GVC and Innovation: Evidence from MENA Firm-Level Data

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Abstract

Despite the broad theoretical and empirical studies diagnosing reasons behind the upscaling global value chains (GVC) participation in recent decades, the latter's learning effect is still not amply studied, especially for the Middle East and North Africa (MENA) region that is disadvantaged in technology production. Relying on the recent World Bank Enterprise Surveys comprehensive dataset, we conceptualize the learning effect of GVC participation in terms of firms' innovation performance in developing countries. We contribute to the existing literature in two ways. First, we examine the effect of GVC participation on different types of innovation, namely technological vs. auxiliary services. Second, we take into consideration the sectoral heterogeneity at three levels: factor (labor vs. capital intensive sectors), skill level (sectors intensive in skilled vs. unskilled labor), and technology intensity (high vs. low technology). We find that the positive effect of GVC participation on technological innovation is not moderated with sectoral heterogeneity. Yet, the GVC positive effect on auxiliary services innovation is positively moderated with medium-low technology intensive activities . Furthermore, labor- and capital-intensive manufacturing, medium-high and high technology intensive activities directly stimulate auxiliary services innovation. Our results are robust when employing propensity score matching and instrumental variables methods in addressing the reverse causality as well as when using alternative GVC measures.

Keywords: Global value chains; innovation; firm-level
JEL Classification: F14 ; O32; F10

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1- Introduction

The fast-growing technological advances witnessed since the fourth industrial revolution single out most developing countries stickily lagging behind the technological frontier (UNCTAD, 2021). Indeed, the spatially clustered innovation in advanced economies can be dispersed through interlinkages between firms in global value chains (GVC) that can be potentially a chief channel for knowledge transmission leading to technological change in developing economies. Moreover, capturing the impact of GVC participation on firms' innovation performance aspires to achieving the ninth UN sustainable development goals (SDGs)[3]. Equally important, unveiling the moderating effect of sectoral heterogeneity to GVC learning is necessary in prospecting a GVC driven technological change in developing countries, especially for a region like the Middle East and North Africa (MENA) which is lagging behind for both GVC and innovation. In this respect, we study the GVC learning effect along with the direct and moderating effect of sectoral heterogeneity in terms of factor, skill level and technology intensities in firms located in the MENA region.

The learning effect of international trade is theoretically emphasized since the product cycle trade model (Krugman, 1979) showing that the importer of a good today will be the exporter of the same good in the future due to the associated knowledge transmission. Nowadays, firms' vertical integration allows for enhanced learning due to the fragmented production process in all stages across firms located in different countries and regions (World Bank, 2020). GVC learning is rationalized with the foreign embedded knowledge and technologies in imported intermediate goods from firms located in advanced economies. Likewise, due to increased competition, GVC participation incentivizes innovation (Aghion et al., 2021). Undoubtedly, the learning effect varies in accordance with firms' position along the GVC. Firms specializing in R&D and marketing for example, have significantly higher value added than firms specializing in fabrication activities (De Vries et al., 2021). The learning effect heterogeneity can be captured by studying the varying sectoral factor, skill level, and technology intensities. Indeed, studying the sectoral heterogeneity effect unveils reasons behind the widening divergence paradox between advanced and developing regions like MENA in terms of technology production given that trade between MENA and an advanced economy like the United States is enhanced by free trade agreements[4]. In light of increased GVC participation, we aim at exploring the externalities' effect to the MENA region in terms of knowledge spillovers at the firm level.

One advantage of firm level analysis is disentangling the underlying firms' sectoral concentration. Notwithstanding the GVC learning opportunity, empirical evidence on the causal effect of GVC on innovation performance and capabilities at the firm level is still scant. Conceptually, innovation is multifactorial and entangled. The Oslo manual distinguishes between innovation outcome and innovation activities (OECD, 2018a). Precisely, innovation outcome -also referred to as technological innovation- includes introducing new products or new processes or a combination thereof. On the other hand, innovation activities -also referred to as non-technological innovation- includes facilitating auxiliary services to technological innovation. Although auxiliary services do not guarantee higher innovation outcomes, they indeed strengthen firms' innovation capabilities.

[3] SDG-9 aims at fostering innovation and infrastructure by the year 2030.

[4] MENA countries together would rank 4th as an export market and 5th as an import market for the United States (Office of the United States Trade Representatives, 2008).

Both innovation types are endogenous to indispensable firms' characteristics and are likely affected by sectoral heterogeneity.

Despite the voluminous literature on international trade and productivity, the GVC effect on innovation at the firm-level is rather limited. In this paper, we aim at contributing to the existing literature in two ways. First, we examine the effect of GVC participation on different types of innovation, namely technological vs. auxiliary services. Second, we take into consideration the sectoral heterogeneity at three levels: factor (labor vs. capital intensive sectors), skill level (sectors intensive in skilled vs. unskilled labor), and technology intensity (high vs. low technology). We rely on the recent World Bank enterprise Surveys (WBES) comprehensive dataset in measuring the likelihood of firms' GVC participation as well as different innovation types (technological vs. auxiliary innovation). Our main findings show that GVC participation has a direct positive effect on both technological and auxiliary services innovation. In addition, the positive effect on auxiliary services innovation is strengthened by medium-low technology intensive activities. Yet, medium-high and high technology intensive activities directly stimulates auxiliary services innovation with a neutral GVC moderating effect. We show that sectoral heterogeneity matters for auxiliary services rather than technological innovation in the MENA region.

This paper is structured as follows: Section 2 presents a review of literature on firm level trade, innovation, and sectoral heterogeneity. Section 3 presents data on firm level GVC, innovation, sectoral differences, and presents the empirical strategy. Section 4 presents the empirical results of the GVC effect on different innovation types along with the direct and moderating effects of sectoral heterogeneity. Section 5 concludes and offers some policy recommendations for developing countries to the end of fostering innovation performance.

2- Literature review

This section summarizes literature on firms' innovation and GVC participation followed by sectoral heterogeneity influence on innovation.

Grounding on product differentiation and increasing returns to scale assumptions, heterogenous firm models empirically verify the interlinkages between innovation and exporting (Melitz, 2003; Bernard et al., 2007; Melitz and Redding, 2014). Despite the scant empirical studies on innovation per se, learning by trade literature evidence the association between firms' productivity and exporting (Alavarez and Lopez, 2005; Bernard et al., 2007; De Loecker, 2013; Aghion et al., 2021), importing (Amiti and Konings, 2007 and Martinéz-Zarzozo et al., 2021) as well as GVC participation (Del Prete et al., 2017). Although the direction of causality is unclear, Urata and Baek (2021) account for the self-selection of productive firms in GVC participation and evidence a robust effect of GVC on productivity using propensity score matching and difference in differences methodology for three Asian economies. Withstanding firms' GVC participation measurement challenge, firms' characteristics can be employed to measure the likelihood of GVC participation (Johnson, 2018; Dovis and Zaki, 2020; Fontaigner et al., 2022).

Relying on enterprise surveys, Dovis and Zaki (2020) provide four definitions for measuring the likelihood of firms' GVC integration ranging from the least strict to the strictest. The fourth and the strictest definition entails that firms are engaged in exporting and importing activities, have

international certification, and have foreign owned shares. Indeed, foreign owned firms are more productive and more innovative than domestic counterparts (Castellani and Zanfei, 2006; Criscuolo and Martin, 2009; Criscuolo et al., 2010; Bloom et al., 2012). Using the four GVC definitions, the positive and significant effect of firms' GVC participation on firms' introduction to new products or services is captured (Elshaarawy and Ezzat, 2022). Indeed, GVC participation incentivizes innovation to the aim of moving to higher value-added activities (Ethier, 1982; Grossman and Helpman, 1991; Schmidt,1997; Humphrey and Schmitz, 2002; Giuliani et al., 2005; Kasahara and Rodrigue, 2008; Brancatti et. Al, 2017; Aghion et al., 2021) through introducing new products or processes to the market. Yet, most empirical studies focus on the role of governance, finance access, and the business environment in fostering innovation and technological upgrading. Incorporating GVC participation as a chief innovation input is key to conceptualizing the learning possibility to firms in developing regions doomed with prevalent mitigators and weak governance.

Although firm size is expected to enhance firms' capabilities[5] (Stock et al., 2002), sectoral factor intensity is expected to heterogeneously affect technological innovation capabilities. As a segment of sectoral heterogeneity, natural resources' intensive and primary sectors can negatively affect R&D investments due to the encountered low value added (Sachs and Warner, 2001; Papyrakis and Gerlagh, 2007). In contrast, human capital-intensive sectors along with strong institutional quality fosters innovation (Kamguia et al., 2022).

As a parallel strand of literature, sectoral skill level discrepancies affect absorptive capacities and hence stimulates innovation performance differently (Ray et al., 2004; Geldes et al., 2017; Bicakcioglu et al., 2019; Edeh et al., 2020). In light of intra industry trade, skill level gaps create mismatches between developed and developing countries hindering technological diffusion (Acemoglu and Zilibotti, 2001). In the same vein, a strong association between skilled labor intensity and innovation is captured across a group of European countries during the years 2004 and 2010 (Falk and Hagsten, 2021).

Technology intensity varies along sectors affecting firms' innovation performance. Ideally, the higher the technological intensity level the easier the technological catch-up. Yet, using the OECD (2007) technological typology classification, technological capability is shown to be inclusive to each stratum of technology intensity (Zawsilak et al., 2018). Results on Brazilian companies show that medium-low technology intensive industries are homogeneous in terms of innovation capabilities with low technology intensive industries. Results conclude that firms can be innovative regardless of sectoral technology intensity (Zawsilak et al., 2018). This conclusion contradicts the association between the learning effect and the degree of product complexity due to higher technological intensity (Pietrobelli and Rabellotti, 2006). Meanwhile, it signals a GVC learning opportunity for firms exporting low-technological intensive traditional manufacturing goods.

Building on reviewed literature, our contribution is threefold. First, we differentiate between technological and auxiliary services innovation types and estimate the effect of GVC participation on each type separately. Second, we provide novel results on sectoral heterogeneity direct and GVC moderating effects on various innovation types. We classify sectors in terms of factor, skill

[5] Firm size is associated with larger number of employees and hence more human capital.

level, and technology intensity. Third, our study is exclusive to firms in an understudied region being it MENA.

3- Data and empirical strategy

3.1. Data and Stylized Facts

Using the recent World Bank Enterprise Surveys (WBES) comprehensive dataset, we construct the variables of interest as follows. First, we measure the likelihood of firms' GVC participation based on the definitions[6] provided by Dovis and Zaki (2020) as shown in equations 1 and 2:

$$GVC_{1i} = \begin{cases} 1, \ if \ X_i \ and \ M_i > 0 \\ 0, otherwise \end{cases} \quad (1)$$

Where X_i is the share of direct or indirect exports in total sales in firm i

M_i is the share of foreign inputs / supplies of foreign origin in total inputs in firm i.

$$GVC_{4i} = \begin{cases} 1, \ if \ X_i, M_i, C_i, and \ FS_i > 0 \\ 0, otherwise \end{cases} \quad (2)$$

Where X_i is the share of direct or indirect exports in total sales in firm i

M_i is the share of foreign inputs / supplies of foreign origin in total inputs in firm i.

C_i is international quality certification provision in firm i.

FS_i is foreign owned shares provision in firm i.

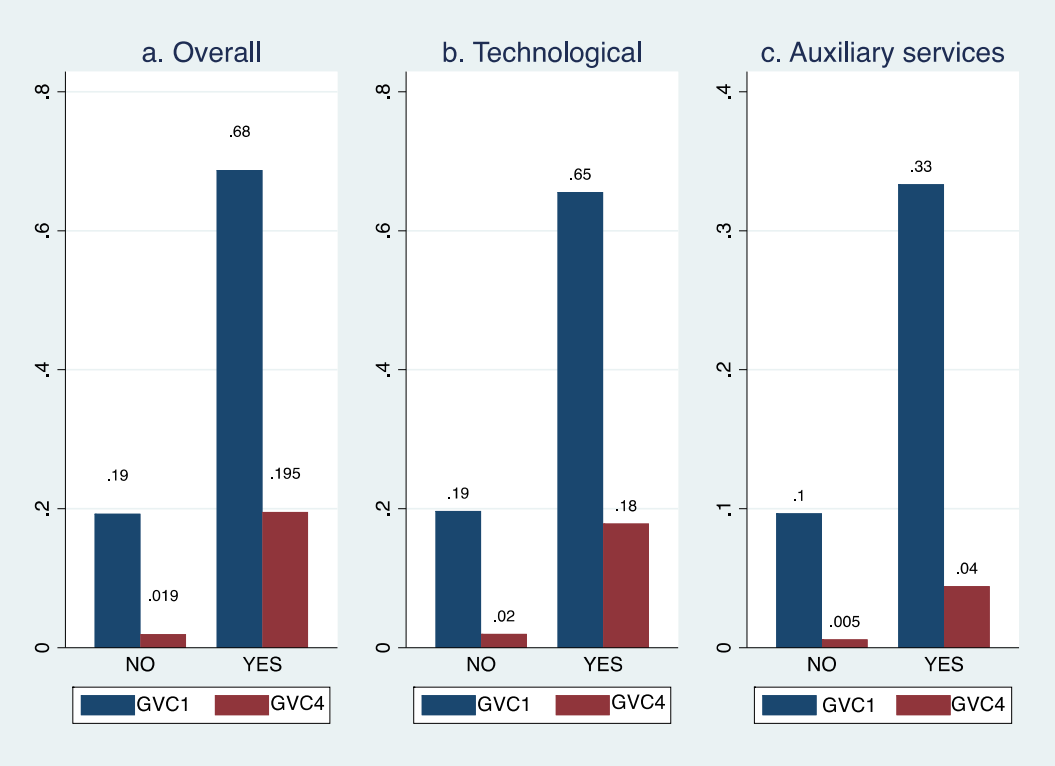
Second, we construct three innovation measures using the seven innovation and technology indicators provided in the WBES dataset as follows. A stringent measure of overall innovation entailing that the firm is engaged in all innovation indices simultaneously. Based on the Oslo manual and following Aboushady and Zaki (2020), we differentiate between technological and auxiliary services innovation. Technological innovation entails that the firm has a licensed foreign technology, has introduced a new product/service, the introduced product/service is also new to the firm's market, has introduced a new process, and spends on R&D. Auxiliary services innovation reflects firm's innovation capabilities and entails that the firm communicates with emails and has a website.

An association between GVC participation and different innovation measures is displayed in the data. Figure 1 presents the share of GVC 1 and GVC 4 against each innovation type on average. Along the three innovation measures, innovating firms have higher shares of GVC 1 and GVC 4 than their non-innovating counterparts. Indeed, GVC 4 is less than GVC 1 on average, since the former is a stricter definition. Likewise, table 1 shows a correlation between the frequencies of different innovation measures and GVC definitions. Throughout the different innovation measures, the share of non GVC participants is considerably correlated with the share of non-innovating firms on average. The overall innovation matrix shows that more than 80% of non-innovating firms in MENA are also non-GVC participants. Whereas more than 60% of firms

[6] The first definition entails that firms are engaged in exporting and importing activities. The second definition entails that firms are engaged in exporting and importing activities and have international certification. The third definition entails that firms are engaged in exporting and importing activities and have foreign owned shares. The second and third definitions are used interchangeably.

having either overall or technological innovation are participating in GVC 1. Despite the presented association in figure 1c, a deterministic correlation between auxiliary services innovation and GVC is unrevealed from the auxiliary services matrix where a substantial number of firms having auxiliary services innovation are non-GVC participants.

Figure 1: GVC definitions against innovation types



Source: Own construction based on the comprehensive WBES dataset.

Table 1 Cross frequency shares of innovation performance and GVC participation

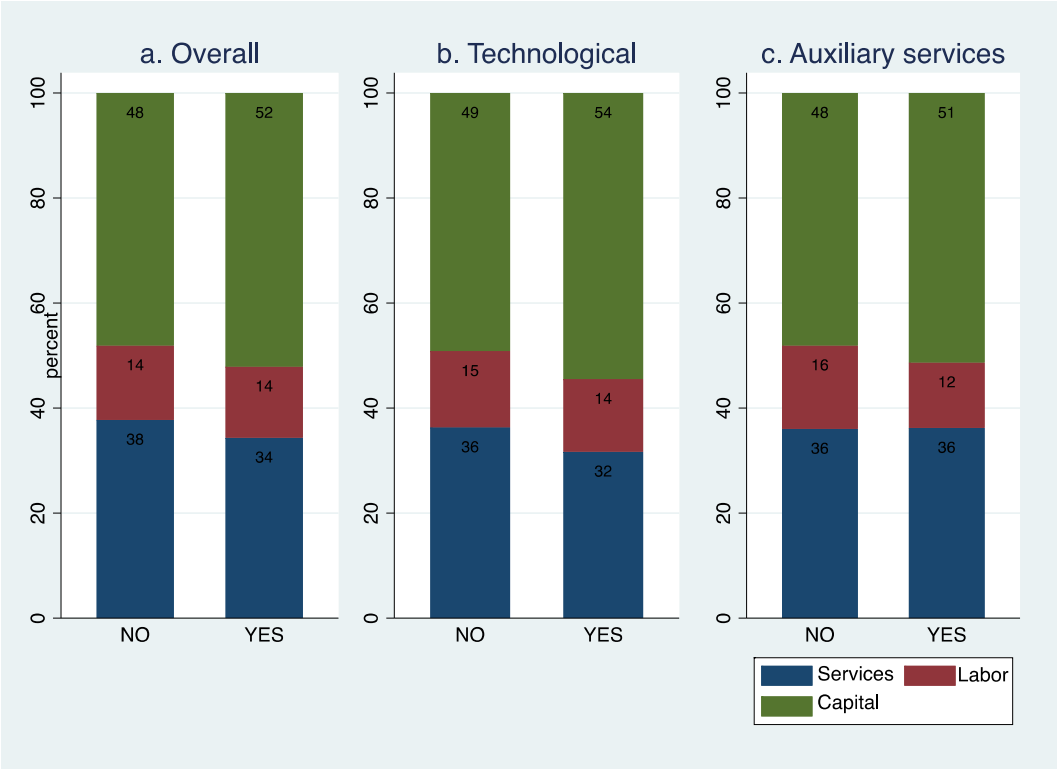
Innovation		GVC 1			GVC 4		
		No	Yes	Total	No	Yes	Total
Overall	No	12,591	3,005	15,596	14,806	293	15,099
	Yes	30	66	96	70	17	87
	Total	12,621	3,071	15,692	14,876	310	15,186
Technological	No	12,173	2,982	15,155	14,374	292	14,666
	Yes	42	80	122	92	20	112
	Total	12,215	3,062	15,277	14,466	312	14,778
Auxiliary services	No	7,551	808	8,359	8,130	49	8,179
	Yes	2,893	1,448	4,341	3,992	185	4,177
	Total	10,444	2,256	12,700	12,122	234	12,356

Source: Own construction based on WBES comprehensive dataset.

To explore the sectoral dimension, we construct three categorical variables as follows. First, a factor intensity (Hanson, 2020) variable divides sectors to services, labor-intensive manufacturing, and capital-intensive manufacturing. Second, skill level intensity (Empirical Trade Analysis Center) variable divides economic activities to primary and natural resources' intensive, unskilled-

labor-intensive, skilled labor intensive, and technology intensive activities[7]. Third, a technology intensity (STAN OECD, 2018b) variable divides economic activities to low technology, medium-low technology, medium-high technology, and high technology intensive activities[8]. Figure 2 a, b, and c presents the association between factor intensity and overall, technological, and auxiliary services innovation respectively. As presented, capital intensive manufacturing is slightly higher in innovating firms on average. Yet, a correlation between either services or labor-intensive activities is unclear. As shown in figure 2, little discrepancies in factors' intensity are revealed across different measures of innovation.

Figure 2: Factor intensity shares against innovation types



Source: Own construction based on WBES and Hanson (2020) sectoral classification

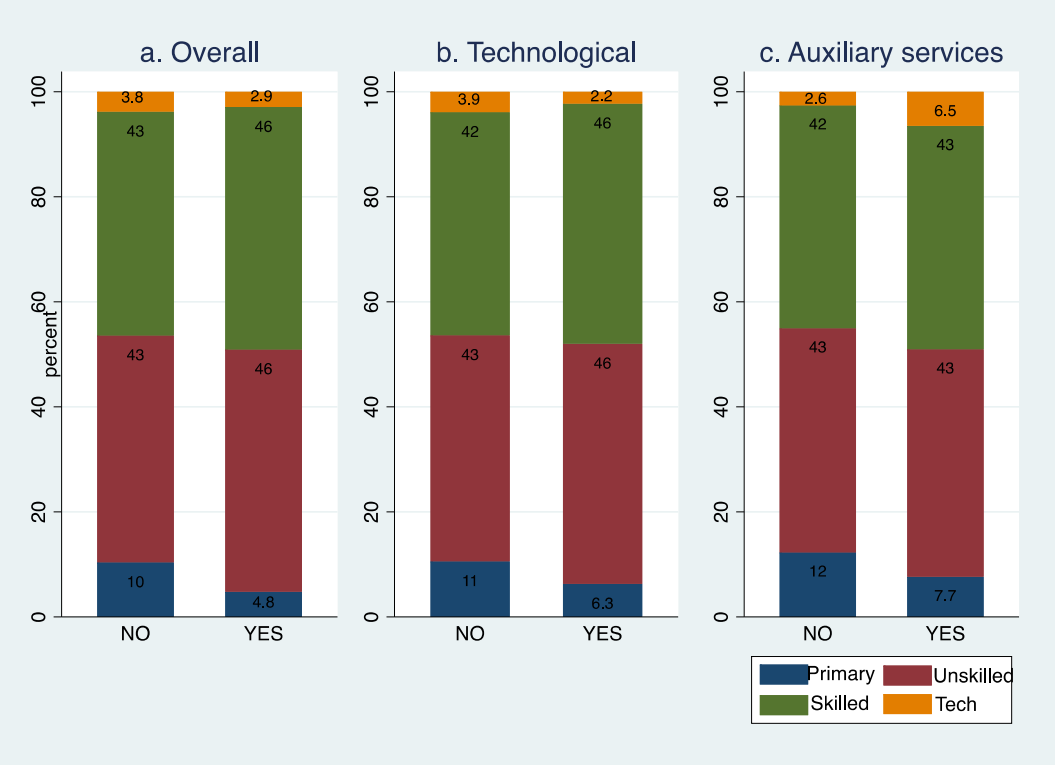
Figures 3 and 4 present the share of skill level and technology intensity in economic activities pooling services and manufacturing sectors. Figure 3 shows that primary and natural resource intensive activities are lower in innovating firms throughout the different measures. Figure 3 c shows that technology intensive activities are higher in firms with auxiliary services innovation. Yet, figure 3 concludes that technology intensive activities are rather limited in MENA. Likewise, heterogeneity in skilled and unskilled labor-intensive activities in regard to different innovation measures is unrecognized from the data. Likewise, figure 4 mirrors ambiguous association between different levels of technology intensity and the three measures of innovation. As presented, low technology intensive activities are higher on average in firms with overall and

[7] Services are classified as unskilled-labor intensive except for IT, hospitality and tourism

[8] Services are classified in accordance with the digital level intensity according to the STAN OECD (2018b) classification.

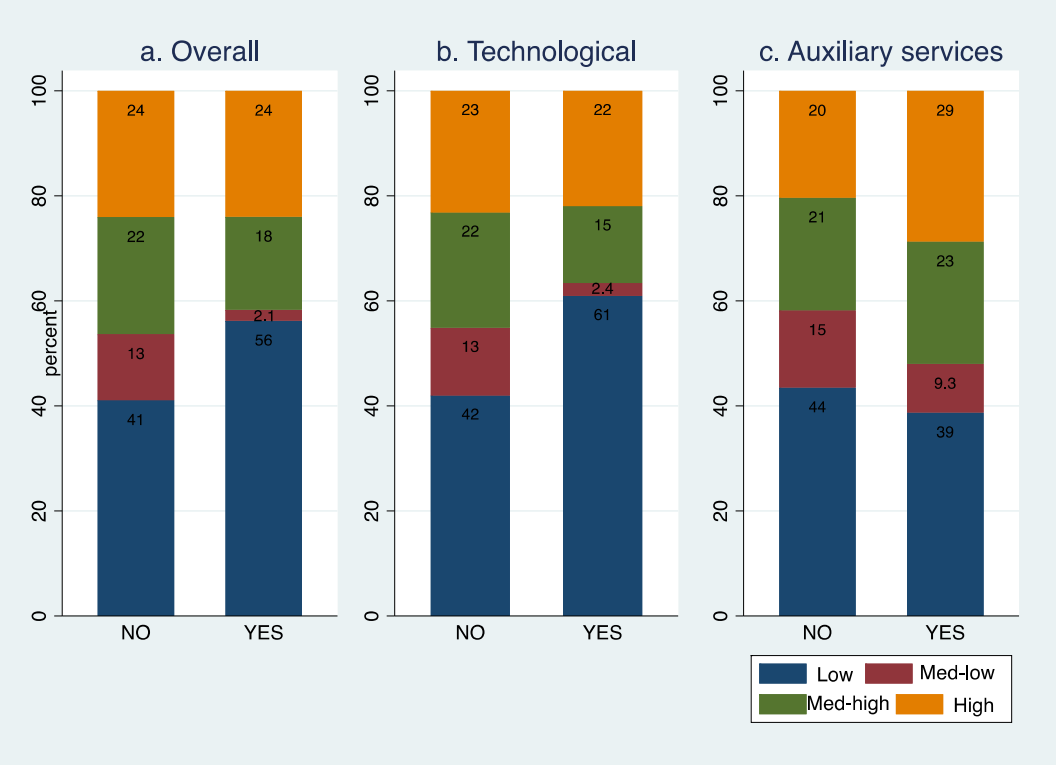
technological innovation. Data matches literature findings that innovation is inclusive to all levels of technology intensities including low technology (Zawsilak et al., 2018). Indeed, data is neither conclusive in regard to the association between innovation and GVC participation nor in the possible sectoral heterogeneity influence. Hence, econometric modelling is necessary for a threefold aim: First, to estimate the effect of each GVC definition on different types of innovation. Second, to capture the sectoral heterogeneity in terms of factor, skill level, and technology intensity. Third, to ascertain a causal effect of GVC participation on innovation in light of the reverse causality concern.

Figure 3: Skill intensity shares against innovation types



Source: Own construction based on WBES and empirical trade analysis center sectoral classification

Figure 4: Technology level shares against innovation types



Source: Own construction based on WBES and STAN OECD (2018) technology classification

3.2.Empirical strategy

The effect of each GVC measure on each innovation type is estimated as follows:

$$Y_{ijst} = a_o + a_1 GVC_{ijst} + a_2 Z_{ijst} + \delta_j + \delta_s + \delta_t + \varepsilon_{ijst} \qquad (3)$$

Where,

Y_{ijst} is the innovation type in firm i country j sector s at time t.

GVC_{ijst} is the likelihood of GVC integration.

Z_{ijst} is a vector of control variables including the firm size and fixed assets purchase to control for absorptive capacity.

δ_j is country fixed effects.

δ_s is sector fixed effects.

δ_t is year fixed effects to control for time-variant unobserved heterogeneity.

ε_{ijst} is a residual error term.

As a first level, we estimate the effect of GVC on innovation indicators individually to detangle the elasticities of each measure. Afterwards, the baseline specification occupies overall, technological, and auxiliary services innovation as dependent variables and alternates GVC 1 and GVC 4 as independent variables. To unveil the sectoral heterogeneity effect, each GVC definition is interacted with the three constructed sectoral categorical variables separately.

We address the expected reverse causality by a twofold methodology. First, we employ propensity score matching (PSM) using the common support method. The PSM common support covariates are firm size, buying physical capital, firm age, and government ownership. Second, we employ an instrumental variables two stage least squares methodology in which GVC measures are instrumented by firms' customs and trade obstacles. As a further robustness check, we replace GVC 1 and GVC 4 with the remaining two GVC definitions in the baseline specification.

The recent WBES includes data for 16,138 firms in 11 MENA countries[9] form the year 2011 till 2020. Data on firms' direct and indirect exports, share of foreign imports in total inputs, international quality certification and foreign ownership are used in constructing the GVC two binary variables. Likewise, the available seven innovation indices are used in constructing the three innovation binary variables. Similarly, firm size, buying fixed assets, firm age, government ownership, and trade and customs obstacles are firm specific and rely on the WBES[10]. In classifying the sectors[11], we rely on three categorizations. First, Hanson (2020) classification is used to differentiate between labor- and capital-intensive manufacturing. Second, the classification of the Empirical Trade Analysis Center is used to differentiate between skill levels in economic activities. Third, STAN OECD (2018b) technology/digital intensity classification is used to categorize the sectoral technology/digital level[12].

4- Empirical results

As shown in Tables 2 and 3, GVC exerts a positive association with each innovation indicator Yet, results show heterogeneity in the magnitude of the effect of GVC 1 and GVC 4 on technological innovation indicators. The magnitude of the effect of GVC 4 on foreign licensed technology and on introducing a new product/service for example, is higher than that of GVC 1. On the other hand, GVC 1 is significantly associated with introducing a new to firm's market product/service whereas GVC 4 conceals significance. Asymmetrically, table 3 shows a homogeneous higher effect of GVC 1 on the two auxiliary services' innovation indicators.

All control variables exert expected associations. Indeed, larger firms have higher absorptive capacities and hence a higher learning effect than smaller counterparts (Stock et al., 2002). Likewise, physical capital mirrors firms' capabilities and therefore affects various innovation types positively (Guan and Pang, 2017). For drawing concise conclusions, results thereof present the GVC effect on the three classified innovation types overall, technological, and auxiliary services.

Table 4 presents the baseline results showing consistent signs for GVC definitions and control variables. The positive and significant effect of the two GVC definitions on the diverse innovation types are depicted in columns 1 through 6. The magnitude of the effect is higher on auxiliary services for two reasons. First, auxiliary services are easier and less costly to adopt compared to the other two stringent innovation types requiring human and physical capital accumulation (Lall, 1992 and Keller, 1996). Second, GVC participation gravitates communication to emails and websites because it involves managing logistics in different countries and regions. Columns 1 to 4

[9] A list of countries and available years is provided in Appendix 1.
[10] Descriptive statistics of data is provided in Appendix 2.
[11] A list of sectors is provided in Appendix 3
[12] Sectoral classifications are available upon request.

show that GVC is positively associated with technological and overall innovation with a higher magnitude of GVC 4 implying that the higher the complexity of GVC participation, the higher the technological progress (Pietrobelli and Rabellotti, 2006) due to the entailed increased exposure to foreign resources.

Table 5 presents the results of the direct and the GVC moderating effects of sectoral factor intensity heterogeneity. Grounding on Hanson (2020), sectors are classified to services, labor intensive manufacturing, and capital-intensive manufacturing. Results show that with respect to services, labor-intensive and capital-intensive manufacturing exert a direct positive and significant effect solely on auxiliary services innovation. Likewise, with respect to services, manufacturing activities are not interacting with GVC in moderating the learning effect in firms located in the MENA region. Yet, the GVC effect is consistently positive with the exception of an insignificant effect of GVC 4 on technological innovation when controlling for factor intensities. Results show that manufacturing activities incentivize auxiliary services innovation but are vigilant in affecting technological innovation in the MENA region. Indeed, labor intensity may vary depending on the labor skill level.

To scrutinize the sectoral skill level intensity effect, sectors are classified following the resource intensity classification of the Empirical Trade Analysis Center to primary and natural resources, unskilled labor, skilled labor, and technology intensive activities. Results of the direct and the GVC moderating effect of the sectoral resource intensity on different innovation types are presented in Table 6. Results entail that with respect to primary and natural resource intensive sectors, skilled labor-intensive activities exert a direct positive effect on technological and auxiliary services innovation. Whereas technology intensive activities exert a positive and significant effect on auxiliary services rather than technological innovation. As expected, unskilled labor-intensive activities have an insignificant direct effect on all innovation types. However, the former negatively moderates the GVC learning effect on auxiliary services with a net positive GVC effect. As presented in columns 5 and 6, technology intensive activities negatively moderate the GVC learning effect on auxiliary services innovation with a net positive GVC effect.

Indeed, technology intensive sectors aggregate various levels of technology. To better understand the heterogeneity of technology in its GVC moderating effect, sectors are further classified following the STAN OECD (2018b) technology level classification. Table 7 presents the results of the direct and the GVC moderating effect of four levels of technology intensity in economic activities on the three innovation types. Results show that with respect to low-technology intensive activities, medium-low activities strengthen the positive GVC effect on auxiliary services. Both medium-high and high technology intensive activities exert a direct positive effect on auxiliary services notwithstanding their non-moderating effect. Seemingly, medium-low technologies are easier to absorb -compared to higher more sophisticated technologies- and are thus positively interacting with different GVC measures on auxiliary services innovation signaling higher innovation capabilities. Indeed, high-technology intensive activities can be “inappropriate” for firms in developing regions to absorb (Acemoglu and Zilibotti, 2001) and are therefore ineffectual in the MENA region.

Table 2 GVC effect on technological innovation indicators

Dependent variable:	Foreign technology		New product/service		New to firm's market		New process		Spends on R&D	
	GVC1	GVC4	GVC1	GVC4	GVC1	GVC4	GVC1	GVC4	GVC1	GVC4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GVC	.101***	.24***	.036*	.161***	.068***	.038	.095***	.07***	.133***	.192***
	(.009)	(.029)	(.022)	(.027)	(.008)	(.041)	(.008)	(.024)	(.003)	(.027)
Medium firms	.04***	.047***	.025***	.034***	.067***	.075***	.023***	.028***	.021***	.029***
	(.006)	(.006)	(.006)	(.006)	(.023)	(.023)	(.006)	(.006)	(.005)	(.005)
Large firms	.118***	.132***	.068***	.093***	.061**	.076***	.04***	.053***	.086***	.103***
	(.009)	(.009)	(.009)	(.009)	(.026)	(.026)	(.008)	(.008)	(.008)	(.008)
Physical capital	.05***	.05***	.164***	.165***	.035*	.031	.182***	.183***	.116***	.121***
	(.007)	(.007)	(.009)	(.009)	(.02)	(.02)	(.008)	(.008)	(.007)	(.007)
Constant	-.074***	-.067***	.206***	.222***	.662***	.684***	.259***	.262***	.041***	.054***
	(.025)	(.025)	(.016)	(.016)	(.044)	(.045)	(.016)	(.017)	(.012)	(.012)
No. of Observations	14,477	14,013	14,448	13,978	2,367	2,231	14,374	13,912	14,436	13,973
R^2	.161	.163	.166	.153	.039	.04	.218	.207	.117	.113
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1. Fixed effects are removed for brevity. Physical capital is buying fixed assets like machinery, equipment, land, or buildings. Number of employees in small firms < 20, 20<medium firms<99, large firms> 100.*

Table 3 GVC effect on auxiliary services indicators

Dependent variable:	Communicates by email		Website	
	GVC1	GVC4	GVC1	GVC4
	(1)	(2)	(3)	(4)
GVC	.17***	.099***	.206***	.162***
	(.01)	(.019)	(.01)	(.021)
Medium firms	.225***	.239***	.194***	.212***
	(.01)	(.01)	(.009)	(.009)
Large firms	.36***	.415***	.349***	.41***
	(.011)	(.011)	(.011)	(.01)
Physical capital	.056***	.063***	.094***	.103***
	(.009)	(.009)	(.009)	(.009)
Constant	.5***	.54***	.129***	.172***
	(.032)	(.032)	(.033)	(.033)
No. of Observations	9,430	9,167	15,714	15,217
R^2	.326	.314	.211	.192
Country FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1. Fixed effects are removed for brevity. Physical capital is buying fixed assets like machinery, equipment, land, or buildings. Number of employees in small firms < 20, 20<medium firms<99, large firms> 100.*

Table 4 Baseline results

Dependent variable:	Overall		Technological		Auxiliary services	
	GVC1	GVC4	GVC1	GVC4	GVC1	GVC4
	(1)	(2)	(3)	(4)	(5)	(6)
GVC	.013***	.042***	.014***	.046***	.18***	.172***
	(.002)	(.013)	(.003)	(.014)	(.011)	(.024)
Medium firms	.003***	.004***	.004***	.005***	.147***	.16***
	(.001)	(.001)	(.001)	(.001)	(.008)	(.008)
Large firms	.013***	.015***	.016***	.019***	.312***	.362***
	(.002)	(.003)	(.003)	(.003)	(.011)	(.011)
Physical capital	.008***	.007***	.012***	.011***	.078***	.084***
	(.002)	(.002)	(.002)	(.002)	(.009)	(.009)
Constant	-.031***	-.032***	-.038***	-.04***	.184***	.218***
	(.011)	(.011)	(.011)	(.012)	(.032)	(.033)
No. of Observations	15,576	15,088	15,163	14,680	12,621	12,288
R^2	.026	.028	.028	.03	.365	.35
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1. Fixed effects are removed for brevity. Physical capital is buying fixed assets like machinery, equipment, land, or buildings. Number of employees in small firms < 20, 20<medium firms<99, large firms> 100.*

Table 5 Factor intensity heterogeneity

Dependent variable:	Overall		Technological		Auxiliary services	
	GVC1	GVC4	GVC1	GVC4	GVC1	GVC4
	(1)	(2)	(3)	(4)	(5)	(6)
GVC	.01**	.068*	.011**	.063	.171***	.174***
	(.005)	(.039)	(.005)	(.039)	(.019)	(.064)
Medium firms	.003***	.004***	.004***	.005***	.144***	.157***
	(.001)	(.001)	(.001)	(.001)	(.008)	(.008)
Large firms	.013***	.015***	.016***	.019***	.311***	.359***
	(.002)	(.003)	(.003)	(.003)	(.011)	(.011)
Physical capital	.008***	.007***	.011***	.011***	.075***	.082***
	(.002)	(.002)	(.002)	(.002)	(.009)	(.009)
Labor intensive	-.003	-.002	-.002	-.002	.044**	.056***
	(.003)	(.003)	(.003)	(.004)	(.019)	(.018)
Capital intensive	-.001	0	-.001	.001	.095***	.115***
	(.003)	(.003)	(.003)	(.003)	(.015)	(.015)
GVC*Labor intensive	.001	-.032	-.001	-.016	-.041	.011
	(.007)	(.048)	(.008)	(.05)	(.029)	(.082)
GVC*Capital intensive	.004	-.031	.007	-.022	.034	-.008
	(.006)	(.042)	(.007)	(.042)	(.023)	(.069)
Constant	-.03***	-.031***	-.037***	-.039***	.115***	.13***
	(.01)	(.011)	(.011)	(.012)	(.036)	(.036)
No. of Observations	15,576	15,088	15,163	14,680	12,621	12,288
R^2	.026	.028	.029	.031	.37	.356
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1. Fixed effects are removed for brevity. Physical capital is buying fixed assets like machinery, equipment, land, or buildings. Number of employees in small firms < 20, 20<medium firms<99, large firms> 100. Factor intensity is based on Hanson (2020) classification.*

Table 6 Skill level intensity heterogeneity

Dependent variable:	Overall		Technological		Auxiliary services	
	GVC 1	GVC 4	GVC 1	GVC 4	GVC 1	GVC 4
	(1)	(2)	(3)	(4)	(5)	(6)
GVC	.007	.043	.011*	.066**	.239***	.239***
	(.005)	(.027)	(.006)	(.032)	(.021)	(.042)
Medium firms	.003***	.004***	.004***	.005***	.145***	.158***
	(.001)	(.001)	(.001)	(.001)	(.008)	(.008)
Large firms	.013***	.014***	.017***	.019***	.308***	.357***
	(.002)	(.003)	(.003)	(.003)	(.011)	(.011)
Physical capital	.008***	.007***	.011***	.011***	.076***	.082***
	(.002)	(.002)	(.002)	(.002)	(.009)	(.009)
Unskilled labor	0	.001	-.001	0	-.012	-.014
	(.001)	(.002)	(.002)	(.002)	(.011)	(.011)
Skilled labor	0	.004**	0	.005**	.06***	.07***
	(.002)	(.002)	(.002)	(.002)	(.012)	(.011)
Technology intensive	-.002**	.001	-.003**	0	.172***	.183***
	(.001)	(.002)	(.001)	(.002)	(.015)	(.014)
Unskilled labor * GVC	.004	.011	-.001	-.016	-.095***	-.063
	(.006)	(.036)	(.007)	(.041)	(.025)	(.059)
Skilled labor * GVC	.012	-.015	.014	-.035	-.047*	-.079
	(.008)	(.035)	(.009)	(.04)	(.027)	(.062)
Technology * GVC	.008	-.004	.003	-.03	-.1***	-.217***
	(.01)	(.044)	(.01)	(.048)	(.031)	(.067)
Constant	-.031***	-.033***	-.038***	-.039***	.17***	.202***
	(.011)	(.011)	(.011)	(.012)	(.033)	(.033)
No. of Observations	15,576	15,088	15,163	14,680	12,621	12,288
R^2	.027	.028	.03	.031	.377	.364
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1. Fixed effects are removed for brevity. Physical capital is buying fixed assets like machinery, equipment, land, or buildings. Number of employees in small firms < 20, 20<medium firms<99, large firms> 100. Skill intensity classification is based on product groups' classification of the Empirical Trade Analysis Center. Benchmark is primary goods and natural resource intensive activities.*

Table 7 Technology intensity heterogeneity

Dependent variable:	Overall		Technological		Auxiliary services	
	GVC 1	GVC 4	GVC 1	GVC 4	GVC 1	GVC 4
	(1)	(2)	(3)	(4)	(5)	(6)
GVC	.015***	.037**	.019***	.046**	.181***	.181***
	(.004)	(.016)	(.004)	(.018)	(.014)	(.031)
Medium firms	.003***	.004***	.004***	.005***	.146***	.16***
	(.001)	(.001)	(.001)	(.001)	(.008)	(.008)
Large firms	.013***	.015***	.016***	.019***	.307***	.36***
	(.002)	(.003)	(.003)	(.003)	(.011)	(.011)
Physical capital	.008***	.007***	.012***	.011***	.078***	.084***
	(.002)	(.002)	(.002)	(.002)	(.009)	(.009)
Medium-low	0	-.002*	-.003**	-.005***	-.056***	-.051***
	(.001)	(.001)	(.001)	(.002)	(.011)	(.011)
Medium-high	.001	0	.001	-.001	.061***	.053***
	(.003)	(.003)	(.003)	(.003)	(.015)	(.014)
High	.001	0	.001	-.001	.101***	.095***
	(.003)	(.003)	(.003)	(.003)	(.015)	(.014)
Medium-low * GVC	-.014**	-.01	-.017**	-.024	.105***	.09*
	(.006)	(.039)	(.008)	(.04)	(.031)	(.05)
Medium-high * GVC	-.008	-.002	-.013*	-.014	-.024	-.024
	(.007)	(.037)	(.007)	(.038)	(.025)	(.06)
High * GVC	.001	.041	-.002	.028	-.03	-.102
	(.008)	(.046)	(.008)	(.047)	(.025)	(.075)
Constant	-.032***	-.032***	-.038***	-.038***	.194***	.226***
	(.011)	(.011)	(.012)	(.012)	(.033)	(.033)
No. of Observations	15,576	15,088	15,163	14,680	12,621	12,288
R^3	.027	.029	.03	.031	.37	.355
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1. Fixed effects are removed for brevity. Physical capital is buying fixed assets like machinery, equipment, land, or buildings. Number of employees in small firms < 20, 20<medium firms<99, large firms> 100. Technology and digital intensity classification are based on STAN OECD classification Benchmark is low technology intensive activities.*

Grounding on learning by trade literature, exporting and importing activities can be innovation driven (Aghion et al. 2021). Hence, to address the expected reverse causality, Tables 8 and 9 present robustness checks to GVC endogeneity. Using propensity score matching (PSM) common support grouping, table 8 shows a positive GVC effect on innovation. Across the three innovation measures, PSM shows a significant expected difference between treated and control groups using either GVC 1 or GVC 2 as treatments. The covariates used for common support are firm size, firm age, buying physical capital, and government ownership. The PSM test shows a less than 5% bias for each mean value of the common support covariates[13].

To further guarantee the GVC causal effect, results of employing an instrumental variables two stage least squares methodology are presented in table 9. Using firms' trade and customs' barriers variable as a GVC instrument, results show a consistently positive and significant effect on the three types of innovation for both GVC definitions. As presented, control variables preserve their

[13] PSM first stage results, common support and covariates bias are presented in Appendix 4a and Appendix 4b .

signs and significance with the exception of firms' size. Columns 1 through 6 show an insignificant large firms' size effect. One reason is the possible collinearity between the used instrument and firm size as larger firms have less trade costs (Bernard et al., 2007).

As a final robustness check, Table 10 presents the results of the baseline regression when different GVC definitions are used as explanatory variables. As presented, both GVC 2 and GVC 3 show similar results to the least and the strictest definitions presented throughout this section. Likewise, control variables preserve their signs and significance.

Table 8 Robustness check 1: Propensity Score Matching results

Dependent variable:	Overall		Technological		Auxiliary services	
	GVC 1	GVC 4	GVC 1	GVC 4	GVC 1	GVC 4
	(1)	(2)	(3)	(4)	(5)	(6)
Difference	.019***	.049***	.023***	.057***	.366***	.466***
	(.002)	(.004)	(.002)	(.005)	(.011)	(.032)
Controls	.002***	.005***	.004***	.006***	.277***	.329***
	(.001)	(.001)	(.001)	(.001)	(.004)	(.004)
No. of Observations	15,271	14,935	14,866	14,534	12,400	12,167
R^2	.01	.008	.01	.009	.086	.018

*Standard errors are in parentheses *** p<.01, ** p<.05, * p<.1 Firm size, physical capital, government ownership, and firm age are the covariates for common support.*

Table 9 Robustness check 2: Instrumental variables' two stage least squares

Dependent variable:	Overall		Technological		Auxiliary services	
	GVC 1	GVC 4	GVC 1	GVC 4	GVC 1	GVC 4
	(1)	(2)	(3)	(4)	(5)	(6)
GVC	.039**	.262**	.039*	.237*	.953***	6.641***
	(.02)	(.125)	(.022)	(.134)	(.114)	(1.765)
Medium firms	.001	.002	.002	.004**	.072***	.115***
	(.002)	(.002)	(.003)	(.002)	(.015)	(.019)
Large firms	.005	-.001	.009	.005	.043	-.161
	(.007)	(.01)	(.008)	(.011)	(.04)	(.139)
Physical capital	.007***	.004	.011***	.008**	.028**	-.024
	(.003)	(.003)	(.003)	(.004)	(.014)	(.039)
Constant	-.014**	-.01***	-.013*	-.008*	-.293***	-.191***
	(.006)	(.004)	(.007)	(.005)	(.034)	(.06)
No of Observations	13,826	13,385	13,472	13,036	11,053	10,756
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

*Robust standard errors are in parentheses, *** p<.01, ** p<.05, * p<.1 GVC 1 and GVC 4 are instrumented by the firm's customs' and trade obstacles.*

Table 10 robustness check 3: Alternative GVC definitions

Dependent variable:	Overall		Technological		Aux services	
	GVC 2	GVC3	GVC 2	GVC 3	GVC 2	GVC 3
	(1)	(2)	(3)	(4)	(5)	(6)
GVC	.027***	.027***	.027***	.032***	.067***	.247***
	(.008)	(.005)	(.009)	(.005)	(.02)	(.014)
Medium firms	.004***	.003**	.005***	.003***	.162***	.151***
	(.001)	(.001)	(.001)	(.001)	(.008)	(.008)
Large firms	.015***	.01***	.019***	.013***	.365***	.307***
	(.003)	(.002)	(.003)	(.003)	(.011)	(.011)
Physical capital	.009***	.006***	.012***	.009***	.089***	.072***
	(.002)	(.002)	(.002)	(.002)	(.009)	(.009)
Constant	-.031***	-.032***	-.039***	-.038***	.223***	.211***
	(.011)	(.011)	(.012)	(.012)	(.032)	(.033)
No. of Observations	15,430	15,205	15,018	14,796	12,524	12,378
R^2	.027	.03	.029	.034	.348	.364
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors are in parentheses

**** p<.01, ** p<.05, * p<.1 GVC 2 is a binary variable equals 1 if the firm is exporting, importing and has foreign owned shares and 0 otherwise. GVC 3 is a binary variable equals 1 if the firm is exporting, importing, and has foreign quality certification and 0 otherwise.*

In summary, GVC participation of firms located in the MENA region has a direct positive effect on firms' overall, technological, and auxiliary services innovation. GVC moderating sectoral heterogeneity is evident in auxiliary services rather than technological innovation. Skilled labor-intensive activities exert a direct positive effect on technological innovation whilst controlling for GVC 4. Both labor- and capital-intensive manufacturing exert a direct positive effect on auxiliary services innovation with a non-moderating GVC effect. With respect to primary and natural resources intensive sectors, technology intensive sectors exert a direct positive effect on auxiliary services innovation and negatively interacts with GVC. Medium-low technology intensive activities positively moderate the GVC positive effect on auxiliary services innovation. In contrast, medium-high and high technologies exert a direct positive effect on auxiliary services innovation with a neutral GVC moderating effect. Notwithstanding the negative GVC interaction with various sectoral classifications, the net GVC effect on all innovation types is consistently positive. Our baseline results remain robust when we use PSM, instrumental variables, and different GVC definitions.

5- Conclusion and policy recommendations

By studying the effect of GVC participation on firms' various innovation types, we draw a principal conclusion that firms in the MENA region have a GVC learning opportunity in terms of technological and auxiliary services innovation. Likewise, technological innovation is directly stimulated by skilled labor-intensive. Furthermore, engaging in labor- and capital-intensive manufacturing, medium-high and high technology intensive activities directly stimulates auxiliary services innovation. Meanwhile, the positive GVC effect on auxiliary services is strengthened with medium-low technology intensive activities. While highlighting the importance of firms' vertical integration in the MENA region to the end of realizing technological change, sectoral heterogeneity moderates the GVC effect exclusively on auxiliary services innovation. Although sectoral heterogeneity foster innovation capabilities through GVC participation, it remains neutral

in catalyzing technological innovation. Our empirical work suggests that technological innovation in the MENA region is rather sticky in accordance with sectoral differences. Yet, encouraging GVC participation is vital to the end of catching up to the fast-shifting technological frontier regardless the heterogenous sectoral intensity.

From a policy standpoint, our study offers two main recommendations aiming at realizing a GVC driven innovation progress in the MENA region. First, facilitating GVC participation by eliminating unnecessary trade costs is necessary being the former a principal innovation input. Indeed, post COVID-19 reshoring recommendations append an opportunity cost to MENA countries in terms of firms' innovation. Second, investing in physical and human capital is key to enhancing firms' absorptive capacities and to stimulating technological innovation. Despite the challenges, promoting formal training programs can compensate for incompetent educational backgrounds in various MENA countries. Finally, conditional on enhanced absorptive capacities, fostering manufacturing and technological activities strengthens the GVC effect on auxiliary services innovation.

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Appendix 1 List of WBES countries and years

Country	Years	Freq.	Percent	Cum.
Iraq	2011	756	4.68	4.68
West Bank & Gaza	2013, 2019	799	4.95	9.64
Yemen	2010, 2013	830	5.14	14.78
Djibouti	2013	266	1.65	16.43
Egypt	2013, 2016, 2020	7785	48.24	64.67
Israel	2013	483	2.99	67.66
Jordan	2013, 2019	1174	7.27	74.93
Lebanon	2013, 2019	1093	6.77	81.71
Malta	2019	242	1.50	83.21
Morocco	2013, 2019	1503	9.31	92.52
Tunisia	2013, 2020	1207	7.48	100.00
Total		16,138	100.00	

Table 2 Descriptive statistics

Variable	No. Obs	Mean	Std. Dev.	Min	Max
Foreign licensed technology	14,822	.129	.335	0	1
Email communication	9,605	.616	.486	0	1
Website	16,092	.491	.5	0	1
New product/service	14,805	.165	.371	0	1
New product/service to market	24,21	.705	.456	0	1
New process	14,723	.152	.359	0	1
R&D spending	14,788	.087	.282	0	1
Overall innovation	15,948	.006	.077	0	1
Technological	14,829	.027	.161	0	1
Auxiliary services	12,882	.343	.475	0	1
Inputs/supplies of foreign origin	12,520	31.929	37.571	0	100
Direct exports % in total sales	15,849	8.93	23.877	0	100
Indirect exports % in total sales	15,860	2.608	11.892	0	100
Foreign ownership %	15,853	5.014	19.493	0	100
International certification	15,709	.199	.399	0	1
GVC 1	15,870	.197	.398	0	1
GVC 2	15,709	.039	.193	0	1
GVC 3	15,476	.089	.285	0	1
GVC 4	15,344	.021	.143	0	1
Firm size	16,138	1.698	.762	1	3
Firm age	15,900	27.4	16.53	4	218
Government ownership %	15,855	.48	5.34	0	99
Physical capital purchase	16,002	.252	.434	0	1
Customs' and trade obstacles	14,310	1.121	1.265	0	4

Appendix 3 WBES sectors

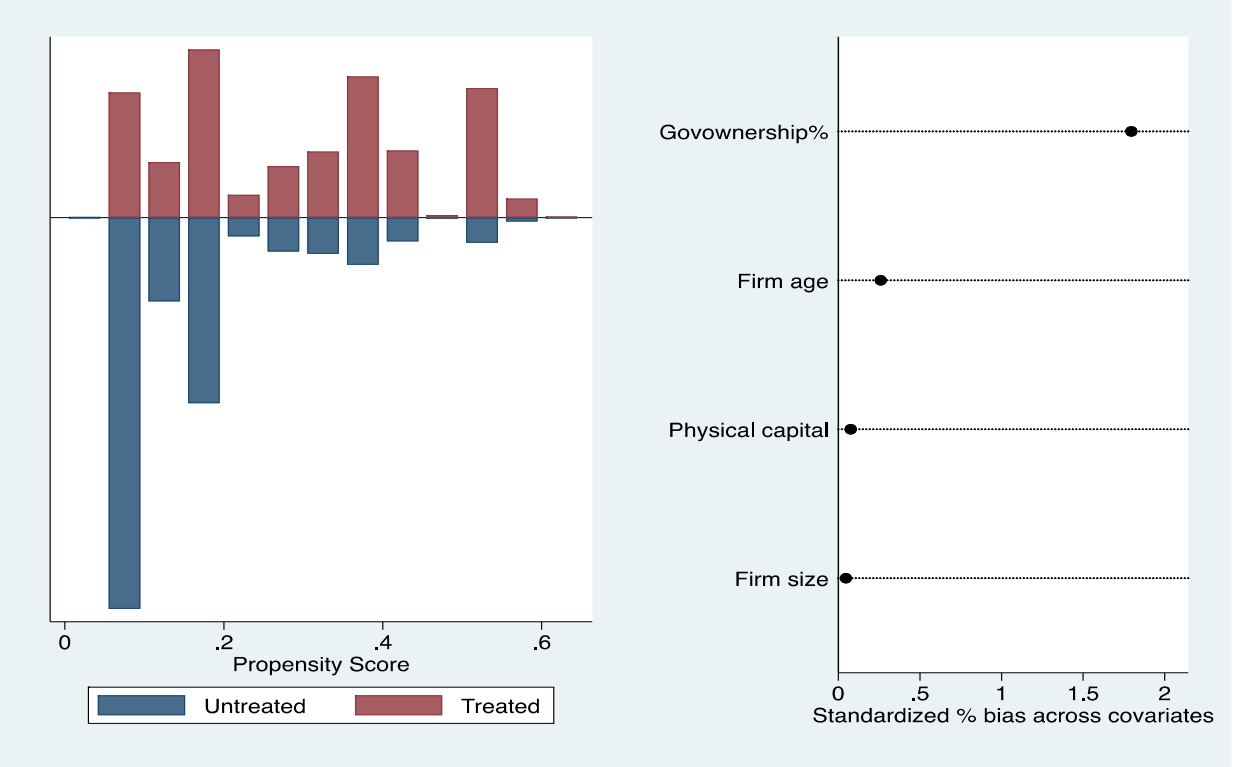
Cut: Stratification Sector	Freq.	Percent	Cum.
Basic Metals & Metal Products	322	2.00	2.00
Chemicals & Chemical Products	467	2.89	4.89
Chemicals, Plastics & Rubber	61	0.38	5.27
Construction	439	2.72	7.99
Fabricated Metal Products	137	0.85	8.84
Food	2,035	12.61	21.45
Furniture	142	0.88	22.33
Garments	677	4.20	26.52
Hospitality & Tourism	270	1.67	28.19
Hotels & Restaurants	163	1.01	29.20
IT & IT Services	70	0.43	29.64
Leather Products	317	1.96	31.60
Machinery & Equipment, Electronics & Vehicles	319	1.98	33.58
Manufacturing	699	4.33	37.91
Non-Metallic Mineral Products	768	4.76	42.67
Other Manufacturing	1,619	10.03	52.70
Other Services	2,883	17.86	70.57
Petroleum products, Plastics & Rubber	330	2.04	72.61
Printing & Publishing	58	0.36	72.97
Retail	1,200	7.44	80.41
Rubber & Plastics Products	121	0.75	81.16
Services	159	0.99	82.14
Services of Motor Vehicles	49	0.30	82.45
Services of Motor Vehicles/Wholesale/Retail	677	4.20	86.64
Textiles	224	1.39	88.03
Textiles & Garments	436	2.70	90.73
Transport, Storage, & Communications	398	2.47	93.20
Wholesale	122	0.76	93.95
Wholesale & Retail	568	3.52	97.47
Wood Products	78	0.48	97.96
Wood products, Furniture, Paper & Publishing	330	2.04	100.00
Total	16,138	100.00	

Appendix 4a PSM logit first stage regression

Dependent variable:	GVC 1	GVC 4
	(1)	(2)
Firm size	1.068***	1.704***
	(.032)	(.106)
Physical capital	.393***	.641***
	(.051)	(.129)
Firm age	0	-.008**
	(.001)	(.004)
Gov ownership %	-.002	-.006
	(.004)	(.009)
Constant	-2.772***	-6.176***
	(.273)	(.777)
Observations	15,434	15,087
Pseudo R^2	.19	.212
Country FE	Yes	Yes
Year FE	Yes	Yes
Sector FE	Yes	Yes

Standard errors are in parentheses
**** p<.01, ** p<.05, * p<.1*

Appendix 4b PSM common support and covariates bias graph



GVC 1 is the treatment variable.