

# **Elaborating the innovative behavior of Low-Medium-Tech sectors in the context of a developing country: a comparison with High-Medium-Tech sectors based on Innovation Survey**

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## **Abstract**

The interesting question of innovation in LMT and HMT sectors is taken into account in order to find out the differences between the contexts of developed and developing countries. This analysis has been made possible by very new data sources from the first round of Innovation survey in Iran containing information of about 2500 firms in different sectors. We developed 4 hypotheses from the literature that could have also been tested by the available data. LMT sectors are not more innovative in terms of process innovation in comparison to the HMT firms while the latter is more product innovative than the former. We found that LMT sectors in Iran are more depended on their suppliers to introduce new innovations in the form of new machineries; although suppliers have not been considered for them as more pivotal source of information or even collaboration in comparison to HMTs. Market consultants found to be very important in linking LMT firms with their suppliers while HMTs are more depended on their customers and competitors information.

**Keywords:** LMT sectors, HMT sectors, Developing Country, Innovation Survey

## **Introduction**

Innovation survey has provided multi-dimensional tool both for academics in order to measure innovation, find the pattern and characteristics of innovation and for policy makers to decide based upon which (Smith 2005). Community Innovation Survey provided an standard approach in order to gather innovation related data from firms based on Oslo manual (OECD 2005). However, member countries usually modify it to add or change some questions according to their internal needs enabling them to conduct more complicated analysis.

The areas of those investigations are very wide including the impacts of collaborations and alliances (Schubert 2015, Arora et al 2016), licensing activities (Lee et al 2017), R&D outsourcing (Spithoven and Teirlinck 2015), local knowledge externalities (Roper et al 2017); a factor that is becoming very important today. Impact of government supports (Szczygielski et al 2017), roles of standards and regulations (Blind et al 2017), barriers and constrains to innovation (Pellegrino and Savona 2017) is also being scrutinized extensively.

Impact of different sources of knowledge (Frenz and Letto-Gillies 2009), heterogeneity of innovation among firms (Fagerberg et al 2012), Effect of innovation activities on innovation outputs (Sharif et al 2012, Lau et al 2013, Hashi and Stojcic 2013, Frank et al 2016), Cross sectoral differences for instance in drivers of innovation (Doran and Jordan 2016), characteristics of innovation in Low-Medium Tech industries (Tsai and Wang 2009), drivers of investment (Archibugi et al 2013), drivers of innovation in different sectors (Ciliberti et al 2015), and differences among countries (Harris and Mate 2014) are worth mentioned areas. Differences among firms is another interesting topic such as distinguished characters of SMEs (Cintio et al 2017), determinants of SMEs' success in export (Love and Roper 2015), different types of firms' strategies (Karlsson and Tavassoli 2015), and persistence of their strategies (Tavassoli and Karlsson 2015).

This paper tries to investigate the characteristics of innovation in LMT industries in comparison to the HMT sectors based on the first round of Iran's innovation survey. Presuming very different innovative behaviors (Robertson et al. 2009), we posit that their differences are mainly pertaining to the types of innovation (product or process), sources of knowledge and ideas, partnership and collaborations as well as importance of suppliers as the main sources of technology for LMT firms.

The paper is organized as follows. The next section investigates the differences between LMT and Hi-Tech sectors in terms of innovation behaviors in order to develop some hypotheses. Then the data and research method will be elaborated and then the sample data will be analysed in order to test the hypotheses of the second section. The results will be discussed in section 5 and the theoretical and some policy related implications will be elaborated in the final section.

## **Innovation in LMT industries**

Since the seminal work of Nelson and Winter (1977) about theories of innovation and the necessity to consider variations of innovation as a crucial factor; understanding differences in innovation activities has always been an important topic of research. Scherer (1982) showed how productivity benefits of a sector

like airline operators could increase because of innovations in jet engine sector that could increase the efficiency of those engines in terms of fuel consumption.

Pavitt's path breaking paper provided a taxonomy of innovative industries as scale intensive, supplier dominated, science based and specialized suppliers, each of which having different sources of technology and different directions of innovation (Pavitt 1984). Although this work then criticized in terms of its inaccuracy in making distinctions between firms and industries (Archibugi 2001), however its basic idea is still promising and scholars paid considerable attention to modify this taxonomy. For instance, Marsilli modified it by replacing scale intensive firms with resource intensive enterprises to show the different pattern of their innovative behavior in small and medium size firms (De Jong and Marsilli 2006); while others suggested to change scale intensive into scale and information intensive firms (Bogliacino and Pianta 2016).

Understanding differences among sectors is another line of research that is still important. Notions of Schumpeter mark 1 and Schumpeter mark 2 suggest that the former is heavily based on small innovating firms with low entry barriers and little cumulative knowledge while the latter is rooted in an innovation pattern governed by large enterprises with high entry barriers and much cumulative knowledge (Malerba and Orsenigo 1995, 1996, 1997). The concept of sectoral systems of innovation and their underlying technological regimes then developed to capture the different ways within which technological knowledge of each sector emerge and develop (Breschi and Malerba 1997, Breschi et al 2000, Malerba 2002).

Marsilli tried to suggest a new classification of different pattern of innovation among sectors by modifying the original methodology used by Pavitt. Her new classification composed from 5 different sectors based on different technological regimes as (Marsilli 2001): Science based, Product engineering, Complex products and systems (CoPS), Continues process, Fundamental process. The nature of innovation for the two last categories is process innovation while the former 3 categories are normally concentrating on product innovation.

The classification of industries according to their R&D budget by OECD opened new area to classify the economy into technology intensive or Hi-Tech (spending more than 5% of value added on R&D) and non-Hi-Tech sectors (Hatzichronoglou 1997). Non-Hi-Tech or Low Medium Tech (LMT) industries have been described as mature sectors with slow rate of change both in their technology and market (Tunzelmann and Acha 2005). The implication of this classification for policy makers was straightforward that LMT sectors are not as important as Hi-Tech sectors and therefore each country needs to concentrate on promoting technology intensive part of its economy (Smith 2002). However, many commentators criticized this view because of the large share of LMT industries in output, value added and employment (Hirsch-Kreinsen et al 2005, Robertson and Paterl 2007). Moreover, they are a main buyer of Hi-Tech products in their production processes (Sandven et al. 2005, Hauknes and Knell 2009, Mendonca 2009) in a way that we could count them as supplier dominated firms in the Pavitt's taxonomy because of their heavy reliance on imported technology (Robertson et al 2008).

The distinctive features of innovation in LMT sectors have been summarized in several studies, and also in comparison to the Hi-Tech ones (e.g. Grimpe and Sofka 2009, Kirner et al 2009, Heidenreich 2009). Heidenreich (2009) used the fourth European Innovation Survey to check special characteristics of LMT

sectors. One of his findings was the lower importance of product innovations in these sectors in comparison to Hi-Tech sectors while process innovations are more important for them, especially in the form of embodied technology. They are also less likely to involve partnerships or to seek for non-R&D sources of knowledge. Main sources of knowledge for innovation are estimated to be different between them as LMT industries are normally looking to their customers and competitors, while Hi-Tech sectors have more predispositions to seek information from suppliers and universities (Grimpe and Sofka 2009). However, Santamaria et al (2009) found that embodied technology is crucial for LMT firms, which is somehow in contradiction with Grimpe and Sofka (2009).

Recently, Trott and Simms (2017) conducted a comparative case study in 4 package food firms in order to examine the features of their innovation. They extracted 8 interdependent features of innovations in these sectors that resemble more a DUI mode of innovation rather than STI mode (Jensen et al 2007). They then developed 5 hypotheses which are confirmed in their case studies:

1. Firms in that sector emphasizes on incremental product and process innovations among their supply chain
2. They rely on learning by doing (trial and error) in order to adapt technologies to their needs
3. The need extensive networking activities to gather the diverse set of required skills
4. The high costs of technologies frame their innovative activities towards responding the existing customer needs
5. Category management is important as its relation to the suppliers will determine the nature of innovation

Although this study is interesting, but it is an in-depth case study in a way that its' suggested propositions could not be easily tested by innovation survey data, except for the first one. To generate our hypotheses, we need also to consider especial characteristics of innovation in the context of developing countries in the next section.

### **Innovation in developing countries**

Not only innovation activities are shown to be different among LMT and HMT sectors, but also the context of countries plays very important role in shaping innovative behavior of firms (Freeman 1987, Nelson 1988, 1993, Lundvall 1988, 1992). Fundamental innovation is costly, risky and path-dependent, and to date ground-breaking innovation is highly concentrated in a few rich countries, linked with specific forms of university science and research capacity, and amongst a small number of firms. Therefore, external sources of technology account for a large component of productivity growth in most developing countries (Zanello et al., 2016).

As developing countries seek to catch up, going beyond routine production and strengthening their own knowledge bases for innovation has become a prime concern of public policy (Hegde & Shapira 2007). While formal R&D is rather weak in developing countries, innovations typically use other inputs including tacit, informal or external sources of knowledge to introduce product, process, organisational and managerial advances (Jaramillo et al., 2001). Also the role of external sources of knowledge assumes greater importance for small and developing country firms which may not have internal institutional arrangements to support

the conduct of formal R&D (Becker and Dietz, 2004). Thus, it is a big mistake for policy makers in those countries to concentrate exclusively on R&D improvements.

In addition, while R&D investment is a good estimator of innovation in developed economies (Nelson 1993), studies of developing countries find only a weak association between R&D expenditure and innovation. This may be because in developing countries, industrial innovation is often highly informal; even when firms innovate; R&D activities are not clearly and formally articulated with the enterprise strategy and accounting procedures (Arocena and Sutz, 2000).

Hegde & Shapira(2007) investigated the applicability of contemporary firm-level innovation concepts to a developing country context by drawing on the results of a survey of Malaysian manufacturing and service establishments. They found that Malaysian firms possess relatively high process and organisational innovation capabilities, but lag in new product development. Further, they more frequently utilise a variety of 'soft factors' like employee training, knowledge management practices, and collaboration with market actors as inputs to innovation rather than formal R&D.

By using data from the third round of Estonian Community Innovation Survey from 1995–2002, Vanter(2006) found that there were differences in labour productivity and total factor productivity (TFP), both of which have been positively influenced by product and process innovations. In similar way Lee and Kang (2007) compared product and process innovations impacts on productivity growth of manufacturing firms in Korea and concluded that process innovation has had more positive effect on productivity performance in the short term. Tracing the differences among CIS three (1998-2000) and four (2002-2004) by (Masso and Vahter 2008) showed that the former is dominated by product innovations within firms while the latter is better characterized by process innovation.

Based on the factor analysis, Seo (2004) found that firms' internal sources have the greatest impact on their innovative activities in relation to other external sources whose impacts are statistically significant. On the contrary Ayadi et al. (2009) found that firms benefit mostly from external knowledge sources (like universities, research centers, laboratories, national and international bodies, other firms, and external technical assistance) in order to be innovative according to the first innovation survey of the Tunisian firms. They also realized that state's intervention could harm the innovative performance of firms.

The following stylized facts thus are seems to characterize innovation in the context of developing countries:

- Their innovations are more incremental rather than radical
- They rely more on external (to the country) sources of innovation, hence R&D is not a determining factor for them
- Process innovations seems to be more important for firms in developing countries in comparison to the product innovation
- Some studies suggest that firms in this context tend to innovate more in collaboration with other actors in the national system of innovation while other studies suggesting the opposite (relying on internal to the firm sources of knowledge).

## Hypotheses

On the one hand, there are interesting studies about different characteristics of innovation between LMT and HMT sectors and on the other hand, many other studies have tried to show the distinctive characteristics of innovation in the context of developing countries in contrast with developed ones. However, the

contribution of our research is in bridging those two topics together to investigate the differences among LMT and HMT innovative behaviors in the context of developing countries.

For this purpose, we developed 4 main hypotheses from studies of innovation in the context of developed countries and we will test them in the context of Iran. In general, we think that although there should be some differences between the context of advanced and developing countries, LMTs still depends more on their suppliers not only in their innovative behaviors, but also as their main source of information and collaboration. We do not expect HMTs in this context to be more active in R&D, however they should be more products innovative and more depends on academic sources of information with different pattern of collaborations. Then, we will explain the differences, if any, between Iran and the current studies, using insights from innovation studies in the context of developing countries.

Following the above discussions, we posit that:

*H1: LMT sectors are supposed to be more process innovators while HMT sectors are expected to be more product innovators*

This means we expect that even in the context of developing countries, the innovation patterns between HMT and LMT sectors to be difference in a way the former relies on product innovations while the latter shows process innovation behavior.

*H2: Their innovative activities differs considerably, especially LMTs should rely more on adopting machineries from suppliers while HMTs are not expected to rely more on internal R&D*

This indicates our different perspective on innovation activities. As a general context that developing countries show more reliance on external sources of knowledge, we therefore assume internal R&D is not more important for HMT sectors in comparison to LMTs. However, similar to advanced countries, we posit LMT sectors should still rely more on adopting machineries from suppliers as a prime method of innovation.

*H3: their source of information is different and LMTs should rely more on their suppliers and market while HMTs are expected to rely more on education and research institutes*

The third hypothesis posit very different source of information for them in a way that LMTs, following hypothesis 2, should rely on information sources of suppliers and also markets while we expect HMT companies do not rely on research institutes and university sources because of their reliance more on external sources of knowledge.

*H4: collaborations within their national systems is expected to play an important role and those two sectors should show different patterns of collaboration in their innovation activities, especially LMTs should rely more on collaborations with their suppliers*

We suggested that collaborations still play important role in their innovative activities, although the pattern should be different among LMTs and HMTs.

## Research Method and Data

This survey has been conducted in 2016 and the data of which is released to the academic community early in 2017. Less than 2500 enterprises contributed to this survey which has been conducted by the Iranian state, the deputy for science and technology. The underlying framework was based on CIS questionnaire with minor revisions on some questions. Initial report of this survey is published in Farsi and is available on the website of this organization<sup>1</sup>. The survey includes firms from various sectors, the data of which is summarized in table I. However, there are some missing data because some enterprises did not answer to all questions.

Table I- contributing firms in the 1<sup>st</sup> round of innovation survey in Iran

| Sector               | Number of Firms | Sector               | Number of Firms |
|----------------------|-----------------|----------------------|-----------------|
| Aerospace            | 44              | Medical herbs        | 80              |
| Agriculture          | 51              | Modern biotechnology | 76              |
| Car suppliers        | 199             | Nano technology      | 66              |
| Cement               | 41              | Oil and gas          | 270             |
| Food industry        | 237             | Petrochemicals       | 74              |
| ICT                  | 962             | Steel                | 71              |
| Laboratory equipment | 161             | Medical herbs        | 80              |

Our selected sectors according to NACE<sup>2</sup> that are considered to be LMT sectors are Agriculture, Food, Medical herbs, Oil and Gas, Cement, Petrochemicals, Car parts suppliers, and Steel that together comprise 1023 firms. On the other side, High-tech sectors are constituted from Modern Biotechnology, Laboratory Equipment, Aerospace, ICT and Nano-Tech companies that together encompass 1309 enterprises.

Table 2 – percentage of innovative and non-innovative firms in both sectors

|                         | LMT(1023)          |                    | HMT(1309)          |                    |
|-------------------------|--------------------|--------------------|--------------------|--------------------|
|                         | product innovation | process innovation | product innovation | process innovation |
| No Innovation           | 269                | 258                | 195                | 195                |
|                         | 26/30%             | 25/22%             | 17/50%             | 14/90%             |
| at least one innovation | 754                | 765                | 1114               | 1114               |
|                         | 73/70%             | 74/78%             | 85/10%             | 85/10%             |

We compared not all firms, but just the firms introduced product innovations in each category. Therefore, our sample consists from 754 LMT firms and 1114 HMT firms. It would have been better if we could study successful innovators. Unfortunately, the data showing their returns from innovations was not complete in a way that about 46% of respondents did not estimate their returns from innovations. As we wanted to examine the behaviors of innovative LMTs in comparison to HMTs, therefore it suffices to meet our purpose.

<sup>1</sup> <http://innosurvey.isti.ir/>

<sup>2</sup> Classification of economic activities in the European community, last revised 2008. <http://epp.eurostat.ec.europa.eu>

## Analysis

The results of our analysis are somehow interesting. We discuss each hypothesis and their results in the context of Iran respectively.

### *HI: product and process innovation*

The results of test is shown in table 3 denoting that HMT sectors are more innovative in products while there is no difference among them in terms of process innovation. It shows that half of our hypothesis holds true while LMT sectors are not more innovative in their processes. We analyzed their differences by more details and as is shown in table 4, HMT firms are significantly above LMT firms in 1- introducing product innovations themselves (without any help) and 2- by adapting and modifying the products developed by others. However, there is no difference in terms of two other types of product innovations including 3- product innovations with collaboration to other firms and institutions and 4- introducing product innovations of others in the company portfolio.

Table 3- t-test for product and process innovations

|                    | Sector's TechnologyType | N    | Mean  | Std. Deviation | Std. Error Mean |
|--------------------|-------------------------|------|-------|----------------|-----------------|
| Product Innovation | High&Medium Tech        | 1114 | .8209 | .23984         | .00719          |
|                    | Low&Medium Tech         | 754  | .7613 | .24991         | .00910          |
| Process Innovation | High&Medium Tech        | 1114 | .5569 | .32192         | .00965          |
|                    | Low&Medium Tech         | 754  | .5782 | .34076         | .01241          |

### Independent Samples Test

|                    |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                |                 |                       |   |        |
|--------------------|-----------------------------|---|------|------------------------------|---------|----------------|-----------------|-----------------------|---|--------|
|                    |                             | F                                       | Sig. | t                            | df      | Sig (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |        |
|                    |                             |   |      |                              |         |                |                 |                       | Lower                                     | Upper  |
| Product Innovation | Equal variances assumed     | 61.478                                  | .000 | 5.184                        | 1866    | .000           | .05964          | .01150                | .03708                                    | .08221 |
|                    | Equal variances not assumed |   |      | 5.143                        | 1.571E3 | .000           | .05964          | .01160                | .03690                                    | .08239 |
| Process Innovation | Equal variances assumed     | 6.194                                   | .013 | -1.376                       | 1866    | .169           | -.02140         | .01555                | -.05189                                   | .00909 |
|                    | Equal variances not assumed |   |      | -1.361                       | 1.554E3 | .174           | -.02140         | .01572                | -.05223                                   | .00943 |

Table 4- t-test for types of product innovation

|   | Sector's Technology Type | N    | Mean  | Std. Deviation | Std. Error Mean |
|---|--------------------------|------|-------|----------------|-----------------|
| Product Innovation (Your enterprise by itself)  | High&Medium Tech         | 1114 | .6486 | .31745         | .00951          |
|   | Low&Medium Tech          | 754  | .5272 | .28507         | .01038          |
| Product Innovation (Your enterprise with other enterprises or institutions)   | High&Medium Tech         | 1114 | .1571 | .28359         | .00850          |
|   | Low&Medium Tech          | 754  | .1485 | .25474         | .00928          |
| Product Innovation (Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions) | High&Medium Tech         | 1114 | .4031 | .38155         | .01143          |
|   | Low&Medium Tech          | 753  | .3161 | .32468         | .01183          |
| Other enterprises or institutions   | High&Medium Tech         | 1114 | .1023 | .24321         | .00729          |
|   | Low&Medium Tech          | 754  | .1068 | .22803         | .00830          |

Independent Samples Test

|  |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                 |                 |                       |   |        |
|--|-----------------------------|---|------|------------------------------|---------|-----------------|-----------------|-----------------------|---|--------|
|  |                             | F                                       | Sig. | t                            | df      | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |        |
|  |                             |   |      |                              |         |                 |                 |                       | Lower                                     | Upper  |
| Product Innovation(Your enterprise by itself)  | Equal variances assumed     | 123.157                                 | .000 | 8.444                        | 1866    | .000            | .12138          | .01437                | .09318                                    | .14957 |
|  | Equal variances not assumed |   |      | 8.621                        | 1.725E3 | .000            | .12138          | .01408                | .09376                                    | .14899 |
| Product Innovation(Your enterprise with other enterprises or institutions)   | Equal variances assumed     | 4.864                                   | .028 | .666                         | 1866    | .506            | .00855          | .01284                | -.01664                                   | .03374 |
|  | Equal variances not assumed |   |      | .680                         | 1.725E3 | .497            | .00855          | .01258                | -.01612                                   | .03322 |
| Product Innovation(Your enterprise by adapting or modifying goods or services originally developed by other enterprises or institutions) | Equal variances assumed     | 18.576                                  | .000 | 5.126                        | 1865    | .000            | .08698          | .01697                | .05370                                    | .12026 |
|  | Equal variances not assumed |   |      | 5.287                        | 1.769E3 | .000            | .08698          | .01645                | .05471                                    | .11925 |
| Other enterprises or institutions  | Equal variances assumed     | .058                                    | .809 | -.396                        | 1866    | .692            | -.00443         | .01119                | -.02637                                   | .01751 |
|  | Equal variances not assumed |   |      | -.401                        | 1.684E3 | .688            | -.00443         | .01105                | -.02610                                   | .01724 |

Although the general test of process innovation shows no difference between the two main categories, we see that there are significant differences in terms of different types of process innovation. Process innovation in the core business process (manufacturing) as well as in the logistics and distribution processes are considered to be higher in LMT firms. On the other hand, process innovation in supply chain is significantly higher for

HMT companies as it is shown in table 5. This could provide an illustration of why the total test shows no differences because LMTs are higher in core as well as distribution processes while HMTs are ahead in terms of supply chain innovations.

Table 5- t-test for different types of process innovation

|  | Sector's TechnologyType | N    | Mean  | Std. Deviation | Std. Error Mean |
|--|-------------------------|------|-------|----------------|-----------------|
| New or significantly improved methods of manufacturing or producing goods or services  | High&Medium Tech        | 1114 | .7208 | .44879         | .01345          |
|  | Low&Medium Tech         | 754  | .7586 | .42820         | .01559          |
| New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services   | High&Medium Tech        | 1114 | .4264 | .49477         | .01482          |
|  | Low&Medium Tech         | 754  | .5093 | .50025         | .01822          |
| New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing | High&Medium Tech        | 1114 | .5233 | .49968         | .01497          |
|  | Low&Medium Tech         | 754  | .4668 | .49923         | .01818          |

Independent Samples Test

|  |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                 |                 |                       |   |         |
|--|-----------------------------|---|------|------------------------------|---------|-----------------|-----------------|-----------------------|---|---------|
|  |                             | F                                       | Sig. | t                            | df      | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |         |
|  |                             |   |      |                              |         |                 |                 |                       | Lower                                     | Upper   |
| New or significantly improved methods of manufacturing or producing goods or services  | Equal variances assumed     | 13.662                                  | .000 | -1.819                       | 1866    | .069            | -.03779         | .02078                | -.07855                                   | .00296  |
|  | Equal variances not assumed |   |      | -1.836                       | 1.666E3 | .067            | -.03779         | .02059                | -.07818                                   | .00259  |
| New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services   | Equal variances assumed     | 15.983                                  | .000 | -3.537                       | 1866    | .000            | -.08289         | .02344                | -.12886                                   | -.03693 |
|  | Equal variances not assumed |   |      | -3.529                       | 1.604E3 | .000            | -.08289         | .02349                | -.12896                                   | -.03682 |
| New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing | Equal variances assumed     | .722                                    | .396 | 2.398                        | 1866    | .017            | .05650          | .02356                | .01030                                    | .10269  |
|  | Equal variances not assumed |   |      | 2.399                        | 1.617E3 | .017            | .05650          | .02355                | .01030                                    | .10269  |

*H2: innovative activities*

This proposition suggests that process innovations within LMT sectors are mainly depended on buying new machineries from suppliers in terms of embodied technologies. The resulted test represented in table 6 shows that this hypothesis holds true in the context of Iran. LMT firms are also superior in terms of acquisition of existing know-how, inventions and patents from other enterprises which is a complementary activity to acquisition of machineries.

Additionally, we expected that in the context of a developing country, R&D should not be a main source of innovation for HMT firms. This second hypothesis is also shown to be true as there are no considerable differences in R&D among two sectors. Moreover, HMTs are shown to be more active vis-à-vis personnel training and market introduction of innovations while there is no substantial differences among them in terms of external R&D and other types of innovative activities.

Table 6- t-test of different types of activities for innovation including acquisition of machines

|  | Sector's Technology Type | N    | Mean  | Std. Deviation | Std. Error Mean |
|--|--------------------------|------|-------|----------------|-----------------|
| In Firm R&D  | High&Medium Tech         | 1114 | .6511 | .32859         | .00985          |
|  | Low&Medium Tech          | 754  | .6273 | .33189         | .01209          |
| External R&D: your enterprise has contracted out to other enterprises (including other enterprises in your group) or to public or private research organisations   | High&Medium Tech         | 1114 | .2460 | .43085         | .01291          |
|  | Low&Medium Tech          | 754  | .2719 | .44523         | .01621          |
| Acquisition of existing know-how, copyrighted works, patented and nonpatented inventions, etc. from other enterprises or organisations for the development of new or significantly improved products and processes | High&Medium Tech         | 1114 | .1445 | .35178         | .01054          |
|  | Low&Medium Tech          | 754  | .1804 | .38475         | .01401          |
| Acquisition of advanced machinery, equipment, software and buildings to be used for new or significantly improved products or processes.   | High&Medium Tech         | 1113 | .4492 | .49764         | .01492          |
|  | Low&Medium Tech          | 754  | .6273 | .48384         | .01762          |
| Training for innovative activities: In-house or contracted out training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes            | High&Medium Tech         | 1114 | .7289 | .44472         | .01332          |
|  | Low&Medium Tech          | 754  | .6790 | .46715         | .01701          |
| Market introduction of innovations: In-house or contracted out activities for the market introduction of your new or significantly improved goods or services, including market research and launch advertising    | High&Medium Tech         | 1114 | .5269 | .49950         | .01497          |
|  | Low&Medium Tech          | 754  | .4191 | .49374         | .01798          |
| Design: In-house or contracted out activities to design or alter the shape or appearance of goods or services  | High&Medium Tech         | 1114 | .5637 | .49614         | .01487          |
|  | Low&Medium Tech          | 754  | .5279 | .49956         | .01819          |
| Other: Other in-house or contracted out activities to implement new or significantly improved products and processes such as feasibility studies, testing, tooling up, industrial engineering, etc.                | High&Medium Tech         | 1114 | .4408 | .49670         | .01488          |
|  | Low&Medium Tech          | 754  | .4509 | .49792         | .01813          |

Independent Samples Test

|   |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                 |                 |                       |   |         |
|---|-----------------------------|---|------|------------------------------|---------|-----------------|-----------------|-----------------------|---|---------|
|   |                             | F                                       | Sig. | t                            | df      | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |         |
|   |                             |   |      |                              |         |                 |                 |                       | Lower                                     | Upper   |
| In Firm R&D   | Equal variances assumed     | .432                                    | .511 | 1.529                        | 1866    | .126            | .02379          | .01556                | -.00673                                   | .05430  |
|   | Equal variances not assumed |   |      | 1.526                        | 1.606E3 | .127            | .02379          | .01559                | -.00679                                   | .05436  |
| External R&D: your enterprise has contracted out to other enterprises (including other enterprises in your group) or to public or private research organisations  | Equal variances assumed     | 6.212                                   | .013 | -1.259                       | 1866    | .208            | -.02592         | .02059                | -.06631                                   | .01447  |
|   | Equal variances not assumed |   |      | -1.251                       | 1.580E3 | .211            | -.02592         | .02073                | -.06657                                   | .01473  |
| Acquisition of existing know-how, copyrighted works, patented and non-patented inventions, etc. from other enterprises or organisations for the development of new or significantly improved products and processes | Equal variances assumed     | 17.067                                  | .000 | -2.080                       | 1866    | .038            | -.03585         | .01723                | -.06965                                   | -.00205 |
|   | Equal variances not assumed |   |      | -2.045                       | 1.517E3 | .041            | -.03585         | .01753                | -.07024                                   | -.00146 |
| Acquisition of advanced machinery, equipment, software and buildings to be used for new or significantly improved products or processes.  | Equal variances assumed     | 43.682                                  | .000 | -7.672                       | 1865    | .000            | -.17808         | .02321                | -.22361                                   | -.13256 |
|   | Equal variances not assumed |   |      | -7.714                       | 1.646E3 | .000            | -.17808         | .02309                | -.22337                                   | -.13280 |
| Training for innovative activities: In-house or contracted out training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes             | Equal variances assumed     | 20.661                                  | .000 | 2.329                        | 1866    | .020            | .04986          | .02141                | .00788                                    | .09184  |
|   | Equal variances not assumed |   |      | 2.307                        | 1.562E3 | .021            | .04986          | .02161                | .00747                                    | .09225  |

|   |                             |        |      |       |         |      |         |        |         |        |
|---|-----------------------------|--------|------|-------|---------|------|---------|--------|---------|--------|
| Market introduction of innovations: In-house or contracted out activities for the market introduction of your new or significantly improved goods or services, including market research and launch advertising | Equal variances assumed     | 20.259 | .000 | 4.599 | 1866    | .000 | .10783  | .02345 | .06185  | .15382 |
|   | Equal variances not assumed |        |      | 4.609 | 1.629E3 | .000 | .10783  | .02339 | .06195  | .15372 |
| Design: In-house or contracted out activities to design or alter the shape or appearance of goods or services   | Equal variances assumed     | 7.200  | .007 | 1.529 | 1866    | .126 | .03588  | .02346 | -.01013 | .08190 |
|   | Equal variances not assumed |        |      | 1.527 | 1.609E3 | .127 | .03588  | .02349 | -.01020 | .08196 |
| Other: Other in-house or contracted out activities to implement new or significantly improved products and processes such as feasibility studies, testing, tooling up, industrial engineering, etc.             | Equal variances assumed     | .721   | .396 | -.434 | 1866    | .664 | -.01017 | .02345 | -.05616 | .03581 |
|   | Equal variances not assumed |        |      | -.434 | 1.614E3 | .665 | -.01017 | .02346 | -.05619 | .03584 |

### *H3: differences in the sources of information*

We presumed that main source of information and ideas for LMT sectors should be suppliers and customers as they rely on the DUI mode of innovation and needs to interact with customers and suppliers more than competitors and universities and research labs. On the other hand, it is expected for HMT firms to find their necessary information more from academic centers. The results of our test are shown in table 7 and 8.

Table 7 asks general questions about information sources including internal, market, different types of education and research institutes or others such as conferences and internet. Intriguingly, the only difference is the crucial role of internet as a source of information for HMT sectors while there is no distinguishable difference regarding other sources. Even research institutes, either universities or government research labs are not being considered more important for HMT companies.

In order to test our hypothesis about market sources including suppliers, the test is applied for 5 categories of information sources from market such as suppliers, public and private clients, competitors and consultants, the result of which is represented in table 8.

It shows that suppliers are not being considered as a more important source of information for the LMT firms. More surprising, clients, either private or public, as well as competitors are being considered more important source of information for HMT sectors. On the other hand, consultants and commercial labs have been reported to be more crucial for LMT companies. These interesting results could help us to model the innovative behavior of both sectors in the context of developing countries as we will discuss later.

Table 7- t-test for different sources of information and ideas

|   | Sector's TechnologyType | N    | Mean   | Std. Deviation | Std. Error Mean |
|---|-------------------------|------|--------|----------------|-----------------|
| Information source: Internal (Within your enterprise or enterprise group)                                 | High&Medium Tech        | 1114 | 3.3160 | 1.88262        | .05641          |
|   | Low&Medium Tech         | 754  | 3.1777 | 1.90135        | .06924          |
| Information Source: Market  | High&Medium Tech        | 1114 | 2.4402 | 1.18191        | .03541          |
|   | Low&Medium Tech         | 754  | 2.3576 | 1.35404        | .04931          |
| Information source: Education & research institutes (Universities or other Higher education institutions) | High&Medium Tech        | 1114 | 1.8384 | 1.78918        | .05361          |
|   | Low&Medium Tech         | 754  | 1.8554 | 1.79243        | .06528          |
| Information source: Education & research institutes (Government, public or private research institutes)   | High&Medium Tech        | 1114 | 1.5601 | 1.70420        | .05106          |
|   | Low&Medium Tech         | 754  | 1.5491 | 1.70254        | .06200          |
| Information source: Other( Conferences, trade fairs, exhibitions)   | High&Medium Tech        | 1114 | 2.5664 | 1.68167        | .05038          |
|   | Low&Medium Tech         | 754  | 2.4987 | 1.73416        | .06315          |
| Information source: Other(Internet Sites)   | High&Medium Tech        | 1114 | 3.7531 | 1.54278        | .04622          |
|   | Low&Medium Tech         | 754  | 3.2401 | 1.75889        | .06405          |

Independent Samples Test

|   |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                 |                 |                       |   |        |
|---|-----------------------------|---|------|------------------------------|---------|-----------------|-----------------|-----------------------|---|--------|
|   |                             | F                                       | Sig. | t                            | df      | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |        |
|   |                             |   |      |                              |         |                 |                 |                       | Lower                                     | Upper  |
| Information source: Internal (Within your enterprise or enterprise group) | Equal variances assumed     | .117                                    | .732 | 1.551                        | 1866    | .121            | .13826          | .08914                | -.03656                                   | .31308 |
|   | Equal variances not assumed |   |      | 1.548                        | 1.606E3 | .122            | .13826          | .08931                | -.03692                                   | .31343 |
| Information Source: Market  | Equal variances assumed     | 24.056                                  | .000 | 1.397                        | 1866    | .162            | .08266          | .05915                | -.03335                                   | .19866 |
|   | Equal variances not assumed |   |      | 1.362                        | 1.466E3 | .174            | .08266          | .06071                | -.03643                                   | .20174 |
| Information source: Education & research                                  | Equal variances assumed     | .091                                    | .762 | -.202                        | 1866    | .840            | -.01702         | .08444                | -.18262                                   | .14858 |

|   |                             |        |      |       |         |      |        |        |         |        |  |
|---|-----------------------------|--------|------|-------|---------|------|--------|--------|---------|--------|--|
| institutes (Universities or other Higher education institutions)  | Equal variances not assumed |        |      |       |         |      |        |        |         |        |  |
| Information source: Education & research institutes (Government, public or private research institutes) | Equal variances assumed     | .004   | .952 | .138  | 1866    | .890 | .01107 | .08034 | -.14649 | .16863 |  |
|   | Equal variances not assumed |        |      | .138  | 1.617E3 | .890 | .01107 | .08032 | -.14647 | .16862 |  |
| Information source: Other (Conferences, trade fairs, exhibitions)                                       | Equal variances assumed     | 2.367  | .124 | .844  | 1866    | .399 | .06775 | .08031 | -.08976 | .22527 |  |
|   | Equal variances not assumed |        |      | .839  | 1.583E3 | .402 | .06775 | .08079 | -.09071 | .22622 |  |
| Information source: Other (Internet Sites)  | Equal variances assumed     | 36.143 | .000 | 6.661 | 1866    | .000 | .51309 | .07703 | .36201  | .66416 |  |
|   | Equal variances not assumed |        |      | 6.496 | 1.471E3 | .000 | .51309 | .07899 | .35814  | .66804 |  |

Table 8- t-test for different market sources

|   | Sector's Technology Type | N    | Mean   | Std. Deviation | Std. Error Mean |
|---|--------------------------|------|--------|----------------|-----------------|
| Information source: Market (Suppliers of equipment, materials, components, or software) | High&Medium Tech         | 1114 | 2.4291 | 1.78113        | .05336          |
|   | Low&Medium Tech          | 754  | 2.5610 | 1.77996        | .06482          |
| Information source: Market (Clients or customers from the private sector)               | High&Medium Tech         | 1114 | 2.9794 | 1.70052        | .05095          |
|   | Low&Medium Tech          | 754  | 2.7175 | 1.81217        | .06600          |
| Information source: Market (Clients or customers from the public sector)                | High&Medium Tech         | 1114 | 2.8043 | 1.78376        | .05344          |
|   | Low&Medium Tech          | 754  | 2.2281 | 1.84051        | .06703          |
| Information source: Market (Competitors or other enterprises in your industry)          | High&Medium Tech         | 1114 | 2.6185 | 1.70956        | .05122          |
|   | Low&Medium Tech          | 754  | 2.3833 | 1.82873        | .06660          |
| Information source: Market (Consultants and commercial labs)                            | High&Medium Tech         | 1114 | 1.3698 | 1.56891        | .04701          |
|   | Low&Medium Tech          | 754  | 1.8979 | 1.76024        | .06410          |

Independent Samples Test

|  | Levene's Test for Equality of Variances | t-test for Equality of Means |      |        |      |                 |                 |                       |   |        |
|--|---|------------------------------|------|--------|------|-----------------|-----------------|-----------------------|---|--------|
|  |   | F                            | Sig. | t      | df   | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |        |
|  |   |                              |      |        |      |                 |                 |                       | Lower                                     | Upper  |
| Information source: Market (Suppliers) | Equal variances assumed                 | .816                         | .366 | -1.571 | 1866 | .116            | -.13192         | .08397                | -2.9661                                   | .03277 |

|  |                             |        |      |        |         |      |         |        |         |         |
|--|-----------------------------|--------|------|--------|---------|------|---------|--------|---------|---------|
| of equipment, materials, components, or software)                            | Equal variances not assumed |        |      | -1.571 | 1.617E3 | .116 | -.13192 | .08396 | -.29661 | .03276  |
| Information source:Market(Clients or customers from the private sector)      | Equal variances assumed     | 17.623 | .000 | 3.179  | 1866    | .002 | .26185  | .08236 | .10032  | .42337  |
|  | Equal variances not assumed |        |      | 3.141  | 1.546E3 | .002 | .26185  | .08337 | .09831  | .42539  |
| Information source:Market(Clients or customers from the public sector)       | Equal variances assumed     | 7.516  | .006 | 6.762  | 1866    | .000 | .57619  | .08521 | .40908  | .74331  |
|  | Equal variances not assumed |        |      | 6.721  | 1.582E3 | .000 | .57619  | .08573 | .40804  | .74434  |
| Information source:Market(Competitors or other enterprises in your industry) | Equal variances assumed     | 17.648 | .000 | 2.836  | 1866    | .005 | .23520  | .08293 | .07255  | .39786  |
|  | Equal variances not assumed |        |      | 2.799  | 1.542E3 | .005 | .23520  | .08402 | .07040  | .40000  |
| Information source:Market(Consultants and commercial labs)                   | Equal variances assumed     | 27.182 | .000 | -6.791 | 1866    | .000 | -.52804 | .07775 | -.68053 | -.37554 |
|  | Equal variances not assumed |        |      | -6.643 | 1.489E3 | .000 | -.52804 | .07949 | -.68397 | -.37211 |

#### *H4: Differences in their collaboration patterns*

The literature on innovation in the context of developing countries was not clear about the extent to which innovation is an interactive activity within their national innovation system. We hypothesized that collaborations play a vital role in their innovation in order to test it in the context of Iran. Thus, following proposition 3, we hypothesized that LMT sectors should collaborate more with their suppliers while HMT sectors are supposed to rely more on collaborations with academic centers.

The results shows that in no category, HMT sectors shows interactive pattern higher than LMTs, while LMTs collaborations are shown to be higher with market consultants as well as other enterprises within their enterprise group. This last one . It is also interesting to see that while customers and competitors are main source of information for HMTs (as is shown in the previous hypothesis), they tend to not collaborate with their customers and competitors as well as academic centers more than what LMTs do.

Table 9- t-test for differences in partners

|  | Sector's TechnologyType | N    | Mean   | Std. Deviation | Std. Error Mean |
|--|-------------------------|------|--------|----------------|-----------------|
| Other enterprises within your enterprise group             | High&Medium Tech        | 1114 | .6741  | 1.53858        | .04610          |
|  | Low&Medium Tech         | 754  | .8700  | 1.71830        | .06258          |
| Suppliers of equipment, materials, components, or software | High&Medium Tech        | 1114 | .8636  | 1.52819        | .04579          |
|  | Low&Medium Tech         | 753  | .9548  | 1.61462        | .05884          |
| Clients or customers from the private sector               | High&Medium Tech        | 1114 | 1.0027 | 1.63492        | .04898          |
|  | Low&Medium Tech         | 754  | .9708  | 1.64731        | .05999          |
| Clients or customers from the public sector*               | High&Medium Tech        | 1114 | .9255  | 1.59537        | .04780          |
|  | Low&Medium Tech         | 754  | .8276  | 1.51819        | .05529          |
| Competitors or other enterprises in your sector            | High&Medium Tech        | 1114 | .8411  | 1.49238        | .04471          |
|  | Low&Medium Tech         | 754  | .8276  | 1.49527        | .05445          |
| Consultants or commercial labs                             | High&Medium Tech        | 1114 | .5395  | 1.17505        | .03521          |
|  | Low&Medium Tech         | 754  | .8090  | 1.47691        | .05379          |
| Universities or other higher education institutes          | High&Medium Tech        | 1114 | .6571  | 1.34419        | .04027          |
|  | Low&Medium Tech         | 753  | .7570  | 1.44607        | .05270          |
| Government, public or private research institutes          | High&Medium Tech        | 1114 | .6095  | 1.30075        | .03897          |
|  | Low&Medium Tech         | 754  | .6485  | 1.30982        | .04770          |

Independent Samples Test

|  |                             | Levene's Test for Equality of Variances |      | t-test for Equality of Means |         |                 |                 |                       |   |         |
|--|-----------------------------|---|------|------------------------------|---------|-----------------|-----------------|-----------------------|---|---------|
|  |                             | F                                       | Sig. | t                            | df      | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |         |
|  |                             |   |      |                              |         |                 |                 |                       | Lower                                     | Upper   |
| Other enterprises within your enterprise group             | Equal variances assumed     | 25.148                                  | .000 | -2.574                       | 1866    | .010            | -.19588         | .07609                | -.34511                                   | -.04665 |
|  | Equal variances not assumed |   |      | -2.520                       | 1.494E3 | .012            | -.19588         | .07772                | -.34834                                   | -.04342 |
| Suppliers of equipment, materials, components, or software | Equal variances assumed     | 6.189                                   | .013 | -1.238                       | 1865    | .216            | -.09129         | .07377                | -.23597                                   | .05338  |
|  | Equal variances not assumed |   |      | -1.224                       | 1.554E3 | .221            | -.09129         | .07456                | -.23753                                   | .05495  |
| Clients or customers from the private sector               | Equal variances assumed     | .232                                    | .630 | .412                         | 1866    | .680            | .03187          | .07734                | -.11980                                   | .18355  |
|  | Equal variances not assumed |   |      | .412                         | 1.608E3 | .681            | .03187          | .07745                | -.12004                                   | .18378  |
| Clients or customers from the public sector*               | Equal variances assumed     | 6.972                                   | .008 | 1.327                        | 1866    | .185            | .09791          | .07379                | -.04681                                   | .24262  |
|  | Equal variances not assumed |   |      | 1.340                        | 1.669E3 | .181            | .09791          | .07309                | -.04544                                   | .24126  |

|   |                             |        |      |        |         |      |         |        |         |         |
|---|-----------------------------|--------|------|--------|---------|------|---------|--------|---------|---------|
| Competitors or other enterprises in your sector   | Equal variances assumed     | .025   | .873 | .192   | 1866    | .848 | .01353  | .07043 | -.12461 | .15166  |
|   | Equal variances not assumed |        |      | .192   | 1.614E3 | .848 | .01353  | .07046 | -.12468 | .15173  |
| Consultants or commercial labs                    | Equal variances assumed     | 76.336 | .000 | -4.379 | 1866    | .000 | -.26952 | .06156 | -.39025 | -.14880 |
|   | Equal variances not assumed |        |      | -4.193 | 1.367E3 | .000 | -.26952 | .06428 | -.39563 | -.14342 |
| Universities or other higher education institutes | Equal variances assumed     | 7.422  | .007 | -1.527 | 1865    | .127 | -.09988 | .06540 | -.22814 | .02838  |
|   | Equal variances not assumed |        |      | -1.506 | 1.533E3 | .132 | -.09988 | .06632 | -.22998 | .03022  |
| Government, public or private research institutes | Equal variances assumed     | .762   | .383 | -.634  | 1866    | .526 | -.03903 | .06151 | -.15967 | .08162  |
|   | Equal variances not assumed |        |      | -.634  | 1.609E3 | .526 | -.03903 | .06160 | -.15984 | .08179  |

## Discussion and analysis

We have tested 4 main hypotheses about innovative behavior of LMT sectors in the context of Iran in comparison to HMT ones. The results of our tests are shown in Table 10.

Table 10– The results of testing of hypotheses

| Hypothesis  | Result of Test             | Description   |
|---|----------------------------|---|
| <i>H1</i> : LMT sectors are more depended on process innovations while HMTs are more innovative in terms of products  | Half Reject<br>Half Accept | <ul style="list-style-type: none"> <li>HMT sectors are more innovative in product, but LMTs are not more innovative in process</li> </ul>   |
| <i>H2</i> : their innovation is heavily based on adopting machineries from their suppliers while HMTs are not expected to rely on internal R&D                  | Accept                     | <ul style="list-style-type: none"> <li>Acquisition of knowledge and technology from suppliers are significantly higher in LMTs, while internal R&amp;D is not higher in HMTs</li> </ul>   |
| <i>H3</i> : their source of information is different and LMTs should rely more on their suppliers and customers while HMTs should rely more on academic centers | Reject                     | <ul style="list-style-type: none"> <li>Suppliers are not more critical source of information for LMTs</li> <li>HMTs are more dependent on information from clients and competitors than LMTs, but not academic centers</li> </ul> |
| <i>H4</i> : collaborations with suppliers is more important for LMT sectors and research centers are supposed to be main partners of HMTs                       | Reject                     | <ul style="list-style-type: none"> <li>Market consultants are more crucial for LMTs</li> <li>No other agents are seen to collaborate with HMTs</li> </ul>   |

For the first hypothesis, the results show that while HMT sectors are more innovative than LMTs in terms of product innovation, there are no substantial differences among them in terms of process innovation. Details of our analysis about types of process innovations demonstrate that LMTs are however more innovative in their core as well as distribution processes while HMTs are more innovative in supply chain processes. Our further analysis about organizational and market innovation show that HMT sectors are more innovative even in terms of organizational innovation, although there is no significant difference between them regarding market innovations. This means that LMT sectors in Iran suffers from managerial capabilities and it is also evident when they counted market consultants as a more important source of information in comparison to HMTs.

The second hypothesis holds true for LMTs even in the context of Iran confirming that embodied machines are the prime mode of innovation for them in accordance with acquisition of know-how and patents in comparison to HMTs, which are more active in terms of personnel training and market introduction of their products. There are no considerable differences among them in terms of internal and external R&D, design and other in-house activities. . This shows that HMT sectors are in more severe competition that calls for training and market introduction of their innovations. On the other hand, it also suggests that in the context of a developing country with fewer technical complexities, HMT sectors do not also need to pay much attention to internal and external R&D as well as design activities in comparison to LMTs.

It is supposed in the third hypothesis for LMT sectors to rely more on their suppliers and then final customers as the main source of information and ideas. However, this also does not hold true in the context of Iran. The only source of which, LMTs are more depended in comparison to HMTs is market consultants denoting they trust them to find out which technology is better to buy. It should not also be surprising to see that public and private clients, competitors and internet are more important sources of information for HMT firms. It might be because HMTs are facing more strong competition rather than LMTs that calls for information from their clients and well as competitors. The lower complexity of technology reflected in no reliance on academic sources and conferences could be attributed also the context of a developing country.

In addition to the fact that not only suppliers are not a vital source of information for LMTs, there are not also strong linkages between LMTs and their suppliers in comparison to HMT sectors according to hypothesis 4. In accordance to the importance of market consultants for LMTs, they are also shown to be in more interaction with LMT sectors. On the other side, although both private and public customers as well as competitors are supposed to be more important source of information for HMTs, they are not proven to play the interactive role for these sectors. Moreover, collaboration with research centers is not shown to be imperative for HMT sectors.

The innovative behavior of LMT sectors in comparison to HMT sectors thus could be summarized as follows, which is shown in diagram I:

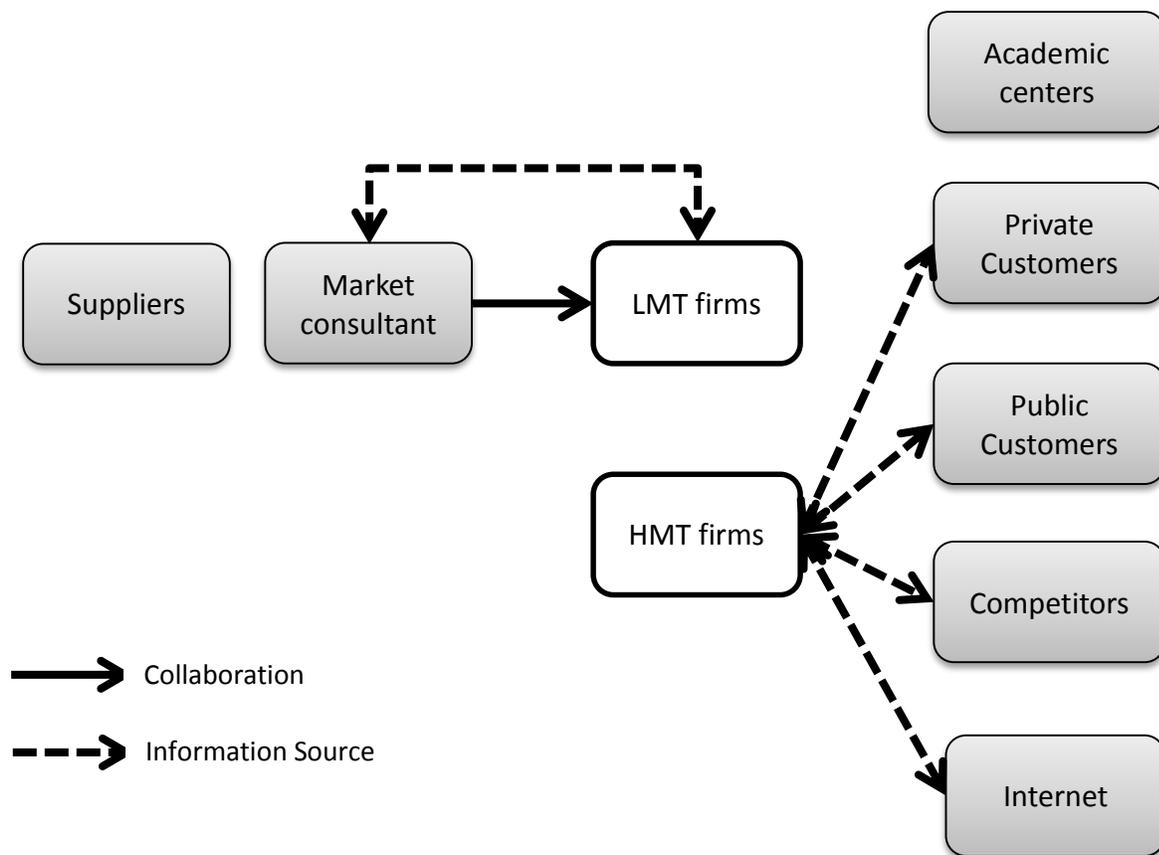


Diagram I- Innovation model of LMTs in comparison with HMTs in terms of information sources and collaborations

- 1- HMTs are more product innovative especially in terms of product innovation by themselves or adopting and modifying products developed by others whereas LMTs are more process innovative in terms of their core manufacturing processes and distribution
- 2- The main different innovation activity of LMTs are buying and replacing their machineries from suppliers in their core manufacturing process as well as acquisition of know-how; while the main innovation activity of HMTs is comparatively personnel training and market introduction of innovations
- 3- LMTs don't pick their necessary information from their suppliers, but mainly from market consultants in comparison to HMTs that rely more on information from customers (public and private), competitors and internet
- 4- LMTs are connected to their market consultants higher than HMTs which tend to not collaborate more than LMTs

We may then propose the following important propositions about innovation models and behaviors in the context of developing countries:

- LMT sectors normally lack even minimal knowledge and absorptive capacity to connect and link directly with their suppliers
- HMTs tend not to innovate based on internal or external R&D

- Interactive learning is not deemed to be a useful theory of innovation in this context as most firms tend not to interact with other agents in NIS
- Distinction between DUI and STI mode of innovations could not be applied to discriminate the patterns of innovation in LMT and HMT sectors in those contexts

## Conclusion

The first round of innovation survey in Iran, accepting its possible shortcomings in design or implementation; it provides useful insights not only for policy makers, but also for academics to analyse the distinctive features of innovation in this context. This paper is among the first to research on this database and report on its findings.

We extracted 4 main hypotheses regarding innovative behavior of LMT and HMT sectors in order to find out the more general and more context specific features of innovation among them. The results are promising as it demonstrated that the context of a developing country within which competition is not intense, the differences between LMTs and HMTs have major dissimilarities from what is predicted in studies from more advanced countries.

Although we found that embodied machines are still much more important source of technology for LMT sectors, intriguingly suppliers and clients are not more key sources of information for them, but market consultants play the chief role. On the other hand, HMTs are more innovative in products, and not more based on internal and external R&D. Information sources from their clients and competitors as well as internet are more pivotal for them. They normally do not link with research centers and international sources of technology more than LMTs. The reasons for this different behavior have been discussed above that calls to pay more attention to understanding innovation in the context of developing countries.

As a practice, we have run our analysis with slightly different sample. Rather than considering firms with just product innovations, we included all firms with at least one product or process innovation in our sample. The results are almost similar with the following minor changes.

- Regarding innovative activities, HMT firms has shown stronger tendency towards internal R&D with significant difference from those of LMTs in comparison to our previous sample
- In terms of sources of information, internal sources has been counted more important for HMTs in the new analysis
- Collaborations with public clients has been shown to be significant for HMT firms

This means that other aspects remained unchanged, except for internal research activity, internal sources of information and collaborations with public sectors for HMTs.

Overall, we suggested following big differences in the context of developing countries that need to be examined by more casual studies. First is the insufficiency of interactive learning as a theory to mode innovation in this context, second is problems in applying STI and DUI mode of innovation to distinct the behaviors of HMTs and LMTs respectively and third is the need to study the organizational processes of firms within this context by more detail to understand their innovation processes.

This calls more attention to study the specific context of developing countries and the innovative behaviors of firms. We have drawn a preliminary comparative model for innovation in both LMT and HMT sectors in the context of Iran that could be verified and tested in other developing countries. Finally, we suggest replicating this study in some other developing countries in order to examine the results of this paper.

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