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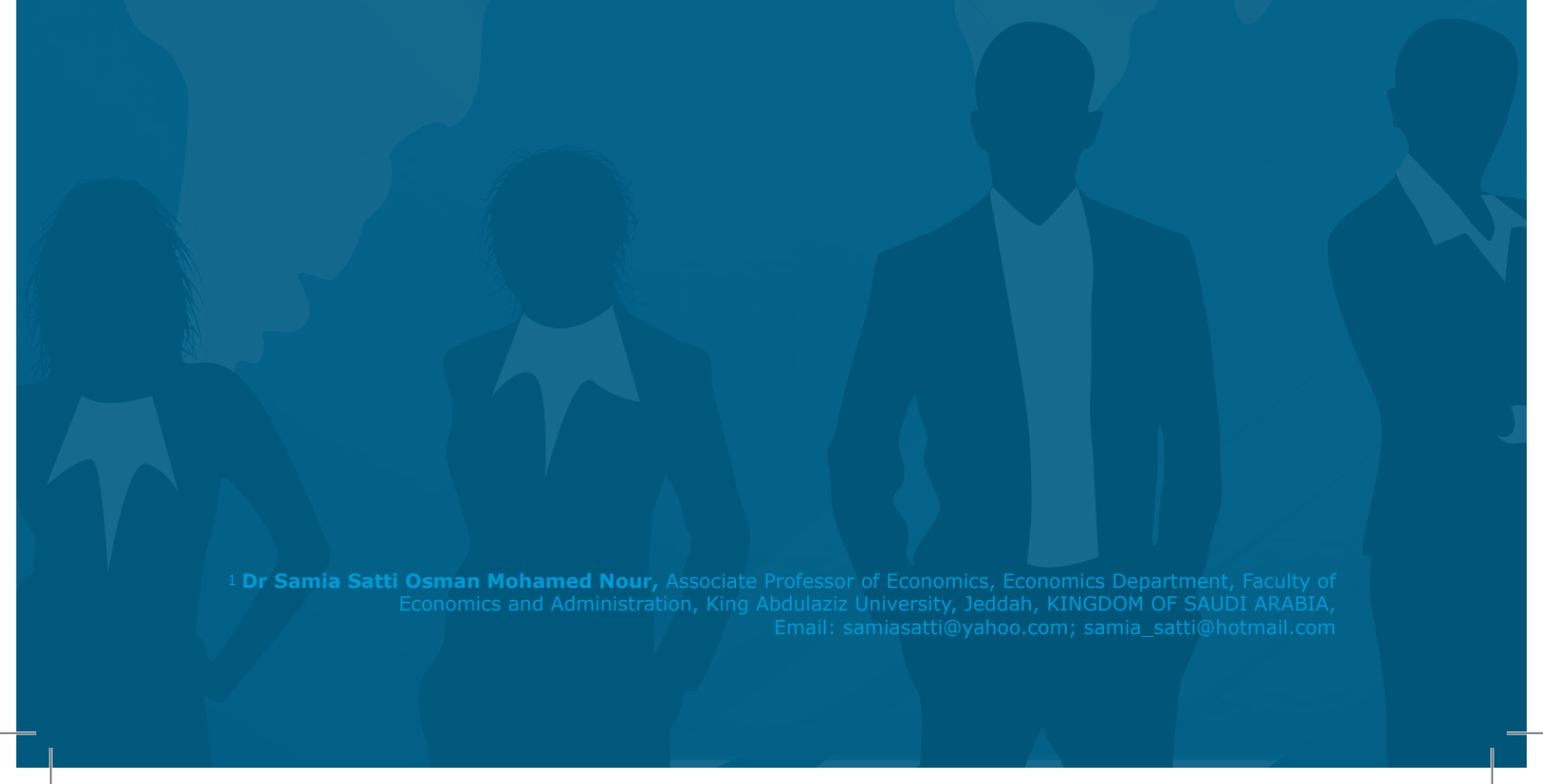
# Overview of technology transfer in the manufacturing industries in the Arab countries: the case of UAE and Sudan



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# Overview of technology transfer in the manufacturing industries in the Arab countries: the case of UAE and Sudan

# Abstract

**Purpose** This paper aims to examine the channels and effects of technology transfer in industrial manufacturing firms in the Arab region, with particular reference to the UAE and Sudan.

**Methodology** This paper uses descriptive and comparative approaches and utilises the definition of technology transfer often found in the international literature to examine the channels and effects of technology transfer in industrial manufacturing firms in the Arab region. An examination of the industrial manufacturing firms in the UAE and Sudan is mostly based on primary data collected from the firm surveys in the UAE (2002) and Sudan (2010).

**Findings** The findings support the first hypothesis that industrial manufacturing firms in the Arab region use several channels of technology transfer. Our results corroborate the second hypothesis that the channels of technology transfer and their respective effects vary enormously across firms according to firm size and industry level in the industrial manufacturing firms in the Arab region. Our findings support the third hypotheses that technology transfer creates important positive effects in industrial manufacturing firms in the Arab region.

**Originality/value** This paper is valuable because it fills the gap in the Arab literature by presenting a more comprehensive, focused and comparative analysis and investigating the channels and effects of technology transfer in industrial manufacturing firms in the UAE and Sudan, based on the firm surveys in the UAE (2002) and Sudan (2010), since these issues are not adequately discussed in the Arab literature. Moreover, the paper supports the efforts aimed at enhancing the positive effects of technology transfer for both building the absorptive capacity and building knowledge-based economies in the Arab region. The findings imply that it is essential for the Arab region to support the absorptive capacity in order to utilise the effects of technology transfer to boost industrial firms and to achieve sustainable economic development in the UAE, Sudan and the Arab region.

**Keywords** Technology transfer, Effects of technology transfer, Firm size, Industry level, UAE, Sudan

**Paper type** Research paper

**JEL classification** F23, O3, O30, O32, O33, D2



 

# Introduction

There is increasing recognition and evidence to confirm the importance of technology and knowledge transfer for the enhancement of scientific and technological progress and economic growth (Ackers, 2005; cf. Grossman and Helpman, 1991, 1994; Romer, 1990). More recently, the continuous move towards globalisation along with the progress in information and communication technologies (ICT), knowledge economy and increasing internationalisation of knowledge has highlighted the centrality of the diffusion of technological knowledge and its intensified impact on the world economy. In recent years there has been a growing body of literature on the role of technology and knowledge transfer to promote technological capabilities in developing countries and to bridge the already widening technological and knowledge gaps between developed and developing countries.

Based on the above, this paper presents an overview of technology transfer in the Arab region, with particular reference to industrial manufacturing firms in Sudan and UAE. It aims to contribute to recently published research studies that aim to improve understanding of the channels and effects of technology transfer in the developing countries [i]. This paper addresses the following questions: What are the major channels of technology transfer in the industrial manufacturing firms in the Arab region?; How important is the effect of industry level and firm size in technology transfer in the industrial manufacturing firms in the Arab region?; and How important is the effect of technology transfer in the industrial manufacturing firms in the Arab region? We examine three hypotheses; the first hypothesis argues that the industrial manufacturing firms in the Arab region use several channels of technology transfer. We examine the second hypothesis that the channels of technology transfer and their respective effects vary enormously across firms according to firm size and industry level in the industrial manufacturing firms in the Arab region. We examine the third hypothesis that technology transfer creates important positive effects in the industrial manufacturing firms in the Arab region.

This paper is important in view of the fact that technology transfer is a vital topic in the discussion of economic development, and therefore understanding the impact of technology transfer in developing and particularly, Arab countries like UAE and Sudan is of great significance. Particularly, in view of the fact that technology transfer and access to foreign technologies, notably, foreign direct investment is perceived as an important tool for building technological capabilities in the economies of developing countries like UAE and Sudan and for bridging the already widening technology gap with the advanced countries. This paper discusses, from an economic perspective, the channels and effect of technology transfer in UAE and Sudan and differs in several ways from studies in the literature, which provides an interesting analysis of technology transfer in the developing countries. First, in contrast to the studies in the literature, we fill the gap in the Arab literature and present a more focused and comparative analysis of the channels and effects of technology transfer at the firm level

based on two criteria: industry level and firm size in the manufacturing sector in UAE and Sudan as new cases from the Arab countries. Secondly, in contrast to the few studies in the Arab literature (cf. Nour, 2012) that examine the importance of knowledge and technology transfer in Egypt, Arab and MENA countries from a macro-perspective, we examine the importance of technology transfer in UAE and Sudan from the micro-perspective, using more recent data based on firm surveys in UAE and Sudan. Thirdly, we differ from the studies in the Arab literature in providing a novel element in our analysis, namely, the provision of an in-depth and comparative analysis of the channels and effects of technology transfer in the industrial manufacturing firms in UAE and Sudan using new primary data at the micro-level based on the firm survey data collected from the industrial manufacturing firms in UAE and Sudan. Moreover, we contribute to the few earlier studies on technology transfer and the impacts of technologies transfer in the Arab region (El Sabaa, 1997; Haan, 1999). Finally, we support the efforts aimed at enhancing the effects of technology transfer for building technological capabilities in the Arab region.

Regarding research methods, in order to investigate the research problem we focus on Sudan and UAE as cases from the Arab countries, and we use descriptive, comparative and qualitative methods of analysis, using primary data at the micro-level, and results from the firm surveys (2002, 2010) that were held in UAE (2002) and in Sudan (2010), as discussed in Nour (2005, 2011, 2013). The firm survey (2002) on 'Technological Change and Skill Development in UAE's Manufacturing Sector' aims to assess skill and technology indicators and the impacts of unskilled foreign workers and to assess the channels and effects of technology transfer amongst the chemical and metal medium and large-sized establishments in UAE. The firm survey (2010) on 'Technological Change and Skill Development in Sudan's Manufacturing Sector' aims to assess skill and technology indicators and the impacts of unskilled workers and to assess the channels and effects of technology transfer amongst the food, textile, chemical and metal small, medium and large-sized establishments in Sudan. We examine the channels and effects of technology transfer in Sudan and UAE across firms defined by firm size and industry, using broad definitions of the major channels of technology transfer used in the international literature and utilising the general background information presented in Section 2 of the firm surveys (2002, 2010) questionnaires, which focuses on the use, level, transfer and dependence on foreign technology, value and trend of ICT expenditures, technology indicators, patent, R&D, ICT and product/process innovations. The firm surveys provide qualitative data to examine the channels and effects of technology transfer for 73 of the respondent firms to the firm survey (2010) and for 44 of the respondent firms to the firm survey (2002).[ii, iii]

Based on the above, the rest of this paper will be organised as follows: the next section reviews the international literature on technology and knowledge transfer. The paper then discusses and compares the channels and effects of technology transfer in the UAE and Sudan, before presenting the conclusions.

## Review of the international literature on technology transfer

Before explaining the effects of technology transfer in UAE and Sudan, it is useful to begin with a brief review of the international literature on technology transfer channels and effects.

This section examines the major technology transfer channels and the effectiveness of these channels in technology transfer that have been investigated in the international literature; these include, for example, foreign direct investment (FDI), international trade, ICT, human capital mobility, and university-industry linkage. The literature shows several channels of technology transfer/flows, "either through arms-length means, such as through licensing, or through trade in intermediate goods, plant and equipment or even products or services, technology flows may also be made available through hierarchies, between affiliated firms within a multinational enterprise or through the modality of FDI" (Narula, 2004) (see Figure 1) [iv]. The factors that facilitate or impede technology transfer are closely related to knowledge transfer channels. Technology transfer is effective for promoting the absorption capacity and transfer of knowledge through FDI and international trade in technological products. The enhancing factors for technology transfer include adequate availability of financial and human resources, high skill and well-educated labour force, good infrastructure, ICT, R&D, IPR, etc.

***Figure 1.*** *Technology flows*

**Technology flows may occur through various means:**

**1. Through trade, embodied in;**
- **Plant and equipment**
- **Intermediate and final goods or other imports**

**2. Through hierarchies (i.e. inward FDI, such as MNEs), embodied in:**
- **Expatriate personnel**
- **Plant and equipment**
- **Intermediate and final goods**
- **Training provided to employees**
- **Intra-firm, inter-subsidiary movement of staff**
- **Inter-MNE alliances**

**3. Arms-length through:**
- **turn-key projects**
- **consultancy projects**
- **licensing**
- **franchising**

**4. Outward FDI (through reverse technology transfer)**

***Sources:*** *Narula, 2004, p. 10*

In the international literature on knowledge and technology transfer, many studies provide general surveys of the channels and impact of international technology transfer (Keller, 2001, 2004; Saggi, 2002), technology transfer through FDI (Görg and Strobl, 2001; Kumar, 1997), learning by exporting (Greenaway and Kneller, 2007; Girma et al., 2004; Wagner, 2007), learning by importing intermediate inputs at country level (Coe and Helpman, 1995; Coe et al., 1997) and at firm level (Kasahara and Rodrigue, 2008; Muûls and Pisu, 2007), and through licensing (Mansfield and Romeo 1980). The international literature on the effectiveness of international technology and knowledge transfer channels in different countries come to mixed results on the effectiveness of different channels of international knowledge transfer on the host countries, but identify both FDI and international trade as two major channels through which technological knowledge developed in one country is transferred across borders (Saggi, 2002; Keller, 2004; Kneller et al., 2009). "The macro-level literature on international R&D spillovers largely tends to concentrate on trade-related spillovers (Keller, 1997; Coe and Helpman, 1995; Caves, 1974), the micro-level literature has tended to focus on inward FDI-related spillovers (Aitken and Harrison, 1999), very few studies have analysed the role of both inward and outward FDI as a channel of technology transfer" (Criscuolo and Narula, 2002) [v]. Finally, technology transfer through human capital mobility (Williams 2005, 2009) and university–industry linkage (Brennenraedts et al., 2006),

Belderbos and Van Roy (2009, 2010, 2012) examine the impact of international and domestic technology transfers on firms' productivity performance in a sample of 448 Belgian innovating firms during 2003–2006. They argue that technology transfers may occur through R&D contracting, purchase of licenses and knowhow, purchase of specialised machinery, hiring of specialised personnel, and various informal channels. Estimates of a dynamic productivity model show that firms engaging in international knowledge transfer strategies record substantially and significantly higher productivity growth. The largest impact on productivity is found if firms combine international and domestic transfer strategies, suggesting that a diverse external technology sourcing strategy combining local knowhow with knowhow from abroad is most effective. Such combined domestic and international technology sourcing strategies are associated with firms' basic research orientation, R&D intensity and the successful use of technology protection strategies to appropriate the benefits of innovation efforts. They find that foreign multinational firms are more likely to adopt technology transfer strategies solely focusing on international transfers. [vi]

Hu, Jefferson and Jinchang (2004) examine R&D and technology transfer at firm level based on evidence from Chinese industry. They argue that in bridging the technology gap with the OECD nations, developing economies have access to three avenues of technological advance: domestic R&D, technology transfer, and foreign direct investment. They examine the contributions of each of these avenues, as well as their interactions, to productivity within Chinese industry. Based on a large dataset for China's large and medium-sized enterprises, the estimation results show that in-house R&D significantly complements technology transfer – whether of domestic or foreign origin. Foreign direct investment, which they assume is an important channel of proprietary technology transfer, does not facilitate the transfer of market-mediated foreign technology. [vii]

The literature identifies eleven most typical knowledge transfer channels used in manufacturing and services sectors, indicating that "the channels of knowledge transfer in manufacturing and services are very similar, because knowledge transfer in both manufacturing and services is taking place in the era of the new economy that is characterised by wide and fast spread of new technologies (especially ICT), which lead to an increasing convergence between goods and services". The literature defines the average importance of these channels for both sectors in five groups. "First, channels of average importance for manufacturing and services are: suppliers, licensing/franchising, intra-company strategic knowledge management, knowledge intensive business services, human capital mobility and internet. Second, channels of average importance for manufacturing and of more importance for services are: foreign direct investment and training. Third, channel of average importance for services and of more importance for manufacturing is the links with academy. Fourth, channel of less importance for manufacturing and of more importance for services is the producer-consumer two-way knowledge transfer. Fifth, channel of less importance for services and of more importance for manufacturing is patents" (Cowan et al., 2001) [viii]. We examine major channels of technology transfer in manufacturing industries in UAE and Sudan.

## The channels and effects of technology transfer in UAE and Sudan

Based on the above background, this part of the paper discusses the research questions and hypotheses concerning the channels and effects of technology transfer in the Arab region, mainly in UAE and Sudan. First we identify the various channels of technology transfer in the Arab region, mainly in UAE and Sudan; next we investigate the effects of technology transfer in the Arab region, mainly in UAE and Sudan.

## The channels and effects of technology transfer in Sudan

Technology transfer and the high dependence on foreign transferred technologies appear from the reported information on the transfer of foreign technology that is made through different channels (see Table 1). For instance, Table 1 illustrates that hiring foreign skills/technologically advanced workers/consultants and FDI are more common channels of technology transfer, while strategic alliances, technology licensing and joint ventures are less-preferred channels. For a few firms, other methods of the transfer of technologies include bringing foreign expertise, the use of the internet and making self-searches as needed or according to the nature of the work. The transfer of technology, mainly the transfer of technologically advanced workers/consultants, has induced important effects in enhancing firm production but has slight less effect in enhancing the capacity to develop the local technologies.[ix]

***Table 1.*** *The channels of technology transfer and their effects on firm production and development of local technology across firms in the Sudan, 2010*

| **(a) Channels of technology transfer (2005–2009)** | All firms | Chemical | Food | Metal | Textile | Large | Medium | Small |
|---|---|---|---|---|---|---|---|---|
| Hiring foreign skills/technologically advanced workers/consultants | 48% | 56% | 35% | 62% | 40% | 57% | 39% | 50% |
| FDI | 31% | 28% | 32% | 31% | 40% | 40% | 29% | 20% |
| Strategic alliance | 18% | 22% | 20% | 8% | 0% | 21% | 11% | 25% |
| Licensing | 15% | 19% | 13% | 8% | 20% | 18% | 21% | 5% |
| Joint ventures | 7% | 8% | 7% | 0% | 20% | 9% | 7% | 5% |
| Others (e.g. in-house technology development by hiring technologically advanced persons) | | | | | | | | |
| Total response (2005–2009) | 85 | 36 | 31 | 13 | 5 | 35 | 28 | 20 |
| **(b) The effects of technology transfer in (2005–2009)** | All firms | Chemical | Food | Metal | Textile | Large | Medium | Small |
| Enhancing firm production | 96% | 95% | 96% | 100% | 100% | 100% | 97% | 90% |
| Enhancing the capacity to develop the local technologies | 85% | 90% | 73% | 93% | 100% | 92% | 82% | 75% |
| Total response (2005–2009) | 85 | 37 | 30 | 13 | 5 | 35 | 29 | 20 |
| **(c) The effects of technologically advanced workers in:** | All firms | Chemical | Food | Metal | Textile | Large | Medium | Small |
| Enhancing firm production | 91% | 95% | 90% | 85% | 100% | 91% | 93% | 90% |
| Enhancing the capacity to develop the local technologies | 81% | 89% | 70% | 85% | 80% | 92% | 75% | 70% |
| Total response (2005–2009) | 84 | 36 | 30 | 13 | 5 | 35 | 28 | 20 |
| **(d) Dependence on foreign technology**[x] | All firms | Chemical | Food | Metal | Textile | Large | Medium | Small |
| The degree of automation/use of sophisticated technologies[xi] (%) | 54% | 35% | 67% | 61% | 80% | 68% | 55% | 35% |
| Dependence on foreign technology (%) | 49% | 49% | 58% | 25% | 60% | 51% | 38% | 63% |
| Dependence on foreign technology (%) | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Dependence on foreign technology-1-q-21 | 56% | 58% | 56% | 46% | 57% | 57% | 48% | 62% |
| Dependence on foreign technology-2-q22 | 45% | 35% | 46% | 65% | 51% | 45% | 53% | 31% |

***Sources:*** *Own calculation based on the firm survey (2010).*

For the chemical and food industries, the most-preferred channels of technology transfer are hiring foreign skills/technologically advanced workers/consultants, FDI, strategic alliance, licensing and joint ventures respectively [xii]. For the metal industries the most-preferred channels of technology transfer are hiring foreign skills/technologically advanced workers/consultants, FDI, strategic alliance and licensing respectively [xiii]. For the textile industries, the most-preferred channels of technology transfer are hiring foreign skills/technologically advanced workers/consultants and FDI, followed by licensing and joint ventures respectively [xiv]. For the large firms, the most-preferred channels of technology transfer are hiring foreign skills/technologically advanced workers/consultants, FDI, strategic alliance, licensing and joint ventures respectively [xv]. For the medium-sized firms the most-preferred channels of technology transfer are hiring foreign skills/technologically advanced workers/consultants, licensing, FDI, strategic alliance, and joint ventures respectively [xvi]. For the small firms, the most-preferred channels of technology transfer are hiring foreign skills/technologically advanced workers/consultants, FDI, strategic alliance, licensing and joint ventures respectively [xvii].

The effect of technology transfer in enhancing firm production (2005–2009) is higher for both textile and metal industries, followed by chemical and food industries, and is higher for large firms followed by medium-sized firms and small firms respectively. Similarly, the effect of technology transfer in enhancing the capacity to develop the local technologies (2005–2009) is higher for both textile and metal industries, followed by food and chemical industries, and is higher for large firms followed by medium-sized firms and small firms respectively [xviii].

The effect of hiring foreign skills/technologically advanced workers as a channel for technology transfer in enhancing firm production (2005–2009) is higher for both textile and chemical industries, followed by food and metal industries, and is higher for medium-sized firms followed by large firms and small firms respectively. Similarly, the effect of hiring foreign skills/technologically advanced workers technology transfer in enhancing the capacity to develop the local technologies (2005-2009) is higher for both chemical and metal industries, followed by textile and food industries, and is higher for large firms followed by medium-sized firms and small firms respectively. [xix]

In the firm survey questionnaire, the question on the channels of technology transfer allows for multiple answers, assuming that firms may choose more than one channel to transfer technology. [xx] Our results indicate that all respondent firms are less interested in transferring technologies through formal licenses. These may not be often requested, probably because of more liberalised and open market policies that led to considerable presence of foreign capital investment and allowed for foreign and mixed ownership (cf. Nour, 2011, 2013). [xxi]

Table 1 shows that further evidence to confirm technology transfer appears from the high dependency on foreign imported transferred technology across firms, which arises from the following: (1) The high dependence on the imported equipment, machines and techniques among all of the respondent firms (100%); (2) The high percentage value of capital equipment to total capital equipment that has been built by foreign companies (56%) among the respondent firms; (3) The considerable percentage value of imported capital equipment to total capital (45%) among the respondent firms in the year

main reasons for the dependence on foreig 2008; (4) The short-run plan for 92% of the respondent firms is based/ depends on imported technology; [xxii] The n technology are the lack of local technology from local suppliers, better quality and better price of foreign technology in that order. Despite the high dependency on imported technologies, it is somewhat surprising that the level of technology used is below international standards amongst the majority of the respondent firms (53%) and a high level of technology used similar to international standards is limited only within 47% of all the respondent firms. Moreover, somewhat surprisingly, a high degree of automation through the use of sophisticated and advanced technology is limited to only within 54% of all the respondent firms (see Table 1). The degree of automation/ sophisticated use of advanced technologies is determined by both firm size and industry/activity. [xxiii]

These findings on high dependence on transfer of foreign technologies at the micro-level are consistent with those at the macro-level and the interaction of these results lead to a large technological gap (see also earlier discussion in Nour, 2011, 2013). These results imply that in the short- and medium-term, Sudan is unable to rely on local technologies and remains heavily dependent on the transfer of foreign technologies. Our results from the firm survey show that both the channels of technology transfer and their respective effects vary enormously across firms and seem determined by both firm size and industry level. [xxiv]

## The channels and effects of technology transfer in UAE

Technology transfer and the high dependence on foreign transferred technologies appear from the reported information on the transfer of foreign technology that is made through different channels (see Table 2). For instance, Table 2 illustrates that strategic alliances, hiring foreign skills/technologically advanced workers/consultants and joint ventures are more common channels of technology transfer, while FDI and technology licensing are less-preferred channels. The transfer of technology, mainly the transfer of technologically advanced workers/consultants, has induced important effects in enhancing firm production but has had only slight effects in enhancing the capacity to develop the local technologies. [xxv]

***Table 2.*** *The channels of technology transfer and their effects on firm production and development of local technology across firms in the UAE, 2002*

| **(a) Channels of technology transfer (1999–2001)** | All firms | Chemical | Metal | Medium | Large |
|---|---|---|---|---|---|
| Strategic alliance | 42% | 33% | 57% | 43% | 42% |
| Hiring foreign skills/technologically advanced workers/ consultants | 32% | 42% | 14% | 43% | 25% |
| Joint ventures | 32% | 25% | 43% | 43% | 25% |
| FDI | 21% | 33% | 0 | 29% | 17% |
| Licensing | 16% | 8% | 29% | 14% | 17% |
| Others (e.g. in-house technology development by hiring technologically advanced persons) | 8% | 8% | 0 | 0 | 8% |
| Total response (1999–2001) | 19 | 12 | 7 | 7 | 12 |
| **(b) The effects of technology transfer in (1999–2001)** | All firms | Chemical | Metal | Medium | Large |
| Enhancing firm production | 87% | 72% | 47% | 77% | 50% |
| Enhancing the capacity to develop the local technologies | 48% | 44% | 20% | 38% | 30% |
| Total response (1999–2001) | 23 | 18 | 15 | 13 | 20 |
| **(c) The effects of technologically advanced workers in:** | All firms | Chemical | Metal | Medium | Large |
| Enhancing firm production | 47% | 63% | 29% | 50% | 45% |
| Enhancing the capacity to develop the local technologies | 33% | 26% | 41% | 25% | 40% |
| Total response (1999–2001) | 36 | 19 | 17 | 16 | 20 |
| Dependence on foreign technology | All firms | Chemical | Metal | Medium | Large |
| The degree of automation/use of sophisticated technologies xxvi (%) | 40% | 54.5% | 26.3 % | 36.8% | 45.5 % |
| Dependence on foreign technology xxvii (%) | 90% | 96% | 84% | 90% | 91% |

***Sources:*** *Own calculation based on the firm survey (2002).*

For the chemical industries, the most-preferred channels of technology transfer are hiring foreign skills/ technologically advanced workers/consultants, FDI, strategic alliance, joint ventures and licensing respectively. [xxviii] For the metal industries, the most-preferred channels of technology transfer are strategic alliance, joint ventures, licensing and hiring foreign skills/technologically advanced workers/consultants respectively. [xxix] For the large and medium-sized firms, the most-preferred channels of technology transfer are strategic alliance, hiring foreign skills/technologically advanced workers/consultants, joint ventures, FDI and licensing respectively. [xxx]

The effect of technology transfer in enhancing firm production (1999–2001) is higher for the chemical industries followed by metal industries, and is higher for medium-sized firms followed by large firms respectively. Similarly, the effect of technology transfer in enhancing the capacity to develop the local technologies (1999–2001) is higher for the chemical industries followed by metal industries, and is higher for medium-sized firms followed by large firms respectively. [xxxi]

The effect of hiring foreign skills/technologically advanced workers as a channel for technology transfer in enhancing firm production (1999–2001) is higher for the chemical industries

followed by metal industries, and is higher for medium-sized firms followed by large firms respectively. In contrast, the effect of hiring foreign skills/technologically advanced workers as a channel for technology transfer in enhancing the capacity to develop the local technologies (1999–2001) is higher for the metal industries followed by chemical industries, and is higher for large firms followed by medium-sized firms respectively.[xxxii]

In the firm survey questionnaire, the question on the channels of technology transfer allows for multiple answers, assuming that firms may choose more than one channel to transfer technology. [xxxiii] Our results indicate that chemical firms are less interested in transferring technologies through formal licenses. These may not be often requested, probably because of more liberalised and open market policies that led to considerable presence of foreign capital investment and allowed for foreign and mixed ownership (cf. Nour, 2005). [xxxiv]

Table 2 shows that further evidence to confirm technology transfer appears from the high dependency on foreign imported transferred technology across firms that appears from the following: (1) The high dependence on the imported equipment, machines and techniques among 90% of the respondent firms. (2) The high percentage value of capital equipment to total capital equipment that has been built by foreign companies (70%) among the respondent firms. (3) The considerable percentage value of imported capital equipment to total capital (40%) among the respondent firms in the year 2001. (4) The short-run plan for 46% of the respondent firms is based/depends on imported technology. [xxxv] The main reasons for the dependence on foreign technology are the lack of local technology from local suppliers, better price and better quality of foreign technology in that order. [xxxvi] Due to the high dependency on imported technologies, it is not surprising that the level of technology used is similar to international standards amongst all the respondent firms. However, a high degree of automation through the use of sophisticated and advanced technology is limited only within 40% of all the respondent firms (see Table 2).

These findings on the high dependence on the transfer of foreign technologies at the micro-level are consistent with those at the macro-level and the interaction of these findings lead to a large technological gap – see also earlier discussion in Nour (2005). These results imply that in the short- and medium-term, the Gulf countries are unable to rely on local technologies and remain heavily dependent on foreign technologies. Our findings from the firm survey suggest that the channels of technology transfer and their respective effects vary enormously across firms and seem determined by both firm size and industry level. For instance, Table 2 shows that the dependence on imported technology, the degree of automation and the use of sophisticated and advanced technology varies across firms and increases with firm size and industry level/activity.[xxxvii]

Therefore, our findings support the first hypothesis that the industrial manufacturing firms in the Arab region (UAE, Sudan) use several channels of technology transfer. Our results corroborate the second hypothesis that the channels of technology transfer and their respective effects vary enormously across firms according to firm size and industry level in the industrial manufacturing firms in the Arab region (UAE, Sudan). Our findings support the third hypotheses that technology transfer creates important positive effects in the industrial manufacturing firms in the Arab region (UAE, Sudan).

# Conclusion

This paper presents an overview of technology transfer in the Arab region, with particular reference to industrial manufacturing firms in Sudan and UAE. It aims to contribute to recently published research studies that aim to improve understanding of the channels and effects of technology transfer in the developing countries.

This paper is important in view of the fact that technology transfer is a very important topic in the discussion of economic development, and therefore understanding the impact of technology transfer in developing and particularly, Arab countries like UAE and Sudan is of great significance. This is especially important in view of the fact that technology transfer and access to foreign technologies, notably, foreign direct investment, are perceived as important tools for building technological capabilities in the developing economies of countries like UAE and Sudan, and for bridging the already widening technology gap with advanced countries.

This paper uses descriptive and comparative approaches and uses the definition of technology transfer in the international literature to examine the channels and effects of technology transfer in the industrial manufacturing firms in the Arab region. We fill the gap in the Arab literature and present a more focused and comparative analysis of the channels and effects of technology transfer in the industrial manufacturing firms in the UAE and Sudan, based on the firm surveys in the UAE (2002) and Sudan (2010). Our findings support the first hypothesis that the industrial manufacturing firms in the Arab region use several channels of technology transfer. Our results corroborate the second hypothesis that the channels of technology transfer and their respective effects vary enormously across firms according to firm size and industry level in the industrial manufacturing firms in the Arab region. Our findings support the third hypotheses that technology transfer creates important positive effects in the industrial manufacturing firms in the Arab region. Therefore, it is essential for the Arab region to support the absorptive capacity in order to utilise the effects of technology transfer to boost industrial firms and economic development in the UAE, Sudan and the Arab region.

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# End notes

**i** The Arab region is composed of twenty-two countries, including Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Mauritania, Morocco, Oman, Occupied Palestine Territories, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen.

**ii** The field research to collect our primary data was held in the period from February to April, 2002 in the UAE. The firm survey (2002) on "Technological Change and Skill Development in UAE's Manufacturing Sector" was circulated amongst 106 of the chemical and metal medium and large-sized enterprises in the UAE. It aimed to collect micro qualitative and quantitative data, and covered the medium and large-sized firms engaged in both the chemical and metal industries in the UAE. The response rate varied according to firm size and industrial activity: for the chemical industry, the total response rate was 40%, and the weighted response rates by employment size was 44% and 37% for medium and large-sized firms respectively. For the metal industry, the total response rate was 44%, and the weighted response rates by employment size were 47% and 41% for medium and large-sized firms respectively. The sample in the firm survey was drawn from the medium and large-sized firms active in the chemical and metal industries, which are located in three emirates of Abu Dhabi, Dubai and Sharjah. We measured the channels and effects of technology transfer qualitatively, we asked firms about their own appreciation or evaluation of the various channels of technology transfer and the respective effects of the transferred technologies they are using in their production (cf. Nour, 2005).

**iii** The field research to collect our primary data was held in the period from January to June 2010 in Sudan. The firm survey (2010) on "Technological Change and Skill Development in Sudan's Manufacturing Sector" was circulated amongst 100 of the food, textile, chemical and metal small, medium and large-sized enterprises in Sudan. It aimed at collecting micro qualitative and quantitative data, and covered the small, medium and large-sized firms engaged in the food, textile, chemical and metal industries in Sudan. The response rate varied according to firm size and industrial activity: for the food industry the total response rate was 88%, and the weighted response rates by employment size were 83%, 92% and 88% for small, medium and large-sized firms respectively. For the textile industry the total response rate was 83%, and the weighted response rates by employment size were 100%, 100% and 67% for small, medium and large-sized firms respectively. For the chemical industry the total response rate was 89%, and the weighted response rates by employment size were 85%, 86% and 83% for small, medium and large-sized firms respectively. For the metal industry the total response rate was 80%, and the weighted response rates by employment size were 80%, 80% and 80% for small, medium and large-sized firms respectively. For the total sample, the total response rate was 87%, and the weighted response rates by employment size were 84%, 88% and 83% for small, medium and large-sized firms respectively. The sample in the firm survey was drawn from the small, medium and large-sized firms working in four industries in the manufacturing sector: the food, textile, chemical and metal industries, which are located in Khartoum state. We

measured the channels and effects of technology transfer qualitatively, we asked firms about their own appreciation or evaluation of the various channels of technology transfer and the respective effects of the transferred technologies they are using in their production (cf. Nour 2011, 2013).

**iv** See Rajneesh Narula (2004) "Understanding absorptive capacities in an "innovation systems" context: consequences for economic and employment growth". MERIT-Infonomics Research Memorandum series: 2004-003.

**v** See Paola Criscuolo and Rajneesh Narula (2002) "A novel approach to national technological accumulation and absorptive capacity: Aggregating Cohen and Levinthal", MERIT-Infonomics Research Memorandum series No. 2002-016. pp. 1-8, 18-20.

**vi** See René Belderbos and Vincent Van Roy (2009, 2010, 2012) "International and Domestic Technology Transfers and Productivity Growth: Firm Level Evidence". Electronic copy available at: http://ssrn.com/abstract=1537008.

**vii** See Albert G.Z. Hu ; Gary H. Jefferson and Qian Jinchang (2004) "R&D and Technology Transfer: Firm-Level Evidence from Chinese Industry", National Bureau of Statistics, December 22, 2004, Forthcoming, Review of Economics and Statistics: http://people.brandeis.edu/~jefferso/REStat%20RD%20technologytransfer.pdf.

**viii** See Robin Cowan, Luc Soete and Oxana Tchervonnaya (2001), "Knowledge Transfer and the Services Sector in the Context of the New Economy", MERIT Research Memoranda- 2001-021. pp. 18-19, 27-28.

**ix** These results are consistent in some respects but differ in others with the findings in the UAE as indicated by Nour (2005), El-Sabaa (1997) and Haan (1999) respectively. "The major channels of technology transfer are: joint ventures, and industrial foreign projects, the latter accounts for the first source of technology transfer. The turn-key projects are preferred channel of technology transfer in the Gulf region mainly because of the keenness to avoid defects of execution and to guarantee the maximum consistency of the project's design, lines of production, quality of the products, facilities of training, etc. But it has very limited role in transferring technology to local industry, because it is confined to their plants, with no minimum leakage allowed. Thus they contribute nothing to implant advanced technologies in the country. Technology transfer to the UAE has obviously contributed to accelerating industrial and economic growth, elevating the standard of national products both quality-wise and quantity-wise. In particular, the transfer of technology contributed to rapid growth of local industrial sector. However, a number of negative factors are still adversely affecting the transfer of technology; the technologies transferred could hardly approach its target of constituting an autonomously developing local technological base, similar to those in the Far East industrial countries. Because of: the inadequate awareness of the end target of technology transfer, the lack of a constitutional framework or comprehensive plan for transferring technology, the insufficient local base of technological data, the lack of qualified local manpower necessary for transferring technology and the contracts of technology transfer". See El Sabaa (1997), pp.23-26. "The UAE is almost completely dependent on imported technologies. And without the necessary adaptations to local conditions (e.g. temperatures, effects of dust and sand winds, special cultural aspects, the country's socio-political system, etc.), even these technologies

cannot be optimally applied". See Haan (1999), p.38.

**x** We measured the dependence on foreign technologies qualitatively; we asked firms if they have an adequate capacity/ability to produce and develop local technologies and if they have purchased equipment, machines and techniques from abroad. Our definition also includes quantitative measurement of the value of imported capital equipment to total capital equipment, the percentage value of capital equipment to total capital equipment that has been build by foreign companies. Finally technology transfer is also an indicator of dependence on foreign technologies.

**xi** We measured the degree of automation/ sophisticated technologies qualitatively, we asked firms about their own appreciation or evaluation of the level of technologies they are using in their production.

**xii** As indicated by 56%, 28%, 22%, 19%, 8% of the chemical firms respectively. As indicated by 35%, 32%, 20%, 13%, 7% of the food firms.

**xiii** As indicated by 62%, 31%, 8%, 8%, 0% of the metal firms.

**xiv** As indicated by 40%, 40%, 0%, 20%, 20% of the textile firms.

**xv** As indicated by 57%, 40%, 21%, 18%, 9% of the large firms.

**xvi** As indicated by 39%, 29%, 11%, 21%, 7% of the medium-sized firms.

**xvii** As indicated by 50%, 20%, 25%, 5%, 5% of the small firms.

**xviii** As indicated by100%, 100%, 96% and 95% of the textile, metal, chemical and food industries respectively, and as indicated by 100%, 97% and 90% of the large, medium and small-sized respectively. As indicated by 100%, 93%, 90% and 73% of the textile, metal, food, and chemical industries respectively, and as indicated by 92%, 82% and 75% of the large, medium and small-sized respectively.

**xix** As indicated by 95%, 90%, 85%, 100%, 91%, 93%, 90% of the textile, chemical, food and metal, medium, large and small respectively. As indicated by 89%, 70%, 85%, 80%, 92%, 75% and 70% of the chemical, metal, textile, food, large, medium and small respectively.

**xx** Our assumption and respective findings are plausible and consistent with the results in the UAE as indicated by Nour (2005) and the results of El Sabaa (1997), which indicate numerous different channels of technology transfer to the UAE, such as: foreign industrial investments, offset programmes, training missions, technological imports, industrialisation licenses, patents, technological products, foreign manpower and industrial consulting offices. See El Sabaa (1997), p.26.

**xxi** For instance, according to Sudan Ministry of Investment, among the efforts that aim at promoting foreign investment, the government has issued the investment encouragement law, which grants encouraging exemptions to investors and indicates that the investor has the right to operate without a Sudanese partner. In addition, in order to promote foreign investment, the government has established free zones including: Suakin Free Zone and Aljaily Free Zone. The Free Zones and Free Markets Law (1994) represents the legislative framework for the establishment and operation of free zones and markets in Sudan. The rules resulting from this law represent the organisational framework for operating and managing free zones in Sudan.

This law provides several advantages of investment in free zones, for instance the industrial, commercial or service investments, which are licensed to be established in the free zones enjoy several advantages. These include the following: exemption of the projects from profits tax for a period of 15 years, renewable for an extra period dependant on the decision made by the concerned minister commencing from the one year period of grace which follows the year of commencement of production; salaries of expatriates working in projects within the free zones will be exempted from the personal income tax; exemption of products imported into the free zone or exported abroad from all customs fees and taxes except service fees and any other fee imposed by the board of Sudan Free Zones Company; real estate establishment inside the free zones area are exempted from all taxes and fees; invested capital and profits are transferable from Sudan overseas through any bank licensed to operate in the free zone and exemption of products of industrial projects established in the free zones from customs fees; depending on materials used and local costs incurred in production, provided that the value be estimated by a committee assigned for this purpose by the board of Sudanese Free Zones Company. See Sudan Ministry of Investment: http://www.sudaninvest.org/English/Sudan-Invest-FreeZone.htm, accessed January ,30 2011. These results are consistent with the findings in the UAE as indicated in Nour (2005). For instance, Fasano (2002) indicates that other than Abu Dhabi, the emirates have established free zones that allow %100 foreign ownership of companies. These zones are particularly important in Dubai, where they have attracted a large number of foreign companies. See Fasano (2002), p.331. El Sabaa (1997) finds that the adoption of an open market philosophy, supported by the existence of nine free zones in the seven emirates and the advantage of %100 foreign ownership and control, encourages foreign industrial investors to set up their projects and to promote technology transfer to the UAE. See El Sabaa (1997), p.23.

**xxii** Short, medium and long run refers to next three years, next three to five years and next ten years respectively.

**xxiii** As reported by %42 ,%71 and %14 of the respondent firms respectively.

**xxiv** These results are consistent with the findings in the UAE as indicated by Nour (2005) and El Sabaa (1997), who notes "The adoption of different approaches in transferring technology differs according to certain criteria, such as: the scale of industry and its activity. Large size and some specific sectors, namely chemical and petrochemicals industries have better use of sophisticated advanced technologies". See El Sabaa (1997), pp.22-21.

**xxv** These results are consistent in some respects but differ in others with the findings of El Sabaa (1997) and Haan (1999) respectively. "The major channels of technology transfer are: joint ventures, and industrial foreign projects, the latter accounts for the first source of technology transfer. The turn-key projects are preferred channel of technology transfer in the Gulf region mainly because of the keenness to avoid defects of execution and to guarantee the maximum consistency of the project's design, lines of production, quality of the products, facilities of training, etc. But it has very limited role in transferring technology to local industry, because it is confined to their plants, with no minimum leakage allowed. Thus they contribute

nothing to implant advanced technologies in the country. Technology transfer to the UAE has obviously contributed to accelerating industrial and economic growth, elevating the standard of national products both quality- wise and quantity-wise. In particular, the transfer of technology contributed to rapid growth of local industrial sector. However, a number of negative factors are still adversely affecting the transfer of technology, the technologies transferred could hardly approach its target of constituting an autonomously developing local technological base, similar to those in the Far East industrial countries. Because of: the inadequate awareness of the end target of technology transfer, the lack of a constitutional framework or comprehensive plan for transferring technology, the insufficient local base of technological data, the lack of qualified local manpower necessary for transferring technology and the contracts of technology transfer" (El Sabaa, 1997: 23-26)."…….The UAE is almost completely dependent on imported technologies. And without the necessary adaptations to local conditions (e.g. temperatures, effects of dust and sand winds, special cultural aspects, the country's socio-political system, etc.), even these technologies cannot be optimally applied" (Haan, 1999: 38).

**xxvi** We measured the degree of automation/sophisticated technologies qualitatively, we asked firms about their own appreciation or evaluation of the level of technologies they are using in their production.

**xxvii** We measured the dependence on foreign technologies qualitatively, we asked firms if they have an adequate capacity/ability to produce and develop local technologies and if they have purchased equipment, machines and techniques from abroad. Our definition also include quantitative measurement of the value of imported capital equipment to total capital equipment, the percentage value of capital equipment to total capital equipment that has been built by foreign companies. Finally technology transfer is also an indicator of dependence on foreign technologies- see Table 5.7.

**xxviii** As indicated by 42%, 33%, 33%, 25% and 8% of the chemical firms respectively.

**xxix** As indicated by 57%, 43%, 29% and 14% of the metal firms respectively.

**xxx** As indicated by 42%, 25%, 25%, 17%  and 17% of the large firms, and as indicated by 43%, 43%, 43%, 29%, and 14% of the medium-sized firms.

**xxxi** As indicated by 72% and 47% of the chemical, and metal industries respectively, and as indicated by 77% and 50% of the medium and large-sized respectively. As indicated by 44% and 20% of the chemical and metal industries respectively, and as indicated by 38% and 30% of the medium and large-sized respectively.

**xxxii** As indicated by 63%, 29%, 50% 45% of the chemical, metal, medium and large-sized respectively.  As indicated by 41%, 26%, 40% and 25% of the metal, chemical, large and medium-sized firms respectively.

**xxiii** Our assumption and respective findings are plausible and consistent with the results of El Sabaa (1997), which indicate numerous different channels of technology transfer to the UAE, such as: foreign industrial investments, offset programmes, training missions, technological imports, industrialisation licenses, patents, technological products, foreign manpower and industrial consulting offices (El Sabaa, 1997: 26).

**xxiv** For instance, Fasano (2002) indicates that other than Abu Dhabi, the emirates have established free zones that allow 100 per cent foreign ownership of companies. These zones are particularly important in Dubai, where they have attracted a large number of foreign companies (Fasano, 2002: 331). El Sabaa (1997) finds that the adoption of an open market philosophy, supported by the existence of nine free zones in the seven emirates and the advantage of 100% foreign ownership and control, encourages foreign industrial investors to set up their projects and to promote technology transfer to the UAE (El Sabaa 1997: 23).

**xxv** Short, medium and long run refers to next three years, next three to five years and next ten years respectively.

**xxvi** As reported by 84%, 37% and 34% of the respondent firms respectively.

**xxvii** These results are consistent with the findings of El Sabaa (1997) "The adoption of different approaches in transferring technology differs according to certain criteria, such as: the scale of industry and its activity. Large size and some specific sectors, namely chemical and petrochemicals industries have better use of sophisticated advanced technologies" (El Sabaa, 1997: 21-22).

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