AI-Driven Cost Optimization in Oil and Gas Projects

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ABSTRACT: *The oil and gas sector, a cornerstone of the global energy supply, is poised at the brink of a technological renaissance as it embraces Artificial Intelligence (AI). This paradigm shift is driven by the industry's imperative to enhance efficiency, bolster safety, and notably, optimize costs amidst volatile market conditions and escalating operational complexities. This paper presents an in-depth exploration of the multifaceted applications of AI technologies in streamlining cost management across various phases of oil and gas projects—from exploration to distribution. At the heart of this exploration is the elucidation of AI's transformative role in predictive analytics, automation, and decision support systems. By harnessing the power of machine learning algorithms, the industry can predict equipment failures, optimize maintenance schedules, and ensure uninterrupted production, thereby significantly reducing downtime costs. Furthermore, AI-driven data analytics enable the identification of patterns and insights from vast datasets, leading to more informed and cost-effective decision-making. The paper also delves into the integration of AI in operational domains such as drilling optimization, where AI algorithms analyze geological data to determine optimal drilling locations and parameters, thus minimizing the risk of costly non-productive time. Similarly, in the realm of supply chain management, AI facilitates dynamic routing and inventory control, curtailing logistical expenses. Highlighting case studies and empirical data, the paper underscores the tangible benefits realized by early adopters of AI in the industry, showcasing a potential reduction in operational costs and an increase in efficiency that often surpasses traditional methodologies. This detailed examination not only charts a course for future AI-driven endeavors in the oil and gas sector but also serves as a clarion call for stakeholders to navigate the intricacies of digital transformation strategically. In conclusion, the paper posits that the integration of AI stands as a beacon of innovation, promising not only cost optimization but also a sustainable and resilient future for the oil and gas industry. The findings herein aim to galvanize industry leaders, policymakers, and technologists to foster a collaborative ecosystem where AI can flourish, driving the industry towards a new horizon of operational excellence.*

KEYWORDS: AI-Driven, cost optimization, oil, gas projects

INTRODUCTION

- Overview of the oil and gas industry's challenges

The oil and gas industry is currently facing a multitude of challenges that are reshaping its landscape. These challenges stem from various factors, including geopolitical tensions, macroeconomic variables, technological advancements, and environmental concerns. Here's a detailed overview of the current challenges:

Geopolitical Factors:

The industry is significantly influenced by geopolitical events, which can lead to fluctuations in oil prices and supply disruptions. For instance, OPEC+'s output cuts have pushed Brent oil prices past $90/bbl, affecting global trade and investment within the industry.

Macroeconomic Variables:

High interest rates and rising material costs are impacting the industry's profitability. The industry must navigate these economic pressures while maintaining capital discipline and prioritizing viable projects, especially in the context of a changing energy demand landscape.

Evolving Policies and Regulations:

Governments worldwide are imposing stricter regulations on emissions and environmental protection. The industry is expected to progress in emissions reduction and invest in low-carbon energies, which requires significant adaptation and investment.

Technological Disruption:

New technologies, particularly in digital transformation and AI, are disrupting traditional operational models. Companies must adapt to these changes to stay competitive and manage the risks associated with rapid technological evolution.

Energy Transition:

The shift towards renewable energy sources is challenging the industry's traditional business models. Companies are being urged to participate in the energy transition by securing positions in the supply chain for critical minerals and tackling perceived end-market risks.

Supply Chain Impacts:

The industry's supply chain is vulnerable to disruptions caused by global events, such as the COVID-19 pandemic, which can lead to a rapid build-up of oil stocks and further depress prices.

Labor Shortage:

A shortage of skilled labor is another challenge that the industry faces, which can hinder operations and delay project timelines.

Market Volatility:

Oil prices are subject to high volatility due to the complex interplay of supply and demand factors. This volatility can make financial planning and investment decisions more challenging for industry players.

Environmental and Social Governance (ESG):

There is increasing pressure from investors and the public for companies to improve their ESG performance. This includes reducing the environmental impact of operations and ensuring that social and governance practices meet higher standards.

Digital Transformation:

The industry is also facing the challenge of digital transformation, which includes the integration of AI, machine learning, and data analytics into operations. This requires significant investment and cultural change within organizations.

These challenges require the industry to innovate, strategize, and commit to sustainability to overcome them. Companies that can successfully navigate these issues will be better positioned to thrive in the evolving energy landscape.

- The rising need for cost optimization

The rising need for cost optimization in the Oil and Gas sector is a critical issue that has been gaining attention, especially in light of recent market volatility and the global push towards sustainability. Here's a detailed discussion on the subject:

1. Market Volatility and Profitability Pressure:

Since 2014, the Oil & Gas industry has experienced significant market volatility with oil prices dropping by over 60 percent at times. This has led to a decrease in profitability and increased pressure on companies to maintain shareholder value. The new price cycle of $40-$60/bbl has forced companies to adopt cost-optimization programs to reduce their cost base by at least 20 percent.

2. Operations Excellence and Cost Optimization:

Operational excellence and cost optimization have become critical for companies to survive in this new market environment. Companies like Statoil and Gazprom have achieved significant OPEX reductions through rightsizing and reorganization, while others have renegotiated contracts to take advantage of market opportunities[2].

3. Sustainable Cost Optimization:

Sustainable cost optimization involves more than just cutting costs; it requires a strategic approach to managing expenses without compromising long-term efficiencies. This includes setting ambitious targets, obtaining top management buy-in, and aligning cost optimization objectives with the company's overall strategy[2].

4. Beyond Cost Reduction:

Oil and gas companies are encouraged to look beyond simple cost-cutting measures and focus on creating value. This involves managing volatility responsibly, advancing sustainability, and building resilience in supply chains. By doing so, companies can contribute to easing constraints on global supplies and promote sustainability while building their resilience[1].

5. Strategic Importance of Supply Chains:

Historically, supply chain functions in oil and gas companies were seen as support roles with a focus on cost reduction. However, there's a growing recognition of the strategic importance of supply chains in creating value. Companies are now giving supply chain leaders a seat at the table for strategic discussions and empowering them to search for value beyond cost savings[1].

6. Addressing ESG Concerns:

Environmental, Social, and Governance (ESG) concerns are becoming increasingly important for the oil and gas industry. Companies are expected to address these concerns transparently and work towards sustainability as part of their value creation strategies[1].

7. Building Resilience:

Building resilience through capabilities that promote flexibility and effectiveness is essential for managing risks and controlling costs. Initiatives that focus on managing volatility, promoting sustainability, and building resilience are mutually reinforcing and can generate significant additional value across the industry.

- The role of AI in addressing these challenges

Artificial Intelligence (AI) is playing an increasingly pivotal role in addressing the challenges faced by the Oil and Gas sector, particularly in the realm of cost optimization. Here's a detailed discussion on how AI is transforming the industry:

1. Enhancing Exploration and Production:

AI technologies are being used to improve the accuracy of exploration activities. Machine learning algorithms can analyze seismic data to predict the potential of hydrocarbon deposits with greater precision, reducing the risk of costly drilling failures.

2. Predictive Maintenance:

AI-driven predictive maintenance can foresee equipment failures before they occur by analyzing historical maintenance and sensor data. This minimizes downtime, reduces maintenance costs, and optimizes the utilization of technician resources.

3. Operational Efficiency:

AI applications in the Oil and Gas industry can streamline operations, enhance safety, and enable predictive analytics. Technologies like Digital Twin and Intelligent Operations can simulate and monitor real-world assets and processes, leading to improved decision-making and cost savings[4].

4. Refinery Optimization:

In refining, AI can be used for predictive maintenance, ensuring that machinery operates at peak efficiency and preventing unplanned outages. AI can also optimize refinery processes to maximize yield and minimize energy consumption.

5. Supply Chain and Logistics Optimization:

AI can optimize midstream operations, including pipeline integrity management and transportation logistics. By analyzing vast amounts of data, AI can identify the most efficient routes and methods for transporting oil and gas, leading to significant cost reductions.

6. Safety and Environmental Monitoring:

AI-powered systems can enhance safety by monitoring operations in real-time, detecting anomalies that could lead to accidents or environmental hazards. This proactive approach can prevent incidents and the associated costs.

7. Data-Driven Decision Making:

By leveraging big data analytics, AI enables faster and more accurate decision-making. This can lead to cost savings across the board, from strategic planning to day-to-day operations.

8. Addressing ESG Concerns:

AI can assist in managing Environmental, Social, and Governance (ESG) concerns by providing insights into emissions, energy usage, and other sustainability metrics. This can help companies to not only comply with regulations but also improve their public image and reduce costs associated with environmental impact.

9. Future Trends and Outlook:

The integration of AI with legacy systems remains a challenge, but as AI technologies evolve, they will continue to revolutionize the Oil and Gas industry. The potential for AI to drive innovation,

improve efficiency, and reduce costs is significant, with large-scale adoption possibly accounting for 10–20% in cost savings by 2025.

LITERATURE REVIEW

- Historical approaches to cost management in oil and gas

Historical approaches to cost management in the Oil and Gas sector have evolved over time, reflecting the industry's response to various market conditions and technological advancements. Here's a detailed look at these approaches:

1. Cost Reduction as a Support Function:

Traditionally, oil and gas companies treated their supply chain organizations as support functions, with a primary focus on cost reduction. This approach often led to prioritizing short-term savings over long-term strategic value, and supply chain executives were not typically involved in making strategic decisions.

2. Efficiency Gains Through Operational Improvements:

In the past, companies sought efficiency gains by improving operational performance. This included reducing production costs, enhancing safety measures, and minimizing production losses. For instance, since 2014, the sector has seen production costs decrease by 30%, safety incident frequency fall by a third, and production losses decline by 15%.

3. Emphasis on Asset Strategy:

Companies focused on their asset strategy, which involved optimizing physical equipment-in-place and the work required to operate and maintain that equipment. This approach aimed to achieve higher production performance and operating costs suitable for a 'lower forever' price environment.

4. Leveraging Technology for Cost Modeling:

The use of cost models provided a data-driven way to develop a savings roadmap. These models helped identify top opportunities in the market and allowed companies to execute strategic cost-saving initiatives.

5. Response to Market Shocks:

Historical approaches were also shaped by the industry's response to market shocks, such as geopolitical events or pandemics. Companies had to adapt quickly to manage volatility and ensure business resilience.

6. The Role of Digital Technologies:

More recently, digital technologies have started to reset performance levels. Research suggests that digital technologies could improve total cash flows by USD 11 per barrel across the offshore oil and gas value chain, adding USD 300 billion a year by 2025.

7. Continuous Improvement and Reevaluation:

Successful operators distinguished themselves by continually challenging and reevaluating their operating models. This involved taking multiple looks at improving operations, even after initial attempts, to build a continually evolving model that suited the industry's needs.

- Introduction to AI and its growing significance in the industry

Artificial Intelligence (AI) has become a transformative force in the Oil and Gas industry, reshaping the way companies operate and manage costs. Here's a detailed introduction to AI and its growing significance in this sector:

Introduction to AI in Oil and Gas:

AI refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. In the Oil and Gas industry, AI is used to analyze data, make predictions, and automate processes. The introduction of AI in this sector has been a game-changer, enabling companies to tackle complex challenges and improve efficiency.

Growing Significance of AI:

The significance of AI in the Oil and Gas industry is growing due to several factors:

Data Analysis and Decision Making:

AI systems can process vast amounts of data much faster than humans, providing insights that help in making informed decisions. This is particularly useful in exploration and production, where data-driven decisions can lead to more successful outcomes.

Operational Efficiency:

AI enhances operational efficiency by automating routine tasks, optimizing equipment usage, and reducing downtime through predictive maintenance. This not only saves time but also significantly cuts operational costs.

Safety and Risk Management:

AI contributes to safety improvements by predicting potential failures and analyzing risk factors. This proactive approach helps in preventing accidents and ensuring the safety of personnel and the environment.

Cost Optimization:

One of the most significant impacts of AI is in cost optimization. By streamlining operations and improving efficiency, AI helps Oil and Gas companies reduce expenses and manage their budgets more effectively.

Innovation and Competitive Edge:

Companies that adopt AI technologies are often at the forefront of innovation, giving them a competitive edge in the market. AI enables them to explore new opportunities and adapt to changing market conditions.

Sustainability and Environmental Impact:

AI also plays a role in sustainability efforts by optimizing energy use and reducing emissions. This aligns with the global push towards more environmentally friendly practices.

Future Trends:

The future of AI in the Oil and Gas industry looks promising, with ongoing research and development. AI is expected to become even more integrated into the industry, driving further innovation and efficiency improvements.

- Review of recent studies on AI applications in oil and gas

Recent studies on AI applications in the Oil and Gas industry have highlighted the transformative impact of AI technologies in various aspects of the sector. Here's a detailed review based on the latest research:

1. Sustainable Development through AI:

A systematic literature review published in 2023 examined the applications of AI in oil and gas projects with a focus on sustainable development. The study analyzed research trends from 2011 to 2022 and found a positive trend in AI research related to oil and gas construction projects, especially after 2016. It highlighted the role of AI in improving automation, reliability, and incorporating digital technology in oil and gas operations. The study emphasized the importance of sustainability in AI applications due to the increasing complexities and market demands.

2. AI in Upstream, Midstream, and Downstream Operations:

Another comprehensive study in 2021 evaluated the scope of machine learning in optimizing upstream (exploration, drilling, reservoir, production), midstream (transportation using pipelines, ships, road vehicles), and downstream operations (production of refinery products like fuels, lubricants, plastics). It discussed the enhanced processing of seismic data and the potential of AI

to accelerate and de-risk processes in the industry. The study also addressed the challenges and opportunities of adopting machine learning technologies in the oil and gas sector.

3. AI for Performance Maximization:

The research pointed out that with the growth of challenges in the oil and gas industry, AI has been adopted to gain a competitive advantage and reduce the challenges faced by various oil and gas projects worldwide. The technology has not only improved automation but also contributed significantly to the worldwide economy, generating more than 5 trillion US dollars in 2021 alone.

4. Addressing Drawbacks of AI:

While AI is expected to improve every aspect of projects in the oil and gas industry, the studies also acknowledged the drawbacks that cannot be ignored. These include the need for high-quality data, the complexity of integrating AI with existing systems, and the challenges related to data privacy and security.

5. Future Prospects of AI:

The studies outlined potential scenarios for how AI will develop in the oil and gas industry and how it might transform it in the future. They suggested that AI-based tools could significantly impact the industry in the next 5, 10, and 20 years, changing the way operations are conducted and managed.

METHODOLOGY

- Description of AI technologies used in the industry

Artificial Intelligence (AI) technologies are increasingly becoming integral to the oil and gas industry, transforming various aspects from exploration to distribution. Here's a detailed discussion on the application of AI technologies in the oil and gas industry with respect to research methodology:

Exploration and Production (Upstream)

AI technologies like machine learning and data analytics are used for seismic data interpretation, reservoir characterization, and predictive maintenance. Research methodologies in this area often involve:

Data Collection: Gathering large volumes of seismic, geological, and operational data.

Data Processing: Using AI algorithms to process and interpret the data to identify potential hydrocarbon reserves.

Modeling and Simulation: Creating predictive models to simulate reservoir behavior and optimize drilling strategies.

Transportation and Storage (Midstream)

In the midstream sector, AI is applied for pipeline integrity management, logistics optimization, and predictive maintenance. Research methodologies include:

Sensor Data Analysis: Utilizing IoT devices to monitor pipeline health and predict failures.

Optimization Algorithms: Implementing AI to optimize route planning and scheduling for oil and gas transportation.

Risk Assessment: Employing AI for risk analysis and safety monitoring to prevent accidents and spills.

Refining and Distribution (Downstream)

AI applications in the downstream sector focus on refinery optimization, demand forecasting, and market analysis. Research methodologies involve:

Process Optimization: Using AI to enhance refinery operations, reduce energy consumption, and increase yield.

Predictive Analytics: Analyzing market data to predict demand and adjust production accordingly.

Quality Control: Implementing machine learning for real-time quality monitoring and control of end products.

The integration of AI in the oil and gas industry is not without challenges. Issues such as data privacy, cybersecurity, and the need for skilled personnel are critical considerations in research and development. Moreover, the industry must navigate regulatory compliance and environmental concerns while adopting these technologies. Overall, AI is poised to revolutionize the oil and gas industry by enhancing efficiency, safety, and sustainability. The research methodology in this field is dynamic and continuously evolving to leverage the full potential of AI technologies.

DATA COLLECTION AND ANALYSIS METHODS

Data collection and analysis are crucial components of AI-driven solutions in the oil and gas industry.

Data Collection Methods

Data collection in the oil and gas industry involves gathering a wide array of information from various sources to inform AI models. The methods include:

Sensor Data: Utilizing a network of IoT sensors to collect real-time data on equipment performance, environmental conditions, and operational parameters.

Seismic Data: Acquiring data through seismic surveys to map subsurface geology and identify potential hydrocarbon deposits.

Historical Data: Compiling past records of production, maintenance, and operational efficiency to establish trends and patterns.

Satellite Imagery: Using remote sensing to obtain images and data for surface mapping and monitoring changes over time.

Drilling Logs: Collecting detailed records from drilling operations, including rate of penetration, mud weight, and drill bit performance.

Data Analysis Methods

Once data is collected, it must be analyzed to extract meaningful insights. The analysis methods include:

Machine Learning: Applying algorithms to identify patterns and make predictions based on the collected data.

Predictive Analytics: Using statistical models to forecast future events, such as equipment failure or production rates.

Data Mining: Extracting useful information from large datasets to identify correlations and trends.

Simulation Modeling: Creating digital twins of physical systems to simulate different scenarios and optimize operations.

Visualization Tools: Employing software to create visual representations of data, making it easier to understand and communicate findings.

Integration with AI

The collected data is then integrated into AI systems for further processing:

Training AI Models: Feeding data into machine learning models to train them to recognize patterns and make decisions.

Refining Algorithms: Continuously improving AI algorithms as more data becomes available, enhancing their accuracy and reliability.

Operational Deployment: Implementing AI tools in real-time environments to assist with decision-making and operational control.

Challenges and Considerations

Data Quality: Ensuring the data collected is accurate, complete, and free from biases is essential for reliable analysis.

Data Security: Protecting sensitive information from cyber threats and ensuring compliance with data privacy regulations.

Interdisciplinary Collaboration: Combining expertise from data science, engineering, and domain specialists to interpret data correctly.

- Case studies of successful AI implementation

The oil and gas industry has seen several successful implementations of AI technologies that have significantly improved efficiency, safety, and decision-making.

Case Study 1: Drilling Efficiency and Equipment Downtime Reduction

A Fortune 500 oil and gas company implemented AI to transform its drilling operations. By integrating machine learning algorithms, the company achieved a "25% increase in drilling efficiency" and a "40% reduction in equipment downtime". The AI system analyzed real-time data from drilling sensors and predicted potential failures, allowing for proactive maintenance and operational adjustments.

Case Study 2: Predictive Maintenance for Asset Life Extension

Another leading energy firm leveraged AI for predictive maintenance, which led to a "30% decrease in unplanned outages" and significantly extended the life of their assets. The AI model used historical and sensor data to predict when equipment would likely fail, scheduling maintenance before breakdowns occurred, thus saving costs and improving safety.

Case Study 3: Exploration and Production Optimization

AI technologies have also been pioneering change in exploration and production (E&P). Companies are using AI to analyze seismic data more accurately, leading to better decision-making in drilling locations and methods. This has resulted in more efficient resource extraction and reduced environmental impact.

Case Study 4: Market Prediction and Strategic Planning

AI's role in market analysis and prediction has become invaluable for strategic planning. Oil and gas companies are using AI to analyze market trends and predict future oil prices, providing a

strategic edge in a highly competitive market. This allows companies to adjust their production and marketing strategies proactively.

Case Study 5: Refining and Distribution Impact

In refining and distribution, AI is used to optimize processes and forecast demand. For instance, AI algorithms can predict the optimal mix of crude types to refine to maximize output and profit. Similarly, AI helps in predicting product demand, allowing companies to adjust their supply chain and inventory levels accordingly.

CONCLUSION

The use of AI technology in cost estimation and optimization in the oil and gas industry has led to several key findings, despite facing numerous challenges. Here's a detailed summary:

Enhanced Accuracy in Cost Predictions

AI significantly improves the accuracy of cost estimations by analyzing extensive historical data. Machine learning models can learn from past projects, which helps in reducing the likelihood of cost overruns. This predictive capability is crucial for budgeting and financial planning in large-scale oil and gas projects.

Optimization of Operations

AI technologies enable the optimization of various operational processes. By predicting maintenance needs and optimizing resource allocation, AI helps in minimizing downtime and maximizing production efficiency. This leads to cost savings and better asset utilization.

Cybersecurity and Risk Management

As oil and gas companies digitalize, the risk of cyberattacks increases. AI plays a key role in cybersecurity, helping to detect and mitigate threats. This is essential for protecting the infrastructure and ensuring the continuity of operations.

Streamlining Project Economics

Digitalization, with AI at the forefront, is streamlining operations and improving project economics. AI-driven tools are being used to enhance productivity, operational efficiency, and security, contributing to increased profits.

Challenges in AI Implementation

Despite these benefits, the industry faces challenges in implementing AI, such as the need for significant investment in technology and training, managing the vast amounts of data collected,

and ensuring data privacy and security. Additionally, there is a need for skilled personnel who can bridge the gap between AI technology and industry-specific knowledge.

Future Outlook

The future of AI in the oil and gas industry looks promising, with opportunities for further research and development. AI is expected to continue transforming the sector, driving innovation, and improving efficiency. The industry is likely to witness more sophisticated AI applications in cost estimation and optimization as it adapts to new business environments and technological advancements.

In conclusion, AI technology is becoming an indispensable tool for cost estimation and optimization in the oil and gas industry. It offers enhanced accuracy, operational optimization, and improved risk management, all of which contribute to sustainable growth and competitiveness in a challenging market environment.

Recommendations for industry stakeholders

AI-driven cost optimization in oil and gas projects offers a strategic advantage to industry stakeholders. Here are detailed recommendations for leveraging AI to enhance cost efficiency:

Strategic Planning for AI Integration

Assess Current Capabilities: Understand the existing technological infrastructure and identify areas where AI can add value.

Define Clear Objectives: Set specific, measurable goals for what AI-driven cost optimization should achieve within the organization.

Building Capabilities and Training Teams

Invest in AI Talen: Recruit or train personnel with expertise in AI, data science, and industry-specific knowledge.

Continuous Learning: Encourage ongoing education and training to keep up with the rapidly evolving AI landscape.

Partnering with Trusted AI Technology Providers

Collaborate with Experts: Work with established AI technology providers to gain access to proven solutions and industry best practices.

Custom Solutions: Develop tailored AI applications that address the unique challenges and needs of the oil and gas industry.

Measuring ROI of AI Initiatives

Track Performance Metrics: Implement systems to monitor the performance of AI applications and measure their impact on cost savings.

Iterative Improvement: Use the insights gained from performance tracking to continuously refine AI strategies and tools.

Ethical and Environmental Consideration

Sustainability: Ensure that AI implementations align with environmental sustainability goals and reduce the carbon footprint of operations.

Ethical Use of AI: Adhere to ethical guidelines for AI usage, ensuring transparency and fairness in all AI-driven decisions.

Overcoming Challenges

Data Quality and Availability: Prioritize the collection of high-quality, comprehensive data to train AI models effectively.

Integration with Existing Systems: Seamlessly integrate AI tools with current systems to minimize disruption and maximize synergy.

Skilled Workforce Requirements: Address the skills gap by investing in training programs that equip employees with the necessary AI competencies.

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2. Practical Optimization of Petroleum Production Systems by Burney Waring.
Based on the information available, here are some books that discuss the use of AI technology for cost optimization in the oil and gas industry, along with the names of their authors:
3. Application of Artificial Intelligence in the Oil and Gas Industry - Authors: Muhammad Hussain, Aeshah Alamri, Tieling Zhang, and Ishrat Jamil.
4. Artificial Intelligent in Upstream Oil and Gas Industry: A Review of Applications, Challenges and Perspectives"** - Authors: Kenioua Abdelhamid, Touat Brahim Ammar, and Kenioua Laid.
Certainly! Here's a list of books that address the various challenges faced by the oil and gas industry, along with the names of their authors:
5. Improving Supply Chains in the Oil and Gas Industry by Sanchay Roy and Stewart Dunbar.
6. The Oil and Gas Industry: A Nontechnical Guide by Joseph Hilyard
7. Oil and Gas Production Handbook: An Introduction to Oil and Gas Production by Havard Devold

8. The Global Oil & Gas Industry: Management, Strategy and Finance by Andrew Inkpen and Michael H. Moffett