International Journal of Accounting Information Systems 28 (2018) 1–13

Contents lists available at ScienceDirect

International Journal of Accounting Information Systems

journal homepage: www.elsevier.com/locate/accinf

Do health information technology investments impact hospital financial performance and productivity?

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ARTICLE INFO

Keywords:
Hospital financial performance
Hospital productivity
Meaningful use
Information technology expense
Hospital quality
Hospital business processes

ABSTRACT

In this study, we examine the associations between health information technology expenses, intermediate business processes, hospital financial performance and productivity. Research using hospital financial data prior to the Health Information Technology for Economic and Clinical Health Act is limited. Using Definitive Healthcare data, we find that health information technology expenses, including information technology operating expense and capital expense, are positively associated with hospitals' return on assets and productivity. In addition, investments also generate effects via hospital's intermediate business processes, such as electronic health records (EHR) adoption, and quality measures. Our findings suggest that hospitals' health information technology investments involving intermediate business processes are associated with positive financial performance and productivity following the implementation of the Health Information Technology for Economic and Clinical Health Act.

1. Introduction

The Health Information Technology for Economic and Clinical Health (HITECH) Act, enacted as part of the American Recovery and Reinvestment Act of 2009, promotes the adoption and use of Health Information Technology (HIT) by providing significant financial incentives and penalties to healthcare organizations. With large investments in information technology such as Electronic Health Record (EHR) systems, questions related to financial and productive payoffs become increasingly important. EHRs meet the goals of integrating patient medical history with current treatment thereby facilitating improved quality of care and increased productivity, but are expensive for organizations, potentially impacting financial performance and productivity (Kohli and Tan, 2016; Devaraj and Kohli, 2000; Li and Collier, 2000). Since the enactment of HITECH, the adoption rate of EHR systems has increased significantly.[1] As of 2015, 84% of hospitals report adopting at least a basic EHR system, representing a nine-fold increase since 2008 (Henry et al., 2016).

To encourage EHR adoption, the Centers for Medicare & Medicaid Services (CMS) provides incentive payments to hospitals that successfully demonstrate *Meaningful Use* of EHR technology. The meaningful use initiative supports several health care goals including the improvement of quality, safety, and efficiency; the reduction of health disparities; the engagement of patients and families in care decisions; the improvement of public health; and the ascertainment of privacy and security of patient health information. Ultimately, it is hoped that Meaningful Use compliance will result in better clinical outcomes, improved population health outcomes, increased transparency and efficiency, empowered individuals, and more robust research data on health systems (HealthIT.gov,

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[1] In this paper, we use HIT as the broad concept, and EHR as the application system of HIT.

https://doi.org/10.1016/j.accinf.2017.12.002
Received 14 December 2016; Received in revised form 10 November 2017; Accepted 12 December 2017
1467-0895/

2015). Introduced in three stages, Meaningful Use Stage[2] 1 focused on data capture and sharing from 2011 to 2014. Stage 2 focuses on advance clinical processes from 2015 to 2017, and Stage 3 focuses on improved outcomes after 2017 (Holland, 2015). Meaningful Use sets specific objectives that hospitals must achieve to qualify for CMS incentive payments. For example, to meet Meaningful Use Stage 2 requirements for 2015 to 2017, EHR systems should support objectives such as protecting electronic health information and using clinical decision support systems to improve performance (CMS, 2016). In addition to CMS Meaningful use standards, HITECH also requires EHR systems be interconnected to improve the quality of health care. Because of these issues and requirements, Accounting Information Systems researchers continue to call for an expansion of healthcare research to include business process influences (Fichman et al., 2011).

In theory, IT investment can improve healthcare service efficiency and generate positive financial returns (Menon et al., 2000). However, the expected efficiencies and quality improvements remain elusive. Adding to these concerns, previous research used organizational data developed prior to the HITECH Act and its financial incentives. With the rapid adoption of EHRs, an examination of contemporary IT environments is required. Therefore, the purpose of this study is to examine the associations between health information technology expenditures, intermediate business processes, hospital financial performance and productivity. In the next section, we review related literature and propose our hypotheses. Then, we describe our sample selection procedure and empirical methods. Next, we present our results and conduct sensitivity analysis to alleviate endogeneity concerns and follow with a discussion, limitations and concluding comments.

2. Literature review[3] and hypothesis development

The benefits of using information technology have been widely studied, however the IT-performance relationship has been far from conclusive (Devaraj and Kohli, 2000). Melville et al. (2004) summarize how information technology can contribute to organization performance, including productivity enhancement, profitability improvement, cost reduction, competitive advantage, inventory reduction, and other measures of performance. Similarly, information technology has been shown to significantly change the way hospitals interact with patients and other healthcare stakeholders (Kohli and Tan, 2016). HIT can contribute to hospital profitability by reducing paper chart pulling and document transportation (Wang and Biedermann, 2010), reducing medical errors, potentially lowering medical liability costs (Mello et al., 2010) as well as decreasing back office expense (McLeod et al., 2008).

Li and Collier (2000) developed a theoretical model to analyze the causal relationship between HIT and financial performance in hospitals. Their model suggests that HIT can improve clinical quality, process quality and intermediate business processes contributing to hospital financial performance. Using survey data gathered from 142 community hospitals, they find that information technology directly affects a hospital's financial performance.

The advent of new information technology typically builds heightened expectations, but often such expectations fall short and the expected benefits of new technology do not come to fruition (Venkatraman, 1994). HIT increases hospital capital and operating expenses (Smith and Coustasse, 2014), however, many studies find no evidence of positive associations between hospital financial performance and HIT investments. For example, Kazley and Ozcan (2007) found operating margin was not associated with EHR adoption. Wang et al. (2005) found IT adoption was not associated with hospitals' return on assets. The results of Ginn et al. (2011) are consistent with Wang et al. (2005) and Kazley and Ozcan (2007) indicating no association between IT investments and hospital margins. These findings align with Kohli and Tan's (2016) call for the development of analytical revenue models.

Some researchers suggest positive financial performance based on estimated savings with assumptions that EHRs would be interconnected, interoperable, adopted widely, and used effectively (e.g., Grieger et al., 2007; Wang et al., 2003.) Health information exchanges, standardization and financial incentives have been proposed to meet these EHR goals (Yasnoff et al., 2004). Other studies provide limited evidence of positive financial measures from HIT investments using empirical methods and include a number of hospital-related variables and financial measures deemed to affect hospital profitability (Devaraj and Kohli, 2000). Menachemi et al. (2006) looked at 82 Florida hospitals' financial statements and an IT survey administered finding a positive association between case mix (i.e., inpatient revenue, net patient revenue, hospital expenses, and total expenses) and intermediate processes involving clinical IT use. Their financial performance indicators were revenue and expense indicators, instead of financial returns, which are better measures of financial performance.

In another revenue model evaluation, Collum et al. (2016) merged data from the 2007–2010 American Hospital Association Annual Survey with its Information Technology Supplement, and the 2007–2011 Medicare Cost Reports from the Centers for Medicare and Medicaid Services. Using operating margin, return on assets, and total margin as financial performance measures, their results indicate no association between operating margin, return on assets and the level of EHR adoption, but total margin significantly improved after two years, in hospitals adopting an EHR system. These findings are consistent with Lee and Kim (2006) who noted a "Lag Effect" of IT investment on performance and this effect has also been noted in healthcare (Devaraj and Kohli, 2000).

Finally, Baker et al. (2017) examined IT investment from the perspective of productivity measures. This work expands the current understanding of how IT investments might improve productivity, reversing the question – Can increased productivity lead to greater IT investments? This study adds to the discussion, considering if the relationship of productivity followed by IT investment is positive or negative, while suggesting a positive impact. Analyzing data from 1236 health organizations, results indicated support for this

[2] In 2010, the timeframes and objectives for each Meaningful Use Stage were set in the Meaningful Use Final Rule (2011 Edition). In 2015, CMS revised the timeframes and objectives for each Meaningful Use Stage. Here, we use the modified stage timeframe and objectives because they are the most current requirement.

[3] We limit our literature review in hospital settings.

positive association and suggest that unidirectional causality is a poor explanation. Going further, Baker et al. (2017) proposed more dynamic models using multiple time periods to help understand the cycle of IT inputs and productivity. The authors suggest future work might include organizational performance measures such as ROA, ROI and ROE.

Summarizing, prior research in healthcare financial performance exhibits some shortcomings. First, many papers use only regional data. For example, Menachemi et al. (2006) use data from 82 Florida hospitals from 2003, while Goes and Zhan (1995) use data from 300 California hospitals from 1981 to 1990. The utilization of regional data limits the generalizability of these studies.

Second, prior research uses sample data collected earlier than 2010 (e.g., Molinari et al., 1995; Alexander et al., 2006; Shen and Ginn, 2012; and Collum et al., 2016). With the rapid adoption and utilization of HIT after the HITECH Act, the data used in prior studies becomes less valuable. In addition, Collum et al. (2016) found that the effects of EHR adoption show up two years later, consistent with the "Lag Effect." We therefore chose to use data collected after 2010 to examine the association between financial performance, productivity, HIT investments and intermediate business processes in hospitals.

Third, prior studies examined direct effects of HIT investment without considering the role of intermediate business processes associated with efficiency, and EHR adoption. Prior literature in information technology theorizes that adoption and use of information technology generates positive financial performance for firms (e.g., Melville et al., 2004; Menon et al., 2000). We consider these intermediate business processes important influencers of financial performance and therefor propose hypotheses supporting our examination.

Fourth, some work has independently considered whether IT investment affects organizational productivity or organizational productivity affects IT investment (Baker et al., 2017). This research suggests the inclusion of performance and productivity to create a more dynamic model explaining the cyclical nature of investment, performance and productivity (Baker et al., 2017; Devaraj and Kohli, 2000, 2003; Menachemi et al., 2006; Menon et al., 2000).

Because prior literature in information technology theorizes that adoption and use of information technology generates positive financial performance for firms (e.g., Melville et al., 2004; Menon et al., 2000) and that investments in information technology have positive effects on productivity, we propose the following hypothesis in the alternative form:

H1. Health information technology investments in hospitals are positively associated with financial performance and productivity.

The above hypothesis is further elaborated into the following two sub-hypotheses according to different financial performance and productivity measures.

H1a. Health information technology investments in hospitals are positively associated with return on assets (ROA).

Recognizing the argument by Devaraj and Kohli (2000, 2003); Menachemi et al. (2006); Menon et al. (2000), Baker et al. (2017, p. 5–6) state that "…revenue-based measures of productivity (rather than profit-based measures) are more appropriate in healthcare contexts, because most health systems operate on a nonprofit basis," we constructed the proxy for productivity, "Q". We proposed H1b as follows,

H1b. Health information technology investments in hospitals are positively associated with productivity (Q).

The HITECH act played a critical role, increasing hospital IT spending, and requiring hospitals to meet the Meaningful Use stage requirements. Therefore, hospital IT investments should impact hospitals' Meaningful Use stage status. As such, we proposed H1c as follows,

H1c. Health information technology investments in hospitals are positively associated with Meaningful Use (MU) stage status.

Prior research suggests that HIT has been shown to improve healthcare quality (see, Chaudhry et al., 2006; McCullough et al., 2010). Li and Collier (2000) show that besides direct impact, hospital information technology indirectly affects hospital financial performance, i.e., hospital information technology can improve clinical quality, and higher clinical quality enhances hospital financial performance.

According to the above theory, we proposed the following hypotheses:

H2. Health information technology investments in hospitals are positively associated with hospital intermediate business processes.

We adopted the following intermediate business processes: electronic health record (EHR) adoption, and bed utilization rate (BUR). These measures represent hospital processes concerning efficiency (bed utilization rate) and costs (EHR adoption) related to Chaudhry et al. (2006). H2 is further elaborated into the following two sub-hypotheses according to different quality measures.

H2a. Health information technology investments in hospitals are positively associated with hospital electronic health record adoption (EHR).

H2b. Health information technology investments in hospitals are positively associated with hospital bed utilization rates (BUR).

There are many ways in which intermediate business processes may affect financial performance. Several researchers have confirmed positive effects of Electronic Health Record adoption on financial performance (Wang et al., 2015; Wang and Biederman 2012; McLeod et al., 2008). Recently, Collum et al. (2016) explored panel data to determine if EHR adoption impacted financial performance measures. While studies show increased revenue following adoption of EHR, modified business processes have also affected productivity and brought into question the quality of care administered (Howley et al., 2015; Campanella et al., 2016).

Healthcare quality is another intermediate process potentially affecting financial performance and productivity. Richter and

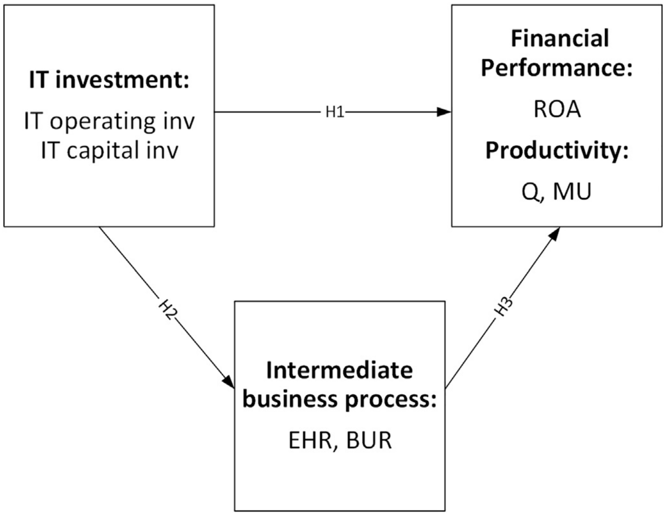

Fig. 1. Intermediate business process model.

Muhlestein (2017) modeled the relationships between healthcare quality, net patient revenue, net income, and operating margin. Their findings indicate that better healthcare quality is positively associated with increased profitability, but more strongly, a reduced quality of healthcare is associated with decreased profitability. Harkey and Vraciu (1992) considered the link between intermediate business process involving quality and financial performance. Using a survey and financial data from 82 hospitals, they found a positive association between operating margin and quality measures and suggested further studies involving more institutions.

Similarly, in H3 we tested the relationships of the intermediate business processes with respect to financial performance, productivity, and Meaningful Use stage status.

H3. Hospital quality measures are positively associated with hospital financial performance.

H3 is further elaborated into the following two sub-hypotheses according to different quality measures in sub-hypotheses.

H3a. Electronic Health Record investments in hospitals are positively associated with financial performance, productivity, and Meaningful Use stage status.

H3b. Hospital Bed Utilization Rates in hospitals are positively associated with financial performance, productivity, and Meaningful Use stage status.

3. Research design

Following the literature, a research model was crafted to demonstrate the relationships among IT investments, financial performance, and intermediate business processes, such as EHR, and Bed Utilization Rate (*BUR*) as measures of efficiency and quality. Fig. 1 shows the relationships between constructs and their hypotheses.

3.1. Sample selection

In order to overcome the limitations of dated and/or regional hospital data, we selected Definitive Healthcare (https://www.definitivehc.com), a subscribed healthcare data provider. There are three advantages to using this data set. First, the dataset is comprehensive, covering over 8000 hospitals in the United States. These hospitals provide a broad range of health care services. Second, Definitive Healthcare frequently updates its dataset. Therefore, its dataset is timely and new. Third, prior research often focuses on the effects of EHR adoption on hospital financial performance (e.g., Menachemi et al., 2006; Collum et al., 2016). EHR adoption requires considerable IT capital investment and the Definitive Healthcare dataset provides information concerning these implementations. In addition, IT operating expenses were ignored in many of the prior studies, while the Definitive Healthcare data includes IT operating expenses - a variable of interest for this paper.

The original dataset contains 8825 unique hospital observations from 2011 to 2016. The dataset contains historical financial data, which included net patient revenue, total operating expenses, operating income, net income, cash on hand, discharges, bad debt and capitalization ratio, back to 2009. The pooled data used in this paper was downloaded on October 21st, 2016. We dropped observations with unreasonable values, including 64 observations with *total assets* less than or equal to zero and 513 observations with *total uncompensated care unreimbursed cost* less than zero. We further dropped observations lacking the information required to calculate dependent, independent, and control variables. After data cleaning, our final sample contained 3266 observations. This pooled data allowed us to examine hospital financial information over multiple years, however other data related to intermediate business processes was only available for the current year. Given our literature review, we examined the data set and calculated variables to be used in our analysis.

3.2. Dependent variables: hospitals' financial performance and productivity

Financial performance is normally measured by return on assets (ROA) (e.g., Gunny, 2010), therefore, we use *ROA* as the dependent variable measuring hospital financial performance in this paper.[4]

To examine associations related to productivity and expenditures, we followed Baker et al. (2017), constructing *Q* (productivity) as the revenue-based measures of productivity. In Baker et al. (2017), net revenue was divided by the total number of licensed beds. In the Definitive Healthcare dataset, the number of staffed beds rather than licensed beds is available. The number of licensed beds includes staffed beds, and unstaffed beds. Unstaffed beds have limited impact on hospitals' performance, so we used the number of staffed beds to construct *Q*.

The Definitive Healthcare dataset also records hospitals' Meaningful Use status. Hospitals may attest to Meaningful Use stage 1, Meaningful Use stage 2, or have not attested for Meaningful Use.[5] We coded the three stages as Meaningful Use (*MU*) of 1, 2, and 0, with 0 as the base in analysis.

3.3. Independent variables: information technology expenses

Collum et al. (2016) use EHR adoption status as the independent variable. Menachemi et al. (2006) use hospital clinical information technology as the independent variable. These articles focus on the use of HIT, rather than information technology expenses. In our first hypothesis, we use information technology expenses as the variable of interest, including *operating IT expense* and *capital IT expense*. The healthcare database used in this study contains annual *operating IT budget* and *capital IT budget*, so we use these variables as proxies for IT expenses. Budgets are planning tools for expenses utilized by executives managing organizational spending. If there is significant variance in budgeting expenditures, executives must execute formal budget adjustment requests to the chief executive officer, chief finance officer, or the Board to revise the budget (Wang et al., 2015). Because most executives would prefer to avoid these types of adjustments, we consider IT budgets good proxies for IT expenses.

We selected two hospital quality measures and intermediate business processes – adoption of an Electronic Health Record system (*EHR*), and Bed Utilization Rate (*BUR*). In this analysis, *EHR* is set equal to 1 if a hospital adopts an EHR system. *BUR* is the hospital's bed utilization rate. The two variables are the dependent variables in H2, and the independent variables in H3.

3.4. Control variables

There is little agreement concerning which control variables should be included in financial performance models. The regression model utilized in Gunny (2010) includes firm size, market to book ratio (MTB), size adjusted abnormal stock returns, and *Z*-score for public firm financial performance. These control variables are widely accepted in business research; however, most hospitals are not publicly traded and lack MTB, abnormal stock returns, and z-score information. Following Gunny (2010), we chose to use the natural logarithm of *total assets* as *size*.

Gapenski et al. (1993) studied the determinants of hospital profitability finding several predictors of hospital profitability, including patient-mix (i.e., Medicare/Medicaid mix, and uncompensated care mix), organizational characters (i.e., size, and teaching status), and managerial variables (i.e., labor intensity, age of plant, and service index). Molinari et al. (1995) used size, region, and ownership as control variables. They found size, public chain, and for-profit chain significantly associated with hospital financial performance.

Subsequent financial healthcare scholars often included variables identified by the previous two articles. Some also use *market concentration index* as a control variable for market competition (e.g., Collum et al., 2016; Goes and Zhan, 1995; Alexander et al., 2006), although results were mixed. Following Watkins (2000), we considered the relationship between non-accounting information and historical financial ratios. In this research, we include all control variables available in our healthcare dataset. The managerial variables were not available. Market concentration index, ownership, teaching status, and location variables were available and are included in our model.

The healthcare dataset categorizes hospital *Ownership* into three groups, *governmental*, *proprietary*, and *voluntary nonprofit*. Each group has further sub-groups. For example, *proprietary* includes *corporation*, *individual*, *partnership*, and *other*. In this paper, we use the main categories to create two indicator variables, *governmental* and *proprietary* to distinguish hospitals' ownership, setting *voluntary* as the reference group. *Medical School Affiliation* includes five categories: *graduate*, *major*, *limited*, *no affiliation*, and *unknown*. We create one indicator variable for teaching status termed "*teaching*." For teaching status, *teaching* is set equal to 1 if *Medical School Affiliation* is

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[4] Prior research often uses multiple financial indicators to assess hospital fiscal performance, including *ROA*, *total margin*, *operating margin* (Molinari et al., 1995; Chiang et al., 2014; Nguyen et al., 2016; Collum et al., 2016), and *cash flow ratio* (Menachemi et al., 2006). *Cash flow ratio* was not included in the healthcare dataset and therefore not incorporated into our models. We chose not to use *Operating Margin* or *Total Margin* due to their relationship with the independent variable, IT expenses, which are part of operating cost, therefore increasing IT expenses reduces net income, decreasing the operating/total margin. We examine the association between IT expenses and operating/total margin. As predicted, the associations are negative and significant. The result is not reported.

[5] Meaningful Use Stage 3 requirements will become effective in 2018 (https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Stage3Medicaid_Require.html). As thus, all hospitals in our sample are in Meaningful Use 1, Meaningful Use Stage 2 or not attested for Meaningful Use.

Table 1
Variable descriptions.[a]

Dependent variables in H1 and H3	
ROA	Return of Assets (*Net Income/Total Assets*), ROA is winsorized at the top and bottom 1% of its distribution;
Q	Productivity ((*Net Revenue*/1,000,000)/*number of staffed beds*);
MU	Categorical indicators for Meaningful Use status, coded as 0, 1, or 2.
Dependent Variables in H2	
EHR	An indicator variable that is set equal to 1 if *Electronic Health Medical Record* is not missing, zero otherwise;
BUR	*Bed Utilization Rate*
Independent variables in H1 and H2	
operating_IT	Operating IT expenses (*Est. IT Operating Expense Budget*/1,000,000);
capital_IT	Capital IT expenses (*Est. IT Capital Expense Budget*/1,000,000);
Independent variables in H3	
EHR	An indicator variable that is set equal to 1 if *Electronic Health Medical Record* is not missing, zero otherwise;
BUR	*Bed Utilization Rate*
Control variables	
MCI	Market Concentration Index (*Market Concentration Index*)
MedicareMix	Medicare Mix (*Payor Mix Medicare*)
MedicaidMix	Medicaid Mix (*Payor Mix Medicaid*)
uncomp	Uncompensated cost (*Total Uncompensated Care Unreimbursed Cost*/1,000,000)
size	Hospital size (the natural logarithm of *Total Assets*, i.e., ln(*Total Assets*/1,000,000))
teaching	An indicator variable that is set equal to 1 if *Medical School Affiliation* is “Graduate” or “Major”, zero otherwise;
gov	An indicator variable that is set equal to 1 if *Ownership* is “Governmental”, zero otherwise;
prop	An indicator variable that is set equal to 1 if *Ownership* is “Proprietary”, zero otherwise;
urban	An indicator variable that is set equal to 1 if *Geographic Classification* is “Urban”, zero otherwise;
Year	Indicator variables that is set equal to 1 if observation's *Year* is equal to one unique year.

[a] *Italic* indicates the variable names in the Definitive Healthcare Dataset.

graduate or *major*, 0 otherwise. Regarding location, we create one indicator variable, *urban*, which is set equal to 1 if *Geographic Classification* is *urban*, 0 otherwise. Table 1 provides a brief description of variables used in this analysis.

4. Regression models

Our main model specification is as follows:

$$DV = \beta_0 + \beta_1 IV + \sum Controls + Year + \varepsilon \tag{1}$$

In H1, DV is the dependent variable (*ROA*, *Q* or *MU*); IV is the independent variable (*operating IT expense*, or *capital IT expense*); and ΣControls represents all control variables (*market concentration index*, *Medicare mix*, *Medicaid mix*, *total uncompensated care unreimbursed cost*, *size*, *teaching status*, *governmental*, *propriety*, and *urban*); Year represents fixed effects indicator variables removing the proportion of deviations from the year norm due to different fiscal years.

In H2, the DV is the quality measure (*EHR*, or *BUR*). Because *EHR* is an indicator variable, we used logit regression models when *EHR* was used to test H2.

In H3, the dependent variable is financial performance (*ROA*, *Q* or *MU*), and the independent variable is the intermediate business processes and quality measures (*EHR*, or *BUR*.)

When observations contain multiple industries, industry fixed effects indicators are necessary. In this paper, our sample data contain only hospital observations, thus, our model does not include multiple industry fixed effects indicator variables. With the r and cluster options of the regress function in Stata v14, standard errors are robust and clustered by years.

Outliers in data may bias the results. We winsorized all continuous variables at the top and bottom 1% of its distribution to fix its outlier issue.

With respect to Meaningful Use analysis, we dropped *MCI* and case mix variables, including *Medicare Mix*, *Medicaid Mix*, and *uncomp*, because they are related to financial performance, not MU status. Furthermore, because *MU* is coded as 0, 1, and 2, we use multinomial logistic regressions to analyze the correlations.

5. Results

To begin the analysis of hospital observations, we calculated descriptive statistics including the mean, standard deviation, minimum, 1st quartile, median, 3rd quartile and maximum values for all variables. In sample data, the hospital mean *ROA* is 0.0677, consistent with Collum et al. (2016). The hospital mean size is $118.49 million of total assets; with the median size is $121.99 million. Table 2 contains the descriptive statistics for the variables collected.

To calculate the estimates for H1, we regressed *ROA* as dependent variables with *operating_IT*, and *capital_IT* as independent

Table 2
Descriptive statistics.[a]

Variables	N	Mean	Std. Dev.	Min.	1st quartile	Median	3rd quartile	Max.
ROA	3265	0.0677	0.2073	− 1.1679	0.0011	0.0474	0.1098	0.9467
Q	3266	1.3384	0.7441	0.2485	0.8557	1.1731	1.6509	4.6097
MU	3266	1.7750	0.5083	0	2	2	2	2
operating_IT	3266	4.8620	6.7392	0.1242	1.0124	2.5538	5.6685	38.2672
capital_IT	3266	2.5850	3.7078	0.0894	0.5420	1.3046	2.9032	21.3279
EHR	3266	0.9798	0.1407	0	1	1	1	1
BUR	3265	0.4940	0.1899	0.0750	0.3520	0.5050	0.6400	0.8710
MCI	3266	0.3649	0.3272	0.0200	0.0800	0.2700	0.5400	1.0000
MedicareMix	3266	0.3979	0.1475	0.0680	0.2990	0.3910	0.4860	0.8030
MedicaidMix	3266	0.1056	0.0924	0.0020	0.0380	0.0760	0.1480	0.4390
uncomp	3266	13.3508	18.9501	0.1678	2.8241	6.8173	15.7418	120.1290
size	3266	4.7748	1.3952	1.1369	3.8441	4.8039	5.7476	7.9018
teaching	3266	0.1632	0.3696	0	0	0	0	1
gov	3266	0.1562	0.3631	0	0	0	0	1
prop	3266	0.2312	0.4216	0	0	0	0	1
urban	3266	0.7159	0.4511	0	0	1	1	1

[a] All continuous variables are winsorized at the 1 and 99% level.

variables and controlled for *market concentration index*, *Medicare mix*, *Medicaid mix*, *total uncompensated care unreimbursed cost*, *size*, *teaching status*, *governmental*, *propriety*, *urban*, *and Year* fixed effects indicators. Table 3 reports the regression results from estimating the direct associations between HIT expenses and financial performance and productivity.

When ROA is the dependent variable, the *operating_IT* coefficient estimate is positive and only marginally significance ($p = 0.064$), while, the *capital_IT* coefficient estimate is positive and statistically significant ($p = 0.048$). Therefore, the results provide marginal support for H1a. When Q is the dependent variable, the coefficient estimates on *operating_IT* and *capital_IT* expenses are positive and statistically significant ($p = 0.000$), providing evidence in support for H1b. These associations suggest that when organizations spend more on IT expenses there is an increase in both hospital financial performance as measured by ROA and productivity as measured by Q.

Table 3
The association between HIT expenses and financial performance/productivity.

Variables	*Financial performance*		*Productivity*	
	ROA	*ROA*	*Q*	*Q*
Intercept	0.1145***	0.1143***	0.5605***	0.5551***
	(0.004)	(0.004)	(0.000)	(0.000)
operating_IT	**0.0011***		**0.0327*****	
	(0.064)		**(0.000)**	
capital_IT		**0.0021****		**0.0618*****
		(0.048)		**(0.000)**
MCI	0.0389***	0.0390***	0.0229	0.0247
	(0.000)	(0.000)	(0.314)	(0.282)
MedicareMix	− 0.1486**	− 0.1488**	− 0.2338***	− 0.2390***
	(0.014)	(0.014)	(0.000)	(0.000)
MedicaidMix	− 0.2017***	− 0.2015***	− 0.6263***	− 0.6203***
	(0.001)	(0.001)	(0.000)	(0.000)
uncomp	− 0.0003***	− 0.0003***	− 0.0010***	− 0.0012***
	(0.000)	(0.000)	(0.000)	(0.000)
size	0.0082**	0.0082**	0.1056***	0.1068***
	(0.016)	(0.014)	(0.000)	(0.000)
teaching	− 0.0257***	− 0.0265***	− 0.1001***	− 0.1233***
	(0.009)	(0.008)	(0.000)	(0.000)
gov	− 0.0101**	− 0.0102**	− 0.0484***	− 0.0504***
	(0.043)	(0.041)	(0.001)	(0.001)
prop	0.1007***	0.1007***	− 0.1341***	− 0.1338***
	(0.000)	(0.000)	(0.000)	(0.000)
urban	0.0034	0.0035	− 0.2559***	− 0.2514***
	(0.236)	(0.221)	(0.000)	(0.000)
Year fixed effects	Yes	Yes	Yes	Yes
Observations	3265	3265	3266	3266
Adjusted R-squared	0.058	0.058	0.176	0.179

Notes: *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively, two-tailed. *p*-values are in parentheses. Standard errors are robust and clustered by years.

The effect of IT investments is economically significant. In the financial performance *ROA* model, the coefficient estimate of operating IT investments is 0.0011 with a *p*-value of 0.064. Similarly, for capital IT investments the coefficient estimate is 0.0021 with a p-value equal to 0.048. This means that for every $1 million increase in operating IT investments an increase of 0.0011 in hospital ROA occurs and for every $1 million increase in capital IT investment an increase of 0.0021 takes place for hospital ROA. On average, hospitals' total assets are $118.49 million dollars. These results suggest that on average, a hospital's $1 million increase in operating IT investments can result in $130,339 increase in net income and a similar investment in capital IT budget can see a $248,829 increase in net income. This reflects a 0.74% increase in hospital net income due to the increase in operating IT investment and a 1.41% increase in hospital net income resulting from capital IT investment.[6]

In the productivity *Q* model, the coefficients estimates of operating IT investments are 0.0327 with a *p*-value equal to 0.000 and 0.0618 with a p-value equal to 0.000 for capital IT investment. The results suggest that a $1 million increase in operating IT investments in a hospital can result in $6.05 million increase in hospitals' total revenue and a corresponding investment in capital IT produces an $11.43 million increase in total revenue. These effects reflect a 0.71% increase in hospital net total revenue for operating IT investments and a 1.35% increase in hospital's net total revenue for capital IT investments.[7]

To demonstrate the scale of these effects, we provide examples using $1 million and $100,000 investments. With an average operating IT budget of $4.86 million, a $1 million increase equates to a 20.58% increase in operating IT budget. With an average $2.58 million capital IT budget, a $1 million increase equates to a 38.75% increase in capital IT budget. More likely examples might be when a CIO increases the operating IT budget by $100,000, equaling a 2.06% increase in IT budget, and achieving a $13,034 increase in net income or a $100,000 increase in capital IT budget producing a 3.88% improvement in net income of $24,883. A similar increase in IT budget, on average can result in $605,000 in net total revenue associated with the increase in operating IT budget and $1.14 million increase in net total revenue resulting from the increase in capital IT budget.

The coefficient estimates of the control variables are consistent with predictions noted in the literature review. Specifically, the coefficient estimates of *Medicare mix*, *Medicaid mix*, *total uncompensated care unreimbursed cost*, *teaching status*, and *governmental* are negative and significant in all models. The coefficient estimates of *MCI*, *size*, and *propriety* are positive and significant in ROA models. The coefficient estimates of *urban* are negative and significant in *Q* models. The other coefficients are insignificant. These associated results provide some insight into the relationships between expenses, financial performance, productivity, and various control variables.

It is not surprising to find positive direct financial performance of IT investments in hospitals. Dehning and Richardson (2002) found early 1990s IT investments with negative or zero returns but by the late 1990s, several studies showed positive payoffs from investments in IT. Historically, the healthcare industry has lagged behind in IT adoption (Menachemi et al., 2006; Christensen and Remler, 2009; Venkatesh et al., 2011). Prior research in healthcare IT investments found little evidence of positive financial performance. However, with passage of the HITECH Act and subsequent rapid adoption of HIT due to incentives, we expect to see investment and positive payoffs.

Table 4 shows the multinomial logistic regression outputs for hypothesis H1c. The Relative Risk Ratio (RRR) of coefficients on IT budgets associated with Meaningful Use (MU) stage 1 are greater than 1 and significant in both models, while, the RRR of coefficients associated with MU stage 2 are not significant. The results suggest that operating and capital IT budgets influence MU stage 1 requirements, but do not influence MU stage 2 requirements. These results are supported by the fact that most requirements in MU stage 1 can be met by adopting certified EHR systems. However, requirements in MU stage 2 are much higher, requiring high-level coordination among hospitals, health information exchange, and management integration in hospitals.

Table 5 reports the logit regression results between IT expenses and EHR implementation, and the OLS regression between IT expenses and the quality measure Bed Utilization Rate. In this analysis, IT capital expense, and IT operating expense are positively and significantly associated with two intermediate processes measures, *EHR* and *BUR*. The results provide evidence in support for H2. Table 6 reports the relationship between intermediate business processes, and financial performance and productivity. These results show that the two intermediate business processes, *EHR* and *BUR*, are positively correlated with hospital's financial performance and productivity – *ROA* and *Q*. The results provide evidence in support for H3. Based on the outputs of Tables 4, 5, and 6, we can see that IT operating and capital investments positively impact hospitals financial performance and productivity via enhanced quality and better intermediate business process in hospitals.

Table 7 reports the relationship between quality measures and hospital Meaningful Use status. The RRRs of *EHR* are greater than 1 and significant, suggesting EHR adoption is positively associated with Meaningful Use. However, the RRRs of *BUR* are less than 1 and insignificant, suggesting that *BUR* is not associated with hospital Meaningful Use status. The results are consistent with adopting EHR in achieving Meaningful Use attestation, supporting improved quality, one of the purposes for enacting HITECH.

6. Sensitivity analysis – endogeneity

One potential concern in this research is that environmental (e.g., industry, competition), organizational (e.g., size, profitability, growth, risk), and technological factors might affect managerial allocation of resources related to IT (Kobelsky et al., 2008) resulting in endogenous hospital IT spending. A potential source of endogeneity is simultaneity, that is, managers' allocations of resources to IT may be determined by firms' demand for business process reengineering, which, in turn, is potentially related to operating

[6] The average net income is $17.6 million in sample data.
[7] The average net total revenue is $848 million in sample data.

Table 4
The association between IT investments and Meaningful Use Status (MU).

Variables	Meaningful Use status (*MU*)					
	0	1	2	0	1	2
Intercept		2.3001**	2.3714**		2.2858**	2.3655**
		(0.028)	(0.013)		(0.028)	(0.013)
operating_IT		**1.045***	**1.0191**			
		(0.084)	**(0.263)**			
capital_IT					**1.0851***	**1.0355**
					(0.079)	**(0.261)**
size		1.2230**	1.7966***		1.2253**	1.7979***
		(0.035)	(0.000)		(0.031)	(0.000)
teaching		0.3187***	0.4328***		0.3123***	0.1167***
		(0.000)	(0.002)		(0.000)	(0.002)
gov		1.147	0.3478		1.1445	1.2223
		(0.653)	(0.478)		(0.659)	(0.480)
prop		0.6213**	0.1776		0.6217**	0.8691
		(0.039)	(0.491)		(0.040)	(0.492)
urban		0.6368*	0.1289**		0.6398*	0.5799**
		(0.062)	(0.014)		(0.065)	(0.014)
Observations	3266	3266	3266	3266	3266	3266
Pseudo R-squared		0.0413			0.0413	

Notes: The Relative Risk Ratio (RRR) of coefficients is reported in the table.
*, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively, two-tailed (one-tailed for variables of interest). p-values are in parentheses.

Table 5
The association between IT expenses and intermediate business processes.

Variables	*EHR*	*EHR*	*BUR*	*BUR*
Intercept	1.2509***	1.2356***	0.3079***	0.3050***
	(0.000)	(0.000)	(0.000)	(0.000)
operating_IT	**0.2617****		**0.0041*****	
	(0.011)		**(0.000)**	
capital_IT		**0.5067*****		**0.0068*****
		(0.008)		**(0.000)**
MCI	0.6931*	0.6992*	− 0.0621***	− 0.0622***
	(0.084)	(0.084)	(0.002)	(0.002)
MedicareMix	2.5005***	2.4846***	0.0193	0.0189
	(0.000)	(0.000)	(0.179)	(0.190)
MedicaidMix	− 2.4023***	− 2.3973***	0.0709***	0.0704***
	(0.000)	(0.000)	(0.000)	(0.000)
uncomp	0.0668**	0.0669**	0.0005***	0.0005***
	(0.016)	(0.015)	(0.000)	(0.000)
size	0.4259***	0.4266***	0.0570***	0.0580***
	(0.000)	(0.000)	(0.000)	(0.000)
teaching	− 0.9823***	− 1.0209***	0.0222***	0.0220***
	(0.007)	(0.007)	(0.000)	(0.000)
gov	− 0.2805***	− 0.2838***	− 0.0254***	− 0.0257***
	(0.008)	(0.007)	(0.001)	(0.001)
prop	0.2630	0.2682	0.0040	0.0040
	(0.168)	(0.154)	(0.237)	(0.231)
urban	− 0.5691**	− 0.5507**	0.0364***	0.0368***
	(0.037)	(0.047)	(0.000)	(0.000)
Year	Yes	Yes	Yes	Yes
Observations	3265	3265	3265	3265
Pseudo R-squared	0.2080	0.2082		
Adjusted R-squared			0.440	0.440

Note: *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively, two-tailed. *p*-values are in parentheses. Standard errors are robust and clustered by years.

performance and process quality. We address this endogeneity issue by incorporating a two-stage least square (2SLS) approach using an instrumental variable derived following Armstrong et al. (2016).

The challenge in this approach is the selection of an instrument variable that is highly correlated with IT investments, but not related to financial performance. We identified the Hospital Consumer Assessment of Healthcare Providers and Systems (*HCAHPS*) survey as a suitable instrument variable, as *HCAHPS* is highly correlated with IT investment as shown in Table 8, but not related with *ROA* or *Q* because the HCAHPS rating does not contain cost, revenue, or profit factors, i.e., *HCAHPS* is endogenous in the models.

Table 6
Association between intermediate business processes and financial performance/productivity.

Variables	*Financial performance*		*Productivity*	
	ROA	*ROA*	*Q*	*Q*
Intercept	0.0615***	0.0299	0.2422***	0.3141***
	(0.007)	(0.142)	(0.000)	(0.000)
BUR	**0.1664*****		**0.5549*****	
	(0.002)		**(0.000)**	
EHR		**0.0858*****		**0.0903***
		(0.008)		**(0.082)**
MCI	0.0490***	0.0376***	0.0371**	0.0006
	(0.000)	(0.000)	(0.029)	(0.972)
MedicareMix	− 0.1524**	− 0.1548**	− 0.2408***	− 0.2291***
	(0.015)	(0.014)	(0.000)	(0.000)
MedicaidMix	− 0.2151***	− 0.1973***	− 0.7454***	− 0.6987***
	(0.001)	(0.001)	(0.000)	(0.000)
uncomp	− 0.0003***	− 0.0002**	0.0033***	0.0039***
	(0.001)	(0.048)	(0.000)	(0.000)
size	− 0.0006	0.0086***	0.1254***	0.1598***
	(0.872)	(0.005)	(0.000)	(0.000)
teaching	− 0.0272***	− 0.0189***	0.0403***	0.0654***
	(0.002)	(0.006)	(0.001)	(0.000)
gov	− 0.0060	− 0.0098*	− 0.0382***	− 0.0518***
	(0.174)	(0.055)	(0.005)	(0.003)
prop	0.0999***	0.1003***	− 0.1366***	− 0.1336***
	(0.000)	(0.000)	(0.000)	(0.000)
urban	− 0.0028	0.0041*	− 0.2826***	− 0.2620***
	(0.304)	(0.076)	(0.000)	(0.000)
Year fixed effects	Yes	Yes	Yes	Yes
Observations	3264	3265	3265	3266
Adjusted R-squared	0.070	0.061	0.162	0.151

Note: *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively, two-tailed. p-values are in parentheses. Standard errors are robust and clustered by years.

Table 7
Relationship between quality measures and meaningful use status.

Variables	Meaningful Use status (*MU*)					
	0	1	2	0	1	2
Intercept		1.9513*	2.3726***		0.2663***	0.2481***
		(0.058)	(0.007)		(0.007)	(0.001)
BUR		**0.5006**	**0.5937**			
		(0.266)	**(0.352)**			
EHR					**11.0606*****	**14.8518*****
					(0.000)	**(0.000)**
size		1.3939***	1.9129***		1.1911**	1.6517***
		(0.000)	(0.000)		(0.034)	(0.000)
teaching		0.4177***	0.4764***		0.4398***	0.1325***
		(0.003)	(0.003)		(0.006)	(0.009)
gov		1.1587	1.221		1.2857	0.4031
		(0.630)	(0.483)		(0.430)	(0.311)
prop		0.6162	0.8587		0.5961**	0.1785
		(0.036)	(0.456)		(0.031)	(0.398)
urban		0.674	0.1356**		0.7903	0.1637
		(0.107)	(0.024)		(0.345)	(0.138)
Observations	3265	3265	3265	3266	3266	3266
Pseudo R-squared		0.0403			0.0596	

Notes: The Relative Risk Ratio (RRR) of coefficients is reported in the table.
*, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively, two-tailed. p-values are in parentheses.

We created the instrument for IT investments using predicted values from the following first-stage 2SLS model,

$$\text{IT investments} = \alpha_0 + \alpha_1 \text{HCAHPS} + \sum \textit{Controls} + \textit{Year} + \varepsilon \tag{2}$$

The results of the first-stage regression are shown in Table 8. The coefficient estimates for *HCAHPS* are statistically significant, suggesting that the *HCAHPS* measures of quality are highly correlated with IT investments, and thus, *HCAHPS* represents a proper

Table 8
First-Stage determinants of IT Investments (using HCAHPS as the instrument variable).

Variables	*operating_IT*	*capital_IT*
Intercept	− 8.9820***	− 4.7890***
	(0.003)	(0.003)
HCAHPS	**0.3964*****	**0.2327*** **
	(0.007)	**(0.005)**
MCI	− 0.5968**	− 0.3523**
	(0.019)	(0.016)
MedicareMix	− 0.9886**	− 0.4464**
	(0.013)	(0.018)
MedicaidMix	− 1.5693**	− 0.9059**
	(0.012)	(0.011)
uncomp	0.1454***	0.0798***
	(0.001)	(0.001)
size	2.0822***	1.0826***
	(0.002)	(0.002)
teaching	5.0391***	3.0611***
	(0.000)	(0.000)
gov	− 0.3429**	− 0.1459*
	(0.037)	(0.060)
prop	0.3659***	0.1965***
	(0.009)	(0.010)
urban	− 0.2327**	− 0.1931***
	(0.017)	(0.007)
Year fixed effects	Yes	Yes
Observations	2891	2891
Adjusted R-squared	0.714	0.709

Notes: *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively, two-tailed. *p*-values are in parentheses. Standard errors are robust and clustered by years.

candidate for the instrument variable.

Subsequently, based on Eq. (2), we estimated the *predicted* IT investments and used them as the independent variable in the second-step of the 2SLS model. The equation for this model is specified as follows:

$$\text{Financial Performance} = \alpha_0 + \alpha_1 \text{ IT investments } (\textit{predicted}) + \sum \textit{Controls} + \textit{Year} + \varepsilon \tag{3}$$

The results of the second-stage regression are shown in Table 9 and indicate that IT investments are positively correlated with hospital financial performance, *ROA* and *Q*. Therefore, the 2SLS results are consistent with previous results. We limited our endogeneity test to H1 since IT investments in the financial performance model can be endogenous, but quality is not endogenous, i.e. better financial performance will not *directly* impact hospital quality.

7. Limitations

Our findings are subject to the following limitations. First, the Medicare/Medicaid Electronic Health Record Incentive Program provides incentive payments for eligible acute care hospitals that are meaningful users of certified EHR technology. Since 2011, eligible hospitals could receive annual incentive payments of up to $6.37 million, for a maximum of four years from the Centers for Medicare & Medicaid Services (CMS, 2013a, 2013b). During the same period, other federal, state, and non-profit organizations also provided incentive payments for EHR adoption (Wang et al., 2013). Hospitals have concluded that it is financially appropriate to present the incentive payments as “other revenue” (HFMA, 2011). These EHR incentive payments increase net income, thus, higher *ROA*. Our healthcare dataset does not contain incentive payment information. The CMS payment formula includes three factors - an initial amount, the Medicare/Medicaid share, and a transfer factor. Only the initial amount can be calculated from the current healthcare dataset. Therefore, we are unable to calculate incentive payments. It is possible that the positive and significant associations between HIT expenses and financial performance are influenced by these incentive payments, rather than an increase in financial performance due to HIT expenses.

Second, the healthcare dataset does not represent panel data, i.e., each hospital has only one observation. The data used in this research are best characterized as pooled data. A panel data representation of hospitals may provide a better analysis on the effect of HIT development.

8. Conclusion

This paper uses current pooled hospital data to examine whether HIT investments are associated with positive financial performance and productivity. The robust regression results show that HIT expenses, including *operating IT expense* and *capital IT expense*, are directly and positively associated with hospital *ROA* and productivity. In addition, we looked at the indirect relationship via

Table 9
Second-Stage regressions: IT investments on performance and productivity (using HCAHPS as the instrument variable).

Variables	*ROA*	*ROA*	*Q*	*Q*
Intercept	0.7425**	0.6724**	6.1275***	5.5778***
	(0.012)	(0.011)	(0.000)	(0.000)
***operating_IT* (predicted)**	**0.0851****		**0.6672*****	
	(0.028)		**(0.000)**	
***capital_IT* (predicted)**		**0.1449****		**1.1365*****
		(0.028)		**(0.000)**
MCI	0.0873***	0.0876***	0.3273***	0.3294***
	(0.002)	(0.002)	(0.005)	(0.005)
MedicareMix	− 0.1609	− 0.1803	0.3058***	0.1536***
	(0.213)	(0.170)	(0.002)	(0.008)
MedicaidMix	0.0006	− 0.0016	0.8089***	0.7914***
	(0.993)	(0.981)	(0.001)	(0.001)
uncomp	− 0.0124**	− 0.0116**	− 0.0917***	− 0.0854***
	(0.028)	(0.028)	(0.000)	(0.000)
size	− 0.1707**	− 0.1504**	− 1.2418***	− 1.0830***
	(0.028)	(0.028)	(0.000)	(0.000)
teaching	− 0.4523**	− 0.4673**	− 3.2670***	− 3.3841***
	(0.021)	(0.021)	(0.000)	(0.000)
gov	0.0113*	0.0033	0.1855***	0.1226***
	(0.051)	(0.138)	(0.000)	(0.001)
prop	0.0894**	0.0921**	− 0.2969***	− 0.2761***
	(0.023)	(0.020)	(0.001)	(0.001)
urban	0.0317***	0.0399***	− 0.0951**	− 0.0308
	(0.004)	(0.007)	(0.025)	(0.172)
Year fixed effects	Yes	Yes	Yes	Yes
Observations	2890	2890	2891	2891
Adjusted R-squared	0.095	0.095	0.214	0.214

Notes: *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 level, respectively, two-tailed. p-values are in parentheses. Standard errors are robust and clustered by years.

intermediate business process of EHR as well as quality measures related to *BUR*.

This study adds to our understanding of the associations between IT investment, financial performance, quality, and productivity. First, the empirical results provide evidence that HIT expenses have positive impacts to hospital financial performance. Based on the findings, practitioners can be more confident when investing in HIT. For hospitals without an EHR system, these findings may help hospital administrators decide on EHR adoption. Second, in addition to the capital investments in HIT, we illustrate that operating IT expense also generate some positive financial performance. For those hospitals already adopting EHRs, this finding encourages hospital administrators to continue investing in HIT to gain the benefits of associated with performance and productivity.

References

Alexander, J.A., Weiner, B.J., Griffith, J., 2006. Quality improvement and hospital financial performance. J. Organ. Behav. 27, 1003–1029.
Armstrong, C.S., Core, J.E., Guay, W.R., 2016. Do independent directors cause improvements in firm transparency? J. Financ. Econ. 113, 383–403.
Baker, J., Song, J., Jones, D.R., 2017. Closing the loop: empirical evidence for a positive feedback model of IT business value creation. J. Strateg. Inf. Syst. http://dx.doi.org/10.1016/j.jsis.2016.12.001.
Campanella, P., Lovato, E., Marone, C., Fallacara, L., Mancuso, A., Ricciardi, W., Specchia, M.L., 2016. The impact of electronic health records on healthcare quality: a systematic review and meta-analysis. Eur. J. Pub. Health 26 (1), 60–64.
Centers for Medicare & Medicaid Services (CMS), 2013a. EHR Incentive Program for Medicare Hospitals: Calculating Payments. Retrieved on 11/5/2016 from. https://www.cms.gov/regulations-and-guidance/legislation/ehrincentiveprograms/downloads/mln_tipsheet_medicarehospitals.pdf.
Centers for Medicare & Medicaid Services (CMS), 2013b. Medicaid Hospital Incentive Payments Calculations. Retrieved on 11/5/2016 from. https://www.cms.gov/regulations-and-guidance/legislation/ehrincentiveprograms/downloads/mln_tipsheet_medicaidhospitals.pdf.
Centers for Medicare & Medicaid Services (CMS), 2016. 2016 Program Requirements. Retrieved on 10/28/2016 from. https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/2016ProgramRequirements.html.
Chaudhry, B., Wang, J., Wu, S., Maglione, M., Mojica, W., ... Shekelle, P.G., 2006. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. Ann. Intern. Med. 144, 742–752.
Chiang, J.C., Wang, T.Y., Hsu, F.J., 2014. Factors impacting hospital financial performance in Taiwan following implementation of national health insurance. Int. Bus. Res. 7 (2), 43–52.
Christensen, M.C., Remler, D., 2009. Information and communications technology in U.S. health care: why is adoption so slow and is slower better? J. Health Polit. Policy Law 34 (6), 1011–1034.
Collum, T., Menachemi, N., Sen, B., 2016. Does electronic health record use improve hospital financial performance? Evidence from panel data. Health Care Manag. Rev. 41 (3), 267–274.
Dehning, B., Richardson, V.J., 2002. Returns on investment in information technology: a research synthesis. J. Inf. Syst. 16 (1), 7–30.
Devaraj, S., Kohli, R., 2000. Information technology payoff in the health-care industry: a longitudinal study. J. Manag. Inf. Syst. 16 (4), 41–67.
Devaraj, S., Kohli, R., 2003. Performance impacts of information technology: is actual usage the missing link? Manag. Sci. 49, 273–289.
Fichman, R., Kohli, R., Krishnan, R., 2011. Editorial overview – the role of information systems in healthcare: current research and future trends. Inf. Syst. Res. 22 (3), 419–428.
Gapenski, L., Vogel, W., Langland-Orban, B., 1993. The determinants of hospital profitability. Hosp. Health Serv. Ad. 38 (1), 63–80.
Ginn, G.O., Shen, J.J., Moseley, C.B., 2011. Hospital financial position and the adoption of electronic health records. J. Healthc. Manag. 56 (5), 337–350.

Goes, J.B., Zhan, C., 1995. The effects of hospital-physician integration strategies on hospital financial performance. Health Serv. Res. 30 (4), 507–530.
Grieger, D.L., Cohen, S.H., Krusch, D.A., 2007. A pilot study to document the return on investment for implementing an ambulatory electronic health record at an academic medical center. J. Am. Coll. Surg. 205 (1), 89–96.
Gunny, K., 2010. The relation between earnings management using real activities manipulation and future performance: evidence from meeting earnings benchmarks. Contemp. Account. Res. 27 (3), 855–888.
Harkey, J., Vraciu, R., 1992. Quality of health care and financial performance: is there a link? Health Care Manag. Rev. 4 (17), 55–63.
Healthcare Financial Management Association (HFMA), 2011. Medicare Incentive Payments for Meaningful Use of Electronic Health Records: Accounting and Reporting Developments. Retrieved on 11/5/2016 from. https://www.hfma.org/DownloadAsset.aspx?id=5187.
HealthIT.gov, 2015. Meaningful Use Definition & Objectives. Retrieved on 11/9/2017 from. https://www.healthit.gov/providers-professionals/meaningful-use-definition-objectives.
Henry, J., Pylypchuk, Y., Searcy, T., Patel, V., 2016. Adoption of electronic health record systems among U.S. non-Federal acute care hospitals: 2008–2015. In: ONC Data Brief. No. 35, May 2015, Retrieved on 10/29/2016 from. http://dashboard.healthit.gov/evaluations/data-briefs/non-federal-acute-care-hospital-ehr-adoption-2008-2015.php.
Holland, E., 2015. CMS Medicare and Medicaid Electronic Health Record (EHR) Incentive Programs Final Rule Overview. Retrieved on 11/9/2017 from. https://www.cms.gov/eHealth/downloads/Webinar_eHealth_October8_FinalRule.pdf.
Howley, M.J., Chou, E.Y., Hansen, N., Dalrymple, P.W., 2015. The long-term financial impact of electronic health record implementation. J. Am. Med. Inform. Assoc. 22 (2), 443–452.
Kazley, A.S., Ozcan, Y.A., 2007. Organizational and environmental determinants of hospital EMR adoption: a national study. J. Med. Syst. 31 (5), 375–384.
Kobelsky, K.W., Richardson, V.J., Smith, R.E., Zmud, R.W., 2008. Determinants and consequences of firm information technology budgets. Account. Rev. 83 (4), 957–995.
Kohli, R., Tan, S.S., 2016. Electronic health records: how can IS researchers contribute to transforming healthcare? MIS Q. 40 (3), 553–573.
Lee, S., Kim, S.H., 2006. A lag effect of IT investment on firm performance. Inf. Resour. Manag. J. 19 (1), 43–69.
Li, L., Collier, D., 2000. The role of technology and quality on hospital financial performance: an exploratory analysis. Int. J. Serv. Ind. Manag. 11 (3), 202–224.
McCullough, J.S., Casey, M., Moscovice, I., Prasad, S., 2010. The effect of health information technology on quality in US hospitals. Health Aff. 29 (4), 647–654.
McLeod, A., Carpenter, D., Clark, J.G., 2008. Measuring success in interorganizational information systems: a case study. Commun. Assoc. Inf. Syst. 34 (22) (June).
Mello, M., Chandra, A., Gawanda, A., Studdert, D., 2010. National costs of the medical liability system. Health Aff. 29 (9), 1569–1577.
Melville, N., Kraemer, K., Gurbaxani, V., 2004. Review: information technology and organizational performance: an integrative model of IT business value. MIS Q. 28 (2), 283–322.
Menachemi, N., Burkhardt, J., Shewchuk, R., Burke, D., Brooks, R.G., 2006. Hospital information technology and positive financial performance: a different approach to finding an ROI. J. Health Care Manag. 51 (1), 40–58.
Menon, N.M., Byungtae, L., Eldenburg, L., 2000. Productivity of information systems in the healthcare industry. MIS Q. 11 (1), 83–92.
Molinari, C., Alexander, J., Morlock, L., Lyles, C.A., 1995. Does the hospital board need a doctor? The influence of physician board participation on hospital financial performance. Med. Care 33 (2), 170–185.
Nguyen, O.K., Halm, E.A., Makam, A.N., 2016. Relationship between hospital financial performance and publicly reported outcomes. J. Hosp. Med. 11 (7), 481–488.
Richter, J.P., Muhlestein, D.B., 2017. Patient experience and hospital profitability: is there a link? Health Care Manag. Rev. 42, 247–257 (April 5, 2016).
Shen, J.J., Ginn, G.O., 2012. Financial position and adoption of electronic health records: a retrospective longitudinal study. J. Health Care Finance 38, 61.
Smith, R., Coustasse, A., 2014. The HITECH act and financial challenges of health information technologies in the United States with bottom up approach. Insights Chang. World 2, 39–53.
Venkatesh, V., Zhang, X., Sykes, T.A., 2011. Doctors do too little technology: a longitudinal field study of an electronic healthcare system implementation. Inf. Syst. Res. 22 (3), 523–546.
Venkatraman, N., 1994. IT-enabled business transformation: form automation to business scope redefinition. Sloan Manag. Rev. 35 (2), 73.
Wang, T., Biedermann, S., 2010. Running the numbers on an EHR: applying cost-benefit analysis in EHR adoption. J. AHIMA 81 (8), 32–36.
Wang, T., Biederman, S., 2012. Enhance the accuracy of medication histories for the elderly by using an electronic medication checklist, Perspectives in Health Information Management/AHIMA, American Health Information Management Association. 9.
Wang, S.J., Middleton, B., Prosser, L.A., Bardon, C.G., Spurr, C.D., Carchidi, P.J., ... Bates, D.W., 2003. A cost-benefit analysis of electronic medical records in primary care. Am. J. Med. 114 (5), 397–403.
Wang, B.B., Wan, T.H., Burke, D.E., Bazzoli, G.J., Lin, B., 2005. Factor influencing health information system adoption in American hospitals. Health Care Manag. Rev. 30 (1), 44–51.
Wang, T., Wang, Y., Biedermann, S., 2013. Funding alternatives in EHR adoption: beyond HITECH incentives and traditional approaches. Healthc. Financ. Manage. 67 (5), 86–91.
Wang, T., Wang, Y., Moczygemba, J., 2015. Budget management in an EHR implementation project. Healthc. Financ. Manage. 11, 1–6.
Watkins, A.L., 2000. Hospital financial ratio classification patterns revisited: upon considering nonfinancial information. J. Account. Public Policy 19, 73–95.
Yasnoff, W.A., Humphreys, B.L., Overhage, J.M., Detmer, D.M., Brennan, P.F., Morris, R.W., Middleton, B., Bates, D.W., Fanning, J.P., 2004. A consensus action agenda for achieving the national health information infrastructure. J. Am. Med. Inform. Assoc. 11 (4), 332–338.