, planning and lean manufacturing is well-developed. Before 2000, no one was expecting this kind of development*". Despite this development it seems that Turkey has gained capabilities by and large on manufacturing but not on technology development. *INT8* emphasizes this point "*Turkey is highly capable of automobile mass manufacturing. But this is the least profitable part. Government frequently refers to the association between the automotive industry and export performance. However we are manufacturing cars without absorbing R&D and developing technology*".

Being part of GVCs in manufacturing may create an industry with stable employment and export prospects but at the same time may hinder further development of the industry just as in the case of Turkey. Several arguments can be put forward on why Turkish automotive industry is unable to proceed to the next stage, i.e., sophisticated R&D and innovation capabilities. First of all, manufacturing excellence is more of a delegation problem rather than a choice. *INT7* illustrates this bluntly: "*Common transport is still on four wheels. Boundary conditions are certain and in this well-organized industry, corners are held by big players. The needs are determined and the prices are fixed. Turkey has accepted the rules that the western counterparts has established and has no power to change them. Developed countries are continuously changing and developing these rules in order to protect their leadership".* In such an environment radical (e.g. electric cars) rather than incremental innovation may change the rules of the game. The question is whether Turkish R&D base is strong enough to supply such radical innovations or new technologies in niche fields. Neither the government nor the major players in the industry designed necessary strategies and policy tools that would enable manufacturing capabilities to turn in to innovation capabilities. Turkey rather accepted the so-called delegated position in the GVC.

However one of the most important reasons behind underdeveloped innovation capabilities is the accompanying developments in the electronics industry. *INT11* argues that the lack of physical infrastructure, qualified workforce and more importantly intellectual capital were the main reasons behind why Turkey could not set up a solid electronics industry. The very first attempts to establish R&D labs and to conduct R&D in public (electronics) companies were interrupted by privatization (the Teletaş case, Yücel, 2016): "*By 1980s, there was a critical threshold; unfortunately privatization had slowed down the national efforts towards electronics. We speeded up in automotive but Turkish electronics declined. I strongly think that the failure in the adoption of electronics technologies in automotive has decreased the value-added being created in national automotive industry, particularly the suppliers'. This has also impeded the system design processes. The result is products with lower value-added".*

In a similar vein *INT8* emphasizes the role of electronics in engine design and in designing and integrating smart systems in automobiles: *"Electronics industry is a prerequisite for producing 'smart automotive systems'. Without a good electronics and software industry, it is impossible to design and produce engine control unit." INT1* approaches the issue from a wider perspective arguing that there are hardly any domestic producers of components heavily involving electronics and software: "*We have no manufacturers in automatic transmissions, engines, vehicle control units, software integrating with mechanic parts, brake systems. Furthermore, Turkey has no manufacturer producing boards and cards that are being used in automotive software. Unless you are uniting mechanics with software, it is hard to have more value-added."INT6* and *INT9* also underline the role that electronics played in automotive industry. For instance *INT9* emphasizes the (future) role of telematics as well as telecommunication: "*Among international projects, the most important ones are from the technological fields of telematics and telecommunication…ICT-driven technologies and manufacturing technologies are driving innovation in automobile industry*."

Almost all interviewers agree that electronics will be a key technology in the future especially with the developments in electric vehicles. Moreover most technologies related with customer-based tendencies on safety and comfort (such as heating, air-conditioning, entertainment, parking-assistance, ABS and ESP etc.) are by and large related with electronics. Given the customer satisfaction for the adoption of electrical vehicles and the attainment of rage extension targets seem to increase the probability of substitution of internal combustion engine technologies with electrical engines. This would mean that electronics would reach to the heart of automobiles.

Turkey seems to have ignored the strong effect of electronics on the national automotive industry. Policies towards privatization that emerged after 1980 weakened the national electronics industry particularly in hardware and component development. As such we can safely argue that not being able to establish a solid electronics industry is a crucially missed opportunity for Turkey which also by and large hindered technology development attempts in the automotive industry.

***Assertion 1*****:** For the global automotive industry Turkey is a manufacturing base. Given the well-organized structure of the automotive industry and ever increasing complementarities between electronics and automotive it is unlikely that Turkey will become an innovation base.

**4.3. R&D and innovation**

Looking at the TTGV data it is difficult to arrive to a conclusion regarding how sophisticated the R&D projects are. About half of the firms in our sample indicated that their products involve solely traditional technology and remaining half either focus on contemporary technologies or both. Firm's own assessment of the technology level shows that there is very little R&D that produces knowledge at the world frontier. Most firms argue that they have at least one R&D project in a niche technology that can be viewed as involving sophisticated technology.

We dig deeper to cross-validate these findings. Knowing why firms perform R&D, how R&D process is initiated and how much decision power does the firm have on the commercialization activities is vital to assess the potential of further development. Firms perform R&D either for cost reduction purposes (i.e., improving production processes) or to reach higher quality or produce new (niche) products. We specifically look for the existence of concept design and design confirmation processes when firms initiate R&D projects.

Turkish automotive firms are seldom involved in basic and experimental R&D. The R&D and innovation processes are not nurtured by basic and experimental R&D and accompanying design and design confirmation processes. Most ideas come from foreign partners/firms or outsourcers. Turkey (and Turkish firms) has accepted the delegated role of being a manufacturing base. Incremental R&D and innovation for survival are common elements of such an acceptance. For instance by comparing Turkey with Taiwan *INT3* argue that the source of innovation is not basic or experimental R&D which is an important handicap for the future growth of the industry: *"Turkish firms are performing R&D for survival. Turkish innovation system is incapable of supporting competitive projects. Turkish firms are investing on projects involving lower risks…one of the weakest side of the innovation system is that experimental R&D is not supported…Turkey also seems weak in basic research. In contrast, newly developed countries such as Taiwan are highly specialized in generic and advanced contemporary technologies such as nanotechnology and in basic science such as physics".* If not basic R&D and experimental research, what is the source of R&D in Turkish automotive industry?

A first step is to see where ideas come from i.e., whether R&D initiatives are ignited by market signals or by (direct commissioning of) outsourcers and foreigners. Taking market signals reflect that there is a more suitable environment for concept design unless the firm is assigned for this process by the outsourcer. As *INT1* puts it "*design and design confirmation are the most eminent processes of automotive manufacturing today. If you have presence in design, you take royalty and as a result, higher positions in the GVC.*" Atagan (2011) shows for several suppliers in Bursa (central hub of the automotive industry in Turkey) that reaching a co-designer phase has created opportunities in the upper segments of GVC. In contrast, taking ready specs from outsourcer and neglecting the concept design phase makes the performing firm more dependent on the foreigners. *INT8* emphasizes this point "*Designing concepts requires collecting data from the field – signals from markets, passengers, car users, dealers, manufacturers etc., so that you are able to design brand new models accompanying the needs of the stakeholders. Data help you design new concepts. However, developing countries such as Turkey are skipping this phase since the designs have been readily served by JVs. Without market analysis, it is impossible to develop concepts". INT5* similarly argues that design and innovation capabilities are of utmost importance in the automotive industry: "*Given the ease of reaching capital, investment, technology and resources today, design and innovation are of vital importance to provide competency in the global industry. It is not hard to find money and technology*".

Though data collection for concept design and design confirmation processes are vital for gaining design and innovation capabilities *INT8* argues that most automotive firms in Turkey are far from such understanding: "*We lack in design and design confirmation. We cannot develop concepts maybe because the industry is highly dependent on JVs. We are not even developing engine or power transmission.*" *INT3* also emphasizes the role of designing concepts rather than designing whole vehicle (or component). Interviewers generally associate concept design with a sophisticated phase of technological development which is nurtured by market signals. Firm interviews also corroborate this finding. Table 3 shows that firms seldom take signal from the market but rather depend on foreign partners and outsourcers.

Table 1 (TTGV data) and Table 3 (firm interviews) show that design and design confirmation processes are generally skipped because firms use ready specs made available by foreign outsourcers. We can argue that Turkish firms (domestic, FA or JV) are missing a vital step in routine formation for developing technology. This finding is in parallel with the findings of Ölmezoğulları (2011), stating that there is some kind of a lock-in situation of Turkey on co-designing activities. The only exception to this rule is the large firms (*BIG1*, *BIG4* and *BIG5*, see Table 3) that conduct R&D in niche technologies in addition to their core areas. Most firms rely on signals from the outsourcers to determine the technological area and content of R&D activities. The rest depend on the OEMs and foreign head-quarters. Only one firm in the interviews (*BIG1*) state that they completely rely on market signals to conduct R&D. Some firms use mixed R&D strategies where the original idea either comes from the outsourcer, OEM, foreign-affiliate or the market.

The above picture might seem as the dark side of the R&D and innovation context of the Turkish automotive industry. But on the other side taking R&D projects from headquarters or foreign outsourcers might give the capability of triggering local in-house R&D activities. *INT6* gives a good example for such a case "*In TOFAŞ* (JV of FIAT), *Doblo was the very first car that was fully designed and manufactured in a JV in Turkey. TUBITAK supports were effective in manufacturing the prototype. R&D department in TOFAŞ started up with 10-15 persons and then dramatically increased to 350-400 persons*." However attracting R&D from abroad is not sufficient. The performers of R&D, rather than "*dancing with foreign affiliates*" as *INT3* illustrates, should be involved in comprehensive learning and interactions in order to benefit from the commissioned R&D. This requires an increase in the quality of interactions between Turkish firms and global OEMs as Pamukçu and Sönmez (2011) and Sönmez (2013) argue. This would also help to substitute low value-added production with "high value-added, original and branded-designs" by transforming manufacturing capabilities into design capabilities (Ekmekçi, 2009).

***Assertion 2:*** The delegated role as a manufacturing base shapes the main characteristics of R&D and innovation. Turkish firms conduct R&D and innovation for survival, hardly involve in basic and experimental R&D and mostly skip concept design and design confirmation processes.

***Assertion 3:*** Firms in the DCs can benefit from foreign idea generation and commercialization process if and only if it enhances social capital as well as human and physical capital investments.

### 4.4. Foreign dependency

When the source of R&D activities, their content and decision power in commercialization are considered our findings reveal that Turkish firms are highly dependent on foreign OEMs and JVs. The JV/FA structure in the automotive industry hinders Turkish manufacturers and suppliers to participate in the decision-making processes. Firms are unable to participate in confirmation, regulation and homologation processes.

JVs and the supplier industry in Turkey managed to survive in export-oriented open market policy regime by merging with foreign firms or performing projects based on the decision of the lead firms in the GVC. This helped Turkish firms to survive in fierce global competition at the expense of independence on strategic decision-making on research and innovation activities. JVs took advantage from this structure to a certain extent by gaining R&D capabilities however the foreign-dependent structure in the industry hurts the R&D efforts of the local suppliers. *INT3* summarizes the current situation as *"Between 1995 and 2005, in addition to the main industry, the supplier industry integrated with the foreign markets through mergers and acquisitions. This impedes Turkey's presence on decision-making processes of the global automotive industry. R&D efforts have seriously been lowered because both JVs and the supplier industry are based on foreign partners. Domestic firms are operating solely on defense and bus industries. This situation has inevitably made Turkey dependent upon foreign decision makers."* As we discussed in section 4.2 Turkey has accepted the delegated role of being a manufacturing base rather easily for short-term economic gains (i.e., keeping competitive position, export revenues, employment etc.) which led Turkish firms to depend on foreigners regarding R&D and innovation decisions as *INT5* argues *"If you are highly dependent on the JV structure, it is not allowed to make your own R&D. Your innovations remain at the firm-level or at best national level. Temsa, Otokar, Karsan and BMC are the only Turkish manufacturers having their domestic products".* It is important to note that none of these companies are automobile producers. However the Fiat Doblo and Ford Transit Connect cases reveal that when manufacturing goes hand in hand with decision making in design and design confirmation processes innovative capabilities can nurture.

In the Turkish automotive industry R&D projects are initiated by the foreigners and domestic firms have very little decision power in commercialization which supports previous research (Ölmezoğulları, 2011; Pamukçu and Sönmez, 2011). Big firms try to operate a dual structure, one which is related to their core technologies where most revenues come from (survival); and another which they invest in niche technologies to penetrate in to new markets (growth). In the former case the firms, though big, are mostly dependent on OEMs and outsourcers regarding R&D, innovation and technology production. In the latter case firms are more independent in decision making. For example, *BIG1* which is a design and engineering oriented firm has developed R&D projects in niche areas such as electrical car components but in their core business (building up custom-made automation lines to Turkish JVs and global OEMs) they are highly dependent on foreign partners. Similarly *BIG4* is rather independent in R&D and innovation decision making because it works in niche areas which is not driven and guided by global OEMs and that the foreign partner has departed.

When we look at the commercialization decisions on the performed R&D the structure does not change. Table 3 shows that almost all firms are either dependent on the OEM or the head-quarter (in the cases of *FA1* and *JV1*) in commercialization decisions. Firm interviews also show that only big firms tend to be more independent both in terms of idea generation (where innovative R&D ideas come from) and commercialization. *INT9* puts it bluntly: "*Innovative projects are not being developed within the sector. For international projects, innovative ideas are coming from SMEs and Research Centers. Main car manufacturers are operating as test-beds of these projects"* So not only in commercialization but also in idea generation Turkish firms depend on foreigners as firm (Table 3) and expert (Table 4) interviews show.

***Assertion 4*****:** Most automotive firms in Turkey rely on ideas and specs readily made available by foreigners and lead firms in the GVC that outsource R&D. Local firms are not independent in commercialization decisions even though such R&D activities produce incremental innovations.

***Assertion 5*****:** Firms that rely more on the market signals, invest in concept design and design confirmation processes are more likely to produce niche product innovations in which they have full authority on commercialization.

## 5. Synthesis

Table 5 summarizes the findings of the analyses at the project, firm and macro level. The first column lists statements based on the assertions of section 4. We analyze the robustness of each statement by investigating whether the statements are supported at different levels of analysis. In this manner, Table 3 (firm interviews) and Table 4 (expert interviews) show within-level and Table 5 shows between-level robustness.

The between-level results show that there has been extensive learning in the industry, which was used to establish excellent manufacturing capabilities. But for catching-up or leap-frogging an innovation ecosystem should form on the basis of excellent manufacturing capabilities where the industry can also design, commercialize and sell (radical or niche) new products/processes. As Table 5 shows there are various problems in establishing this ecosystem. Analyses at the project, firm and expert level show that Turkish automotive industry is predominantly involved in R&D activities on traditional components; conduct applied R&D; invest in incremental (process) innovations and rely on foreign (JVs, FAs, headquarter etc.) knowledge in idea generation and commercialization – a structure which has not changed significantly after 2000. With such an R&D and innovation portfolio it is hard to expect radical innovations or niche innovative products.

As discussed in section 4.2 the delegated role of being a manufacturing center resulted in learning and increased capability. However Turkey was not successful in making the next leap towards capability building in design, R&D and innovation. This attempt would mean a "fight back" against the delegated role. Turkish government and the industry made strategic mistakes in the process which constitute the seed-bed for the mid-tech trap. Our findings reveal that complementarities among sectors are crucial for the sustainability of the automotive industry. The privatization attempts in the 1990s especially in the government led electronics sector was an important strategic mistake considering the future of automotive industry where electronics and automotive converge. Lacking complementarities coupled with the decision to maintain short-run competitive position for export revenue and employment the foreign presence that was crucial for learning started to be a handicap for further development. Thus the impact of JVs and FAs on the technological

development of the Turkish automotive industry has an inverted-U shape. Foreign dependence helped technological upgrading and gaining excellent manufacturing capabilities but currently impedes technological knowledge production.
One way to overcome the mid-tech trap is to design government policy accordingly. The government can initiate several policy attempts based on our findings. First of all, Turkish R&D funding schemes (TTGV, TUBITAK and alike) has been useful in capability building and creating awareness regarding R&D and innovation (Üçdoğruk, 2005; Taymaz, 2006; World Bank, 2006; Özçelik and Taymaz, 2008). The R&D and innovation support schemes have helped the automotive industry particularly in a period when the industry face fierce competition and new global challenges. However the current support scheme is very much standard which we think is a major source of inertia for further R&D and innovation efforts. We argue that supporting scheme should be more selective and favor projects that offer technological complementarity, concept design and especially R&D and design attempts in niche products rather than processes. TTGV data and firm interviews reveal that firms whose products involve contemporary technologies (such as whole vehicle manufacturing, electrical vehicle, fuel cell, direct spare technologies) and that are able to diversify core competency by penetrating into niche areas (such as composite material, micro-hybrid and gel accumulators, leaf spring technologies) are more likely to reach a level of technological sophistication.

Learning depends on the linkages between the FAs, JVs and the domestic suppliers or OEM. There should be specific policy tools that would enable firms to leverage foreign know-how. Especially enhancement of backward and forward linkages is crucial for further development of the industry (see Pamukçu and Sönmez, 2011; Sönmez, 2013). However R&D and innovation support scheme in Turkey is very much concentrated on financial supports. Soft tools are hardly being used by policy makers. There is also little demand for such tools to enhance knowledge exchange. The government should devise complementary soft policy tools to support knowledge exchange between foreign parties and domestic firms and within domestic industry. The government can also use this as a signaling device to reflect that the R&D support scheme is changing – from financial funds oriented toward being knowledge exchange oriented.

## 6. Conclusion

This research shows that Turkish automotive industry has come a long way to be accepted as an excellent manufacturing base. The JV and FA led foreign presence and extensive support on production and technological upgrading coupled with an export-oriented government policy shaped the current state of the industry. We argue that the manufacturing abilities have not been successfully transferred to innovation capabilities. Turkish automotive industry has reached a level of technological sophistication that back excellent manufacturing but do not have the necessary impetus to leap forward. On the borders of a weak IS and as strong GVC structure the Turkish automotive industry has fallen in to mid-tech trap.

Our research reveals three important lessons for the developing countries. First of all, complementarity among sectors is crucial for long-run sustainability that entails technology production on top of manufacturing abilities. We show that lack of complementary skills in electronics industry was a major handicap for technology development in the Turkish automotive industry. The case of Turkey can easily be compared to the case of South Korea (e.g., Park, 2003) where capability building in electronics and automotive industries was a joint effort that was aggressively backed by the government. Second diversification strategy is a way out to break the mid-tech trap. Turkish automotive firms are stuck in manufacturing whole vehicle using ready specs provided by the foreigners. At the best firms conduct R&D and innovation activities on traditional auto-components that focus on few areas and which by and large produce incremental knowledge. Our study reveals that firms that are able to diversify especially in niche areas become more independent in generating research ideas and commercialization. Finally, foreign firms in Turkey have penetrated in to the "structure" of the automotive industry and at the moment is a major factor that withholds further technological development. The inverted-U type effect of foreign presence on the automotive industry can best be eluded by active government policy just as in the case of China (e.g., Chu, 2011).

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**Figure 1: Research methodology**

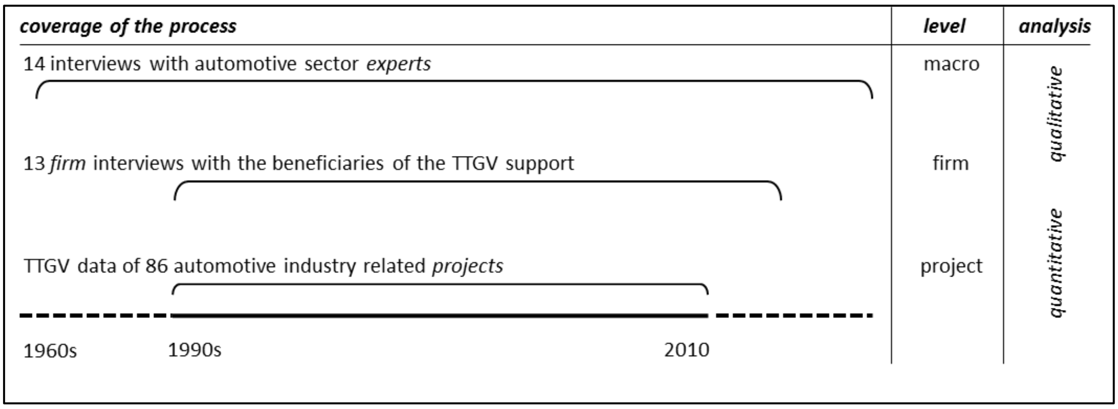

**Table 1: Summary data of TTGV automotive projects, 1996-2011**

| | | |
|---|---|---|
| SMEs | 52 | (0.60) |
| Has R&D department? | 57 | (0.66) |
| Applications by domestic firms | 73 | (0.85) |
| Applications from Doğu Marmara region | 50 | (0.58) |
| Firms having quality certificates (ISO9001; ISO16949 etc.)** | 67 | (0.81) |
| Firms that are involved in R&D activities before application | 61 | (0.71) |
| Core business of applicants | | |
| OEMs and JVs | 19 | (0.22) |
| Auto-suppliers | 53 | (0.62) |
| Engineering and consulting firms | 8 | (0.09) |
| Core business other than automotive | 6 | (0.07) |
| Projects by auto-component classification | | |
| Body & body equipment | 30 | (0.35) |
| Power transmission | 13 | (0.15) |
| Electronic component | 1 | (0.01) |
| Safety component | 1 | (0.01) |
| Engine | 6 | (0.07) |
| Whole Vehicle | 16 | (0.19) |
| Others | 19 | (0.22) |

Note: The numbers in parentheses are the percentages (over total 86 projects).
** indicates that the percentages are calculated over 83 projects because of data availability.

**Table 2: R&D, innovation and technology in automotive projects, 1996-2011**

| | 1996-2003 | column % | 2004-2011 | column % | row total |
|---|---|---|---|---|---|
| R&D content | | | | | |
| modelling, design and design verification (domestic) | 12 | 0.75 | 45 | 0.64 | 57 |
| know-how, specs and technology transfer from abroad | 3 | 0.19 | 23 | 0.33 | 26 |
| no design activity | 1 | 0.06 | 2 | 0.03 | 3 |
| Type of intended innovation | | | | | |
| process | 1 | 0.06 | 12 | 0.17 | 13 |
| product | 15 | 0.94 | 42 | 0.60 | 57 |
| process and product | 0 | 0.00 | 16 | 0.23 | 16 |
| Intended level of innovation | | | | | |
| new to the firm | 5 | 0.31 | 32 | 0.46 | 37 |
| new to the country | 11 | 0.69 | 33 | 0.47 | 44 |
| at the world frontier | 0 | 0.00 | 5 | 0.07 | 5 |
| Projects by auto-component classification | | | | | |
| traditional | 11 | 0.69 | 48 | 0.69 | 59 |
| contemporary | 4 | 0.25 | 22 | 0.31 | 26 |
| both | 1 | 0.06 | 0 | 0.00 | 1 |
| Intended use of the R&D output | | | | | |
| OEMs and JVs | 10 | 0.63 | 40 | 0.57 | 50 |
| other (end users, subcontractors, firms etc.) | 6 | 0.38 | 30 | 0.43 | 36 |
| Market orientation of projects** | | | | | |
| domestic | 4 | 0.25 | 13 | 0.19 | 17 |
| abroad | 5 | 0.31 | 8 | 0.11 | 13 |
| domestic and abroad | 6 | 0.38 | 48 | 0.69 | 54 |

Note: columns 1, 3 and 5 present the project numbers in two different time periods and the row total. Columns 2 and 4 present the column percentages such that the column sum of each indicator panel sum to 1.00.

**Table 3: Summary results of the firm interviews: R&D content, R&D output and innovation**

| Firm | Core Specialization | Core Technology | How R&D projects are initiated? | Product/ Process innovation | Specs from Outsourcer | Commercialization Decision | Projects in niche or sophisticated products | Innovation Level | Diversified Core Competency | Technological Sophistication |
|---|---|---|---|---|---|---|---|---|---|---|
| SME1 | Design and engineering firm of a domestic OEM | Contemporary | affiliated OEM and market signals | Product | Yes | Dependent on OEM | Yes | National | Yes | Yes |
| SME2 | Supplier | Traditional | outsourcer | Both | Yes | Dependent on OEM | No | Firm | No | No |
| SME3 | Supplier | Traditional | outsourcer | Both | Yes | Dependent on OEM | Yes | Firm | Failed | No |
| SME4 | Supplier | Traditional | outsourcer | Both | Yes | Dependent on OEM | Yes | Firm | No | Yes (due to its phase of being a co-designer) |
| SME5 | Supplier | Traditional | outsourcer | Product | Yes | Dependent on OEM | No | Firm | No | No |
| Procurer BIG1 | Engineering firm / assembly line procurer for global OEMs | Contemporary | outsourcer and market signals | Both | Yes (niche projects - No) | Dependent on OEM | Yes | National | Yes | Yes |
| BIG2 | Supplier | Traditional | outsourcer | Both | Yes | Dependent on OEM | Yes | Firm | No | No |
| BIG3 | Supplier | Traditional | outsourcer | Both | Yes | Dependent on OEM | No | National | Failed | No |
| BIG4 | End product manufacturer | Contemporary | market signals | Product | Yes (niche projects – No) | Independent | Yes | National/ international | Yes | Yes |
| BIG5 | Supplier/end product manufacturer | Traditional/ Contemporary | outsourcer and market signals | Both | Yes (niche projects – No) | Dependent (for niche projects – independent) | Yes | National | Yes | Yes |
| BIG6 | Supplier | Traditional/ contemporary | outsourcer and market signals | Both | Yes | Semi-Dependent | Yes | National | Yes | Yes |
| FA1 | Supplier of an affiliated MNE | Traditional/ contemporary | affiliated MNE | Both | Yes | Dependent on headquarter | NA | National | No | No |
| JV1 | Supplier of an affiliated MNE | Traditional/ contemporary | affiliated MNE and firm's own initiative | Both | Yes | Dependent on headquarter | NA | National | Yes | Yes |

**Table 4: Expert opinions in brief**

| | INT1 | INT2 | INT3 | INT4 | INT5 | INT6 | INT7 | INT8 | INT9 | INT10 | INT11 | INT12 | INT13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Position | Univ. | NGO | Firm | JV | Consult | Univ. | Firm | Spec. | Firm | Spec. | Spec. | Firm | Firm |
| Manufacturing capabilities are enhanced | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| There is strong OEM dependence | ● | o | ● | x | ● | o | ● | ● | ● | ● | ● | ● | o |
| R&D capabilities are enhanced | o | ● | o | o | o | o | o | o | o | o | o | o | ● |
| Technological sophistication has increased | x | o | o | o | x | o | o | x | x | x | x | x | o |
| There are signs of technological catching up | x | o | x | o | x | x | x | x | x | x | x | x | x |
| Strategy to own a national brand is viable | x | x | o | x | x | x | x | x | x | x | x | x | x |

Univ. stands for university; NGO for Non-governmental organization; JV for Joint Venture; Consult. for consultant; and Spec. for specialist.

●: strong support for the statement, o: weak support for the statement, x: reject the statement

**Table 5: Consolidation of project, firm and expert level information**

| Automotive industry characteristics | Project level data | Firm interviews | Expert interviews |
|---|---|---|---|
| Existence of basic and experimental R&D | Weak support. Some exceptions. | Weak support. Number of exceptional cases niche products with new technologies. | No support |
| Independence (from foreigners) in strategic decisions on R&D and innovation | Hard to observe from the data | No support. Some exceptions. | No support. Except cases of transport vehicle companies with niche products |
| Existence of domestic local concept design and design confirmation processes | Weak support. No significant differences through time. | No support. Some exceptions. | No support |
| Inclination from process towards product innovation (cost reduction versus product variety) | Increased number of recent projects with process innovation focus | Mostly process innovation but cases of niche product innovations | Mostly process innovation |
| Inclination towards traditional to contemporary technologies | Mostly traditional technologies. Almost no change through time. | Mostly traditional. Some cases of contemporary technologies in niche products | Mostly traditional. Existence of exceptions (niche products) |
| Manufacturing excellence | Hard to observe from the data | Strong support | Strong support |
| Signs of increased technological sophistication | Inconclusive. The project characteristics did not change in time. | Weak support in the case of firms with niche products | Almost no support. There are cases which are by and large exceptions |

## Appendix

### A.1. TTGV data

Technology Development Foundation (TTGV as the Turkish acronym) was founded as a non-profit organization in 1991 to support technology development in Turkey. TTGV aimed at increasing competitiveness by providing seed capital and R&D funds to Turkish industrial firms.

What makes the TTGV data interesting is that it is the antecedent of all R&D support mechanisms in Turkey. The data set covers the whole R&D support period of Turkey starting from the beginning of the 1990s. The TTGV R&D supports in the form of loans with back payment were the only mechanism to support R&D (at the firm level) in Turkey in the 1990s. By 2000 it became complementary to TEYDEB (TUBITAK) funds and gradually lost power as TUBITAK R&D funds developed. In 2000 about one-fourth of R&D supports was initiated by TTGV whereas after 2010 less than one-tenth of total R&D supports was initiated by TTGV. Currently TTGV is being redesigned as a technology consultancy body rather than an organization that gives financial incentives for R&D and innovation.

TTGV has a wide array of support mechanisms the most important of which is the Technology Development Projects Support that provides R&D loans (with no interest but 6% operating costs) up to one million US dollars for industrial R&D firms in Turkey. Under this scheme TTGV supports 50% of the project budget up to 24 months (which means that the project budget should at most be 2 million US dollars). The repayment starts one year after the project is officially completed and continues for three years. The project applications were evaluated in a panel for compliance with the eligibility criteria (R&D project should aim for capability building). By 2011 there were 2356 project applications 938 of which are supported under this scheme (acceptance rate 39%). The total amount of contracted support was about 320 million US dollar and keeping in mind that 50% of the project budget is supported we can argue that this scheme solely created about 650 million US dollars R&D spending in the last 20 years. Previous research has showed that the TTGV supports are deemed successful in creating awareness for R&D and innovation (Üçdoğruk, 2005; Taymaz, 2006; World Bank, 2006; Özçelik and Taymaz, 2008).

## Table A.1: Characteristics of selected firms

| Firm | Description of the firm | Category | City | Title of the interviewee |
|---|---|---|---|---|
| SME1 | A domestic design and engineering firm for automotive design also affiliated with the domestically owned midibus and military vehicle manufacturer. | SME | Kocaeli | R&D Manager |
| SME2 | A domestically owned clutch procurer for automobiles and buses. | SME | İzmir | R&D Manager |
| SME3 | A domestically owned brake components manufacturer for the global brands by using foreign license. | SME | İzmir | R&D Manager |
| SME4 | A domestically owned front/rear axle procurer for global OEMs. | SME | Bursa | R&D Manager |
| SME5 | A domestically owned procurer manufacturing plastic assembly parts for automobiles. | SME | Bursa | Vice Manager |
| BIG1 | A reputable company specialized in automation and installing robotics on mass production lines in JVs. | Big Enterprise | Kocaeli | Vice Manager |
| BIG2 | A highly reputable domestically owned spring supplier for heavy vehicle OEMs. | Big Enterprise | Manisa | R&D Manager |
| BIG3 | A domestically owned supplier for global heavy vehicle manufacturers that operates in a niche market. | Big Enterprise | İzmir | R&D Manager |
| BIG4 | A renowned accumulator and battery producer that is operating worldwide. (former shareholder was foreign). | Big Enterprise | Manisa | R&D Manager |
| BIG5 | A domestically owned tractor, customised automobile, wagon parts and heavy parts manufacturer. | Big Enterprise | Eskişehir | R&D Manager |
| BIG6 | A globally owned domestic cord fabric manufacturer for international tire brands that operates under one of the biggest Turkish business group. | Big enterprise | Kocaeli | R&D Manager |
| FA1 | A foreign-affiliate of a renowned bus manufacturer. | Foreign Affiliate | Ankara | R&D Manager |
| JV1 | A joint venture, which is a sub-branch of a globally renowned automobile manufacturer. | Joint Venture | Bursa | R&D Manager |

## Table A.2: Expert characteristics

| Interviewee | Title | Firm/Institution | Rationale behind selection |
|---|---|---|---|
| INT1 | General Manager | University test/homologation centre | Highly qualified expert |
| INT2 | General Secretary | An umbrella organization | Experienced and well-known in the auto industry |
| IINT3 | General Manager | An R&D design/engineering firm affiliated with an OEM. | Experienced specialist in the auto industry. |
| INT4 | R&D Director | A JV in Turkey | Specialized experience in automotive R&D |
| INT5 | Technology Consultant | Former R&D director of a bus manufacturer | Experience in automotive industry, entrepreneur and consultant |
| INT6 | Professor | Former R&D director and an academic member in a university | One of the first R&D managers in Turkish automotive industry |
| INT7 | R&D Director | R&D director in a Turkish manufacturer | Experienced specialist in the auto industry. |
| INT8 | Technology consultant and specialist | Former senior expert in R&D funding, Automotive Specialist, Technology Policy Maker | Well known in the automotive industry; former policy-maker of the very first R&D grant program |
| INT9 | General Manager | Former manager in an EU program, General Manager in a consulting firm | Specialized in networking and clustering. |
| INT10 | General Secretary | Technology specialist, business developer, General Secretary in a former R&D-funding institution | The expert has wide array of knowledge and vision about several sectors and technologies |
| INT11 | Former Board President | The founder of one of the first R&D departments in electronics in Turkey | Being an expert in a complementary sector to automotive |
| INT12 | General Manager | Manager in an automotive procurer | Experienced in auto supplier industry |
| INT13 | Vice Manager | Financial manager in an engineering firm | Experienced professional in the automotive industry |
| INT14 | Former General Coordinator | An umbrella organization of Turkish Automotive Suppliers | Well-experienced professional in the supplier industry |