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The Effect of Manufacturing Technology Type on Cost Structure: Evidence from Egypt

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Abstract

We investigate the effect of manufacturing technology type on cost structure in Egypt. We argue that firms adopting advanced manufacturing technology are associated with less rigid and more flexible cost structures. A sample of 40 Egyptian manufacturing firms listed on EGX over a 6-year period (2011-2016), producing 240 company-year observations is tested. Overall, evidence supports the view that firms with advanced manufacturing technologies have more flexible cost structure. The result is robust to alternative specifications by replacing cost of goods sold (COGS) by operating expenses and introducing firm size as a control variable. Our finding continues to hold after robustness tests. Our finding is expected to fill up a gap in the extant literature in two ways. First, this study provides evidence on the effect of manufacturing technology type on cost structure in a developing country (i.e., Egypt). Second, unlike the extant literature, which predominately uses case study and refer to anecdotal evidence, the presumed relation between the manufacturing technology type and the cost structure is systematically examined in a cross-sectional design. Thus, the research findings may be more generalizable.

Keywords: cost structure, cost rigidity, cost flexibility, conventional manufacturing technology, advanced manufacturing technology, and Egypt.

I. INTRODUCTION

Understanding a firm's cost behavior is essential to manage costs. Many studies have examined different aspects of cost behavior. For example, Anderson et al. (2003), Chen et al. (2012), and Kama and Weiss (2013), studied the sticky cost behavior. Datar et al. (1993), Anderson (1995), and Banker et al. (1995) studied non-volume cost drivers. Furthermore, Noreen and Soderstrom (1994, 1997) studied the extent to which overhead costs are fixed and variable. However, only few studies examined the factors affecting the cost structure. Cost structure refers to the relative portions of variable and fixed costs in an organization.

It is very important to understand the factors affecting the cost structure as being more rigid or more flexible. This understanding helps in predicting cost behavior. Balakrishnan et al. (2014) found that cost stickiness is higher in companies with more rigid cost structures. The current study focuses on examining empirically one factor affecting a firm's cost structure; namely manufacturing technology type as costs are a function of the type of technology.

The investment in advanced manufacturing technology (AMT) and the replacement of human element with machinery have been growing rapidly over 200 years, since the industrial revolution. This phenomenon has led to several research questions.

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For example, Jaikumar (1986), and Kotha and Swamidass (2000) examined whether AMT increases the firm's productivity and performance. Chenhall and Langfield-Smith (1998) discussed the additional benefits obtained from AMT. Clarke (1995), and Atkinson et al. (1997) studied new directions in management accounting under AMT.

In addition, several case studies were conducted to examine the cost savings from replacing the conventional manufacturing technology by AMT, e.g., Hartley (1983), Hollingum (1983), and Sloggy (1984). These case studies provided evidence that AMT had lower variable costs per unit than conventional technologies. This result is what would be expected as a firm becomes more automated and less labor-intensive. Conversely, these studies found surprising evidence that AMT also had lower annual fixed operating costs than conventional technologies. However, the results of these cases must be interpreted with caution as they depend on small samples (one firm).

All previous studies mentioned above were concerned with examining the cost savings from replacing the conventional manufacturing technology by AMT. However, none of these studies provide details about the cost structure's shape, i.e. whether it is more rigid or more flexible (less rigid). Lederer and Singhal (1988), which is discussed later, is one of the few studies that analyzed the cost structure of one U.S. metal parts manufacturer.

The main objective of this study is to extend the results of prior studies on cost behavior by exploring the effect of manufacturing technology type on the cost structure empirically in one of the developing countries in the middle east, Egypt. Unlike developed countries, AMTs are recently adopted and implemented by manufacturing firms in developing countries as there is a time lag between developed and developing countries.

This study examines the effect of technology type on the cost structure using 40 cross sectional Egyptian manufacturing firms from 2011 through 2016, producing 240 company-year observations. The overall results for the effect of technology type on cost structure indicate that adopting AMT is associated with less rigid and more flexible cost structure.

This study contributes to accounting literature in two ways. First, this study provides additional insights into the AMT effect on the cost structure in developing countries such as Egypt. To the best of our knowledge, this study is the first to provide evidence on the effect of manufacturing technology type on cost structure in Egypt or any developing country for that matter. There are several reasons to expect that the use of AMT might differ between the developed and undeveloped countries (Zhao & Co, 1997). One reason is that companies in undeveloped countries face challenges during the implementation of AMT as opposed to developed countries, e.g., the need for high skilled labor and the lack of technical support from vendors. Another reason is that low labor costs in undeveloped countries makes it more difficult to economically justify the use of AMT and its implementation.

The second contribution is that, all prior studies adopted the case study method and as such their findings are not readily generalizable. In the current study, an archival study utilizing a relatively large sample is used where the presumed relation between the manufacturing technology type and cost structure is more systematically examined in a cross-sectional design. This is expected to fill up a gap in the extant literature.

The remainder of this paper is organized as follows. Section 2 reviews the literature and develops the study hypothesis. Section 3 describes the method. Section 4 presents the conclusions, limitations, implications and directions for future research.

II. LITERATURE REVIEW

In the 1970s and 1980s, researchers in developed countries were interested in AMT because of the Japanese robots and flexible automation revolution. Different studies and surveys were performed and covered various issues related to AMT and its effect on firms. Many case studies provided information on the cost savings from replacing the conventional manufacturing technology by AMT. AMT has different definitions and different shapes, but common among these technologies is the use of computers and numerical systems. In this sense, AMT can be defined as utilizing computers in manufacturing activities either directly or indirectly.

Hartley (1983) described the flexible manufacturing systems (FMS)[1] at Yamazakie's new factory at Miokamo in southern Japan. He found that the number of machines reduced from 90 in the conventional system to 43 in the FMS. In addition, the floor space reduced from 16,500 m^2 to 6,600 m^2 and the number of operators decreased from 195 to 39 operators.

Hollingum (1983) also described another FMS at another Yamazakie's factory that produced different part types for building machine tools. After adopting FMS, the number of machines reduced from 68 to 18. In addition, the floor space reduced from 70,000 ft^2 to 30,000 ft^2 and the number of production workers declined from 215 to 12 operators. The FMS reduced the annual labor cost from $4.0 million to $227,000.

Sloggy (1984) described the FMS for machining locomotive parts at a U.S. manufacturer. The new technology reduced the total annual operating costs by 90%, from $4.75 million to $0.5 million.

Jelinek and Goldhar (1984) examined the benefits from adopting a highly advanced FMS at Messerchmitt-Bolkow-Blohm in West Germany. The new system reduced the number of machines by 44%, floor space by 39%, personnel by 44% and overall annual operating costs by 24%.

Kaplan (1986) compared FMS of one U.S. air-handling equipment manufacturer with its conventional technology. The FMS increased the manufacturer utilization from 30%-40% to 80%-90%, reduces the annual rework and scrap by $60,000, reduced inventory from $2 million to $1.1 million, and the number of employees from 52 to 14 (including indirect workers).

Frost and Sullivan, Inc. conducted a study of 20 U.S. systems indicating that switching from non-FMS manufacturing methods to FMSs resulted in significant benefits (see Palframan, 1987). The number of machines reduced by 70%, floor space reduced by 66%, direct labor reduced by 77% and product cost by 50%.

From the studies mentioned above, it is clear that adopting AMTs affect the firm's cost structure as total cost, number of machines, number of labors and floor space decreased. However, none of these studies provides details about the cost structure's shape, i.e. whether it is more rigid or more flexible (less rigid).

Lederer and Singhal (1988) evaluated the FMS of one U.S. metal parts manufacturer. They made an interesting observation that both the fixed operating costs and the variable costs per unit were reduced upon adopting FMS. The variable costs per unit were reduced by 35% from $3.68 to $2.40 and the fixed operating costs were reduced by 39% from $3.76 million to $2.28 million. The relative reduction in the fixed operating costs was higher than the reduction in the variable costs by 4%, which means that the

[1] FMS is one type of AMT. It is more than one machine controlled by computers or programmable controllers, connected by a material handling system, capable of accepting one or multiple raw material and deliver multiple paths of finished product (Baldwin et al., 1996).

cost structure becomes somewhat less rigid (more flexible). In addition, Lederer and Singhal (1988) provided evidence indicating that the AMT had a breakeven point lower than that of the conventional technology, which supports the assertion that the cost structure after adopting and implementing AMT becomes less rigid (more flexible).

From the studies reviewed above, adopting AMT led to reducing both variable costs and annual fixed operating costs. However, most of prior research did not examine whether the total cost structure resulting from AMT adoption is more rigid or more flexible. According to Lederer and Singhal (1988), it is anticipated to have a less rigid cost structure (lower fixed costs portion and higher variable costs portion) for AMT as in their case study fixed operating costs decreased by a higher rate than variable costs and the AMT had a lower breakeven point. Therefore, the empirical hypothesis is stated as follows:

H_1: advanced manufacturing technology (AMT) is associated with less rigid (more flexible) cost structure.

III. RESEARCH SAMPLE AND METHODOLOGY

3.1. Population and Sample

The population consists of all Egyptian manufacturing firms listed on the Egyptian exchange (EGX). The sample in this study is a convenient sample. Seventy-nine manufacturing firms in different sectors were asked to fill out a questionnaire from which a metric indicating technology type was developed. Sixty-four questionnaires were distributed to the firms which accepted to participate in the study. The response rate is 97% as 62 out of 64 firms replied.

Three firms are excluded from the sample because the respondents are not qualified to answer the questionnaire and their answers might be misleading. In addition, one firm is excluded because of legal problems that led to stopping the exchange on its stock. Therefore, the final sample includes 58 respondents, with a response rate of 90.6%, still a high rate.

The questionnaires are filled through interviews with the head of the cost department or production departments. However, some firms refused to do interviews, so the questionnaires were handed out and were collected later. The number of companies accepted to conduct interviews is 48 out of 58 companies (82.8%). The typical interview lasted about 40-50 minutes.

Additionally, twelve observations are discarded because of missing financial data on revenues and costs. In addition, firms with insignificant β_i that reflect cost flexibility are discarded[2]. Finally, extreme observations were discarded. Therefore, the final sample size is 40 firms.

As for financial data, a six years period (2011 to 2016, inclusive) is used to estimate cost flexibility (β_i), producing 240 company-year observations. Table 1 shows the study's initial and final samples.

It should be noted that the sample size is adequate. This is because of the limited number of manufacturing firms listed on the Egyptian exchange in 2016, which is 94 companies. Thus, the final sample account for 43% of the population. In addition, not all these firms are reachable to ask them to participate in this study, and not all of firms reached accepted to participate.

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[2] The missing β_i is due to regression (1) in the model is insignificant (F-statistic prob. is > 0.05).

Table 1
Study Sample

Initial sample (firms)	58
Less: observations with missing financial data on revenues and costs	(12)
Less: observations with insignificant β_i	(4)
Less: extreme observation	(2)
Final sample (firms)	40
Final sample (company-year observation)	240

3.2. Estimation Model

Following Banker et al. (2014), the model to test the effect of manufacturing technology type on cost structure is as follows:

$$\boldsymbol{\Delta \log COST_{it} = \beta_0 + \beta_i \Delta \log SALES_{it} + \gamma_0 GDP_t + \varepsilon_{it}} \quad (1)$$

$$\boldsymbol{\beta_i = \alpha_0 + \alpha_1 TECH_i + \gamma_1 ASINT_i + \mu_i} \quad (2)$$

Where:

$COST_{it}$ refers to deflated COGS of firm i in year t,
$SALES_{it}$ refers to deflated sales revenue of firm i in year t,
$TECH_i$, a dichotomous variable, refers to manufacturing technology type (whether conventional or advanced technology) of firm i,
GDP_t is a control variable which refers to annual GDP growth rate in year t,
$ASINT_i$ is a control variable which refers to asset intensity of firm i, and
ε, μ refer to the random error.

Consistent with previous studies, e.g., Noreen and Soderstrom (1994, 1997), Banker et al. (1995), Anderson et al. (2003), and Kallapur and Eldenburg (2005), the log-linear model is used for two reasons. First, due to the variation in firm sizes and performance, using the log-linear model makes variables more comparable across firms. Second, cross-sectional estimation is likely to result in heteroscedasticity and the use of a log-linear model reduces the potential for heteroscedasticity in the estimation. In addition, Sales revenue, COGS and total assets are deflated by the GDP deflator to neutralize the inflation effect[3].

Changes in costs are used to capture the short-run costs response to changes in sales revenue, whereas the regression in levels would be influenced by cross-sectional differences and different size of firms. Hence, this would reflect the long-run expansion path of costs (Noreen & Soderstrom, 1994).

3.3. Variables Definitions

3.3.1. Cost Structure

Regression (1) is used to calculate β_i for firm i at time t. β_i captures the log unit change in COGS for the log of one Egyptian pound change in sales revenue and characterizes the degree of cost flexibility. Next, β_i is used in the second regression to capture the relation between technology type and cost structure by estimating α_1.

To test H_1 (advanced manufacturing technology is associated with less rigid cost structure), regression (1) is estimated using time series for the period 2011-2016 to estimate β_i. Such a period is used for estimating β_i because technology type is measured by an index developed from a questionnaire collected in 2016. Thus, the effect of technology type on cost structure cannot be tested for a different period in this study.

[3] GDP and GDP deflator data are obtained from The World Bank website: http://www.worldbank.org.

Another reason for the use of a short period consisting of 6 years to estimate β_i is justified on the basis that cost structure components, fixed and variable costs, are short-run concepts. According to Noreen and Soderstorm (1994), all costs are variable in the long-run as resources are subject to management discretion in the long-run.

After calculating β_i in regression (1), the coefficient α_1 is used in regression (2) cross-sectionally, which captures the relationship between technology type and cost structure. If α_1 is positive, then AMT will increase the slope β_i, indicating a less rigid and more flexible cost structure. Conversely, if α_1 is negative, then AMT will be associated with a more rigid cost structure.

The reason of using COGS to characterize the degree of cost flexibility and then capture the relation between manufacturing technology type and cost structure is that manufacturing technology type would affect the manufacturing costs (direct materials, direct labor and factory overhead) as costs are a function of the type of technology.

Manufacturing costs are allocated to two accounts, ending inventory and COGS. The data about the cost structure's shape (whether it is more rigid or more flexible) are not available. Therefore, the cost structure shape should be inferred from ending inventory and COGS. To use ending inventory cost to characterize cost structure shape, the number of units produced (the activity level) is needed, but these data are not available in the financial reports of Egyptian manufacturing firms. Therefore, COGS is used to characterize the degree of flexibility in regression (1) and sales revenue is used as a proxy for activity level.

3.3.2. Technology Type

Manufacturing technology type, whether a firm adopts a conventional manufacturing technology or an AMT, is measured by an index developed from a questionnaire containing four questions.

Following the information systems literature, e.g., Cooper and Zmud (1990), Rai and Patnayakuni (1996), and Brandyberry et al. (1999), these questions are designed not only to determine the adoption of an AMT, but also the degree of implementing the AMT. Adoption of AMT refers to the stages in which the firm uses computer (automation), while implementation refers to the degree of using automation within the firm. Table 2 presents the technology type index questionnaire.

In the first question, respondents were asked to determine in which stage(s) the firm uses automation. To avoid ambiguous and possibly fuzzy concepts for respondents that may induce random answers, the question is simplified by giving a clear and simple definition for automation with five stages.

In prior literature such as Brandyberry et al. (1999), the respondents were asked about the type of advanced manufacturing technology used by the firm such as computer-aided design (CAD), computer-aided manufacturing (CAM), FMS and others. However, in this study the AMT is simplified and defined as using the computer to control the different stages in the production process, including its all aspects starting from the product design to finishing its production. The reason for this simple definition is because a pilot study was made in which a sample of cost managers, production managers and production engineers were asked about these terms and revealed unfamiliarity with them.

Insert Table 2 here.

In the second question, respondents were asked about the percentage of automation in the firm's processes. Following Boyer et al. (1997), the third question is whether the firm uses robotics in its factory as using robots in manufacturing represents a high level of AMT. The fourth question is whether the firm has significant change in its manufacturing technology used within the last six years. This question has no weight and is not used in calculating the total score. Instead, it is used because cost rigidity is empirically measured using a period consisting of 6 years. Therefore, the manufacturing technology type used by a firm should be the same in these 6 years. Otherwise, the data would be distorted and misleading.

Table 2
The Technology Type Index Questionnaire

Q1: automation is defined as using the computer to control the different stages in production process, including its all aspects starting from the product design to finishing its production. Put tick mark (√) next to each stage(s) in which the computer is used in your company:

		Weights*
_____	In product design stage.	**3**
_____	In testing design stage.	**3**
_____	In production stage.	**5**
_____	In calculation and administrative work.	**1**
_____	The company does not use the computer at all.	**Zero**

* weights are not disclosed in the questionnaire.

Q2: your company applies the automation in its processes at a percentage of (put tick mark (√) next to the level that your company applies):

		Weights*
_____	0 - 20%	**1**
_____	20 - 40%	**3**
_____	40 - 60%	**5**
_____	60 - 80%	**7**
_____	80 - 100%	**9**

* weights are not disclosed in the questionnaire.

Q3: are robotics used in your factories?

		Weights*
_____	Extensive	**12**
_____	Moderate	**8**
_____	Limited	**4**
_____	Not used at all	**Zero**

* weights are not disclosed in the questionnaire.

Q4: is there any significant change in the manufacturing technology used within the last six years?

_____ Yes _____ No

The weights for the previous questions are determined subjectively. To measure whether the firm applies conventional or advanced manufacturing technology, a total score for each firm is obtained by summing the weights of the first three questions. Then, the median for the sample is identified. If the total score calculated for a firm is below the median, the firm is considered to have adopted conventional manufacturing technology and is coded 0. On the other hand, if the total score for a firm is above the median, the firm is considered to have adopted AMT and is coded 1.

3.3.3. Control Variables

In regression (1), one control variable is used, namely; gross domestic product (GDP) growth rate. GDP growth rate is used to control for the aggregate trends in the economy over time, as it is one of signals used by managers. When the economy is growing faster, managers become more optimistic and, therefore, may be more willing to expand committed resources.

In regression (2), following prior cost behavior studies (e.g., Anderson et al., 2003; Chen et al., 2012; and Holzhacker et al., 2015), asset intensity is used as a control variable to proxy for the extent of capacity adjustment costs. Asset intensity is measured by the ratio of total assets to sales revenue[4]. Table 3 presents variables definitions.

Table 3
Variables Definitions

Variables	Definition
$COST_{it}$	Deflated COGS of firm i in year t
$SALES_{it}$	Deflated sales revenue of firm i in year t
β_i	The degree of flexibility of the cost structure of firm i and estimated from regression (1)
$TECH_i$	0 = conventional manufacturing technology 1 = advanced manufacturing technology
<u>Control Variables:</u>	
GDP_t	Annual GDP growth rate in year t.
$ASINT_i$	Asset intensity of firm i and measured by the ratio of deflated total assets to deflated sales revenue.

IV. EMPIRICAL RESULTS

4.1. Descriptive Statistics

The descriptive statistics for the sample are presented in Table 4. There are noticeable differences between the means of sales revenue and COGS and their deflated counterparts which indicate that inflation is an important variable to be controlled for.

Table 4
Descriptive Statistics

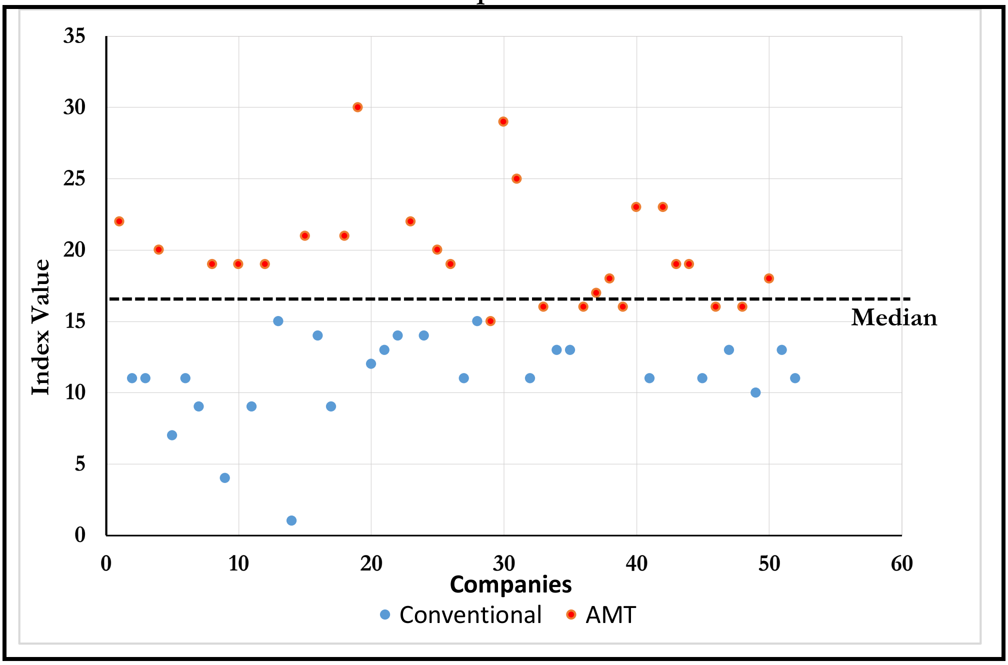
	Mean	Std. Dev.	Median	Min.	Max.
Sales Revenue (millions)	585.35	1000.77	243.74	12.74	11639.01
Deflated Sales Revenue (millions)	65.56	103.51	25.96	0.88	829.77
Log Deflated Sales Revenue	7.464	0.559	7.414	5.945	8.919
Log-changes in Deflated Sales Revenue	0.007	0.262	-0.013	-1.602	0.992
COGS (millions)	482.27	889.93	194.97	1.00	8449.69
Deflated COGS (millions)	54.1	95.85	19.64	0.14	117.57
Log Deflated COGS	7.360	0.568	7.293	5.144	8.070
Log-changes in Deflated COGS	0.006	0.299	-0.007	-2.734	1.397
βi (Cost Flexibility)	0.969	0.044	0.974	0.818	1.040
Technology Type Index	15.50	5.727	15	1	30
Asset Intensity	2.070	5.439	1.195	0.176	94.575

[4] Employee intensity is not used as a control variable because of the scarcity of number of employees' data in Egyptian firms.

The median of technology type indexed value is 15. Thus, a company with indexed value lower than 15 (< median) is designated as adopting conventional manufacturing technology and is coded 0. In contrast, a company with an indexed value greater than 15 (> median) is considered an AMT adopter and is coded 1.

Three firms in the sample have a total indexed value of 15, i.e. equals to the median. So, the question is whether these three firms are adopting conventional or advanced manufacturing technology. Solving this problem and classifying these three firms is based on the third question (whether using robotics in their factory or not). One firm uses robotics in its factory, so it is considered to adopt AMT. The other two firms do not use robotics at all, so they are considered to adopt conventional manufacturing technology. Figure 1 and Table 5 show the index values distribution for the sample.

Figure 1
Index Values Distribution for the Sample



Tables 5
Index Values Distribution for the Sample

	Conventional Manufacturing Technology	Advanced Manufacturing Technology (AMT)
1. **Minimum**	1	15
2. **Maximum**	15	30
3. **Median**	11	19
4. **Std. Dev.**	3. 212	3.804

Table 6 shows the correlations among the variables used in the analysis. There is no significant correlation between the independent variables. The correlations between the dependent and independent variables are significant.

Table 6
Correlations in the Analysis of Technology Type Effect

		1	2	3
1. **B_{it} (Cost Flexibility)**	Pearson Correlation	1		
	Sig. (2-tailed)			
2. **Technology Type**	Pearson Correlation	0.406	1	
	Sig. (2-tailed)	0.009***		
3. **Asset Intensity**	Pearson Correlation	-0.322	-0.190	1
	Sig. (2-tailed)	0.043**	0.239	

Notes: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively, in two-tailed tests.

Table 7 presents summary statistics and the estimates for regression (2). $\widehat{\alpha_1}$ is significant (p-value= 0.020) and have the expected positive sign, which means adopting AMT is associated with less rigid (more flexible) cost structure. Therefore, H_1 is accepted. The model's explanatory power (adjusted R-square) equals 0.185, which means that 18.5% of the variation in the dependent variable (log-change in deflated COGS) is explained by the variation in the independent variables (technology type and asset intensity) in the right-hand side of the model.

Asset intensity is also significant (p-value= 0.000) and has a negative sign as predicted. However, it is not a concern in this study as it is used as a control variable to proxy for the extent of capacity adjustment costs.

Table 7
Empirical Results of Testing H_1

H_1: advanced manufacturing technology (AMT) is associated with less rigid (more flexible) cost structure.

The estimation model is:

$$\Delta \text{logCOST}_{it} = \beta_0 + \beta_i \Delta \text{logSALES}_{it} + \gamma_0 \text{GDP}_t + \varepsilon_{it} \quad (1)$$

$$\beta_i = \alpha_0 + \alpha_1 \text{TECH}_i + \gamma_1 \text{ASINT}_i + \mu_i \quad (2)$$

Variable	Estimator	Predicted Sign.	Coeff.	Prob. > t
1. **Constant**	$\widehat{\alpha_0}$		0.957	0.000***
2. **Technology Type**	$\widehat{\alpha_1}$	+	0.031	0.020**
3. **Asset Intensity**	$\widehat{\gamma_1}$	−	-0.01	0.093*
4. **N**				40
5. **Adjusted R^2**				0.185
6. **Prob. > F**				0.009***

Notes: *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively, in two-tailed tests.

4.2. Robustness Tests (Not Tabulated)

Robustness test is a common exercise in empirical studies to examine how certain "core" regression coefficients behave at different specifications and modifications. If the coefficients are plausible and robust, this commonly is interpreted as evidence for structural validity (Lu & White, 2014). Hence, to check the validity and the persistence of the results, two robustness tests are used.

The first robustness test is by replacing COGS with operating expenses in regression (1). This is due to the inconsistent presentation and disclosure in the financial statements in the Egyptian companies listed on the Egyptian exchange (EGX), as some companies separate selling expenses from COGS while others include them within COGS, leading to a distortion in the data used in the analysis.

The estimate of coefficient $\widehat{\alpha_1}$ in this robustness test is positive (0.024) and significant (p-value= 0.048), which means adopting AMT is associated with less rigid (more flexible) cost structure. This result is consistent with the original result. In addition, the explanatory power of this robustness test improved significantly as the adjusted R-square equals 0.522 as the problem of inconsistent presentation and disclosure in the financial statements has been avoided.

In second robustness test, firm size is used as a control variable in regression (2) as prior studies suggest that firm size has an effect on cost behavior (e.g., Cheng et al., 2012; Balakrishnan et al., 2014). Firm size is measured by the log deflated total assets of firm i. The estimate of coefficient $\widehat{\alpha_1}$ and its significance level are generally similar to the original estimate.

V. CONCLUSION

5.1. Discussion and Conclusion

This study examines the effect of technology type on cost structure using 40 cross sectional Egyptian manufacturing firms listed on EGX. It is hypothesized that AMT is associated with less rigid (more flexible) cost structure. Our empirical evidence supports this hypothesis. Two robustness checks are performed to check the validity and the persistence of the results. The empirical finding continues to hold.

Previous studies such as Hartley (1983), Hollingum (1983), Jelinek and Goldhar (1984), Sloggy (1984), and Kaplan (1986) adopt the case study method and find that adopting AMT leads to reducing both variable costs and annual fixed operating costs. However, they did not examine whether the cost structure resulting from AMT adoption is rigid or flexible. In Lederer and Singhal (1988) case study, they find that adopting AMT leads to a reduction in the fixed operating costs by a higher rate than the reduction in variable costs. In addition, they find that the AMT has a lower breakeven point which could imply a more flexible cost structure. Our result agrees with those of Lederer and Singhal (1988).

The less rigid and more flexible cost structure resulting from adopting AMT is due to several reasons. First, besides the material, labor and energy savings, AMT helps in reducing inventory levels as processes become more flexible, the product flows more orderly, and scheduling gets better, which leads to cutting both work-in-process (WIP) and finished goods inventories. This reduction in inventory levels reduces the floor space needed for storage.

Second, less floor space results from adopting AMT which requires fewer computer-controlled machines to do the same jobs compared to a larger number of conventional machines. Third, adopting AMT results in a significant reduction in direct labor, which in turn reduces the annual fixed operating costs. In Egypt, direct labor cost is generally a fixed cost as it is based on time-wage plans rather than output-based wage plans.

Our study makes two important contributions to the accounting literature. First, this study provides additional insights into the impact of AMT on the cost structure in developing countries. Second, this study is expected to fill up a gap in the extant literature as an archival study utilizing a relatively large sample where the presumed relation between the manufacturing technology type and cost structure is more systematically examined in a cross-sectional design. Therefore, the research findings may be more generalizable. Conversely, findings of prior studies are not readily generalizable as they adopted the case study method.

The current study findings have further implications for the accounting. AMTs have a different cost structure than conventional manufacturing technologies. However, AMT costs more to acquire and install, it has a more flexible cost structure than conventional manufacturing technology. This indicates that AMTs are less risky than conventional manufacturing technologies. Thus, managers should use a lower discount rate in discounted cash flow (DCF) calculations for new technologies. Adjusting the discount rate for the cost structure of AMT leads to different net present values (NPV), which in turn could affect the technology type choice decision. In addition, putting plans for future periods, i.e. budgets, is also affected by the cost structure, as budgets contain many committed costs that cannot be changed or controlled in the short-run.

A major consideration pertinent to management choice of a certain production technology is the nature of the associated cost structure (rigid vs. flexible) and its impact on the operating leverage and hence the persistent and the sustained profitability of the firm.

5.2. Limitations and Future Research Directions

The study results and their interpretations are subject to several limitations. The first limitation is the method of measuring the technology type. Technology type is measured by a questionnaire and depends on the respondents' answers. These answers are subjective and may be biased, which may in turn affect the results due to the noise introduced into the data.

The second limitation is due to the technology type questionnaire structure. In the questionnaire, the respondent is asked in the first question about the degree of automation in firm's processes. Then, in the second question the respondent is asked to determine in which stage(s) the firm uses automation. Perhaps, it would have been more accurate to ask the respondent about the degree of automation implemented in each individual stage (process) rather than in the entire firm's processes.

The third limitation is related to the accounting data. Firms in Egypt do not follow the same rules for calculating and disclosing COGS in the financial statements. Therefore, these figures may be subject to some unintentional and unknown bias in the analysis. To overcome this limitation, operating expenses are used in the regression analysis instead of COGS as a robustness test.

One promising direction for future research is to explore detailed industry case studies to gain a better insight into the relation between the manufacturing technology type and the cost structure.

REFERENCES

Anderson, M. C., Banker, R. D., & Janakiraman, S. N. (2003). Are selling, general, and administrative costs sticky? *Journal of Accounting Research*, *41*(1), 47-63.

Anderson, S. (1995). Measuring the impact of product mix heterogeneity on manufacturing overhead cost. *The Accounting Review*, *70*(3), 363-388.

Atkinson, A., Balakrishnan, R., Booth, P., Cote, J., Groot, T., Malmi, T., Roberts, H., Uliana, E., & Wu, A. (1997). New directions in management accounting research. *Journal of Management Accounting Research*, *9*(1), 79-108.

Balakrishnan, R., Labro, E., & Soderstrom, N. S. (2014). Cost structure and sticky costs. *Journal of Management Accounting Research*, *26*(2), 91-116.

Baldwin, J. R., Sabourin, D., & Rafiquzzaman, M. (1996). *Benefits and problems associated with technology adoption in Canadian manufacturing: Survey of innovation and advanced technology 1993*. Catalogue 88-514E. Ottawa: Statistics Canada.

Banker, R. D., Byzalov, D., & Plehn-Dujowich, J. M. (2014). Demand uncertainty and cost behavior. *The Accounting Review*, *89*(3), 839-865.

Banker, R. D., Potter, G., & Schroeder, R. G. (1995). An empirical analysis of manufacturing overhead cost drivers. *Journal of Accounting & Economics*, *19*(1), 115-137.

Boyer, K. K., Leong, G. K., Ward, P. T., & Krajewski, L. J. (1997). Unlocking the potential of advanced manufacturing technologies. *Journal of Operations Management*, *15*(4), 331-347.

Brandyberry, A., Rai, A., & White, G. P. (1999, September). Intermediate performance impacts of advanced manufacturing technology systems: An empirical investigation. *Decision Sciences*, *30*(4), 993-1020.

Chen, C. X., Lu, H., & Sougiannis, T. (2012). The agency problem, corporate governance, and the asymmetrical behavior of selling, general, and administrative costs. *Contemporary Accounting Research*, *29*(1), 252-282.

Cheng, S., Jiang, W., & Zeng, Y. (2012). *Cost stickiness in large versus small firms*. Working paper. Prince George's County, Maryland: University of Maryland.

Chenhall, R. H., & Langfiled-Smith, K. (1998). Adoption and benefits of management accounting practices: An Australian study. *Management Accounting Research*, *9*(1), 1-19.

Clarke, P. J. (1995, June). The old and the new in management accounting. *Management Accounting*, *73*(6), 46-51.

Cooper, R. B., & Zmud, R. W. (1990, February). Information technology implementation research: A technological diffusion approach. *Management Science*, *36*(2), 123-129.

Datar, S. M., Kekre, S., Mukhopadhyay, T., & Srinivasan, K. (1993). Simultaneous estimation of cost drivers. *The Accounting Review*, *68*(3), 602-614.

Hartley, J. (1983). Mammoth FMS. *The FMS Magazine*, *1*(5), 277-281.

Hollingum, J. (1983). Japan's industry puts its money into FMS applications. *The FMS Magazine*, *1*(2), 102-109.

Holzhacker, M., Krishnan, R., & Mahlendorf, M. D. (2015). Unraveling the black box of cost behavior: An empirical investigation of risk drivers, managerial resource procurement, and cost elasticity. *The Accounting Review*, *90*(6), 2305-2335.

Jaikumar, R. (1986). Postindustrial manufacturing. *Harvard Business Review*, *64*(6), 69-76.

Jelinek, M., & Goldhar, J. D. (1984). The strategic implications of the factory of the future. *Sloan Management Review*, *25*(4), 29-37.

Kallapur, S., & Eldenburg, L. (2005). Uncertainty, real options, and cost behavior: Evidence from Washington state hospitals. *Journal of Accounting Research, 43*(5), 735-752.

Kama, I., & Weiss, D. (2013). Do earnings targets and managerial incentives affect sticky costs? *Journal of Accounting Research*, *51*(1), 201-224.

Kaplan, R. S. (1986). Must CIM be justified by faith alone? *Harvard Business Review*, *64*(2), 87-95.

Kotha, S., & Swamidass, P. (2000, April). Strategy, advanced manufacturing technology and performance: Empirical evidence from U.S. manufacturing firms. *Journal of Operations Management*, *18*(3), 257-277.

Lederer, P. J., & Singhal, V. R. (1988). Effect of cost structure and demand risk in the justification of new technologies. *Journal of Manufacturing & Operations Management*, *1*(4), 339-371.

Lu, X., & White, H. (2014). Robustness checks and robustness tests in applied economics. *Journal of Econometrics*, *178*(1), 194-206.

Noreen, E., & Soderstrom, N. (1994). Are overhead costs strictly proportional to activity? Evidence from hospital departments. *Journal of Accounting & Economics*, *17*(1), 255-278.

Noreen, E., & Soderstrom, N. (1997). The accuracy of proportional cost models: Evidence from hospital service departments. *Review of Accounting Studies*, *2*(1), 89-114.

Palframan, D. (1987). FMS: Too much, too soon. *Manufacturing Engineering*, *98*(3), 34-38.

Rai, A., & Patnayakuni, R. (1996). A structural equation model for case adoption behavior. *Journal of Management Information Systems*, *13*(2), 205-234.

Sloggy, J. E. (1984). How to justify the cost of an FMS. *Tooling & Production*, *50*(9), 72-75.

Zhao, H., & Co, H. C. (1997). Adoption and implementation of advanced manufacturing technology in Singapore. *International Journal of Production Economics*, *48*(1), 7-19.