

Team Glyndwr

L7 Intro to Innovation ACPA7005

A case of Amazon: Innovation through Robotics

As a group, the focus of our study is the use of Robotics within fulfilment centres, at Amazon.
The period of focus is from 2012 through to 2022 and how the move to a higher use of robotics has transformed the business to the market leader within the online shopping arena.

23/11/22

Assessment Content and Brief

Categorise the innovation developments which have taken place in terms of Greg Satell's typology and analyse them in relation to:

1. The extent to which they have shifted the chosen company's market position.
2. The extent to which they have influenced the company's internal structures and management processes.
3. The extent to which they have been technology dependent - and if so which technologies.
4. A consideration as to the outcome of the innovation.

Shifting the Market Position

Callum Cox - 2220983

Amazon was already ahead

- Amazon has always been a market leading platform within its own market
- Amazon evolved its business model from an online business to an online marketplace (Aversa, P., 2021)
- In Amazon's 2011 annual report, they described themselves as market leaders (Amazon, 2011)
- Amazon prime was a catalyst for the whole business
- This drove the expansion of 13 fulfilment centers in 2009 to 109 in 2014 (Amazon, 2014)

“Even before the existence of its online marketplace, Amazon has shown its market leading potential by dominating the online bookshop business.

As the capabilities of the internet evolved, so did Amazon and it's through the development of the business, and the various models it expanded into, that allowed it to maintain this market dominance.

Amazon have been self proclaiming themselves as market leaders since before a significant portion of their growth had even taken place. 2011

A huge catalyst for all areas of the company has been their subscription base premium membership “Amazon prime”.

Amazon Prime being so successful has driven the expansion of 13 to 109 fulfillment centres from 2009 to 2014.”

Amazon's evolution

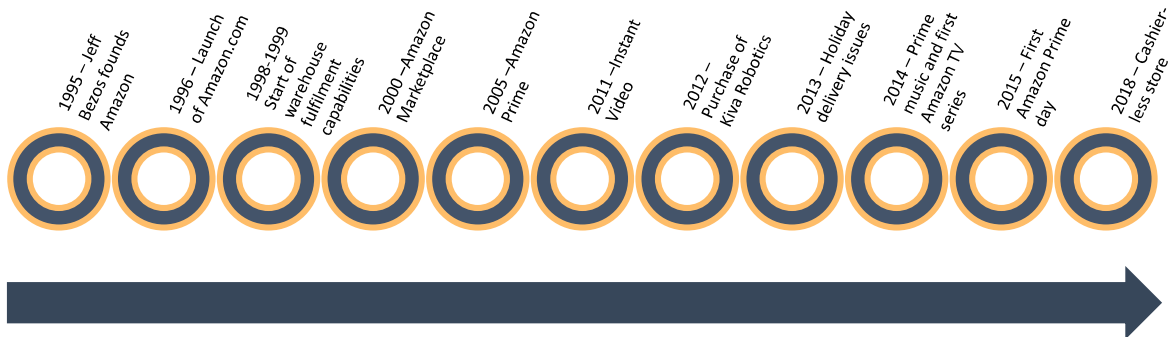


Figure: Amazon's Growth timeline (Aversa, P., 2021, Jain, D., Sharma, Y. 2017)

"Amazon as a business has evolved drastically since it's founding in 1995.

A key event that we would like to focus on begins with the purchase of Kiva Robotics and then the 2013 Christmas period, where the company struggled to deliver a significant amount of Christmas deliveries due to warehouse issues"

Innovation in the Warehouse

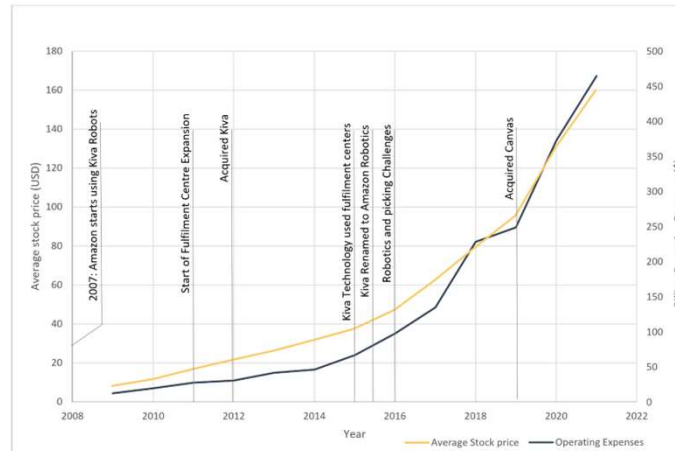


Figure: Stock price and operating costs since 2009, featuring innovation timeline.

Source: (MarketLine 2022; Girija, P. et al, 2021; Wurman, P.R. and Romano, J.M. 2016; Aversa, P., 2021; Gonzalez, C., 2017; MacroTrends, 2022)

“Here is the same graph but this time with some key automation innovation pushes that Amazon has made over the past 10 Years.

These innovations have all assisted in some way the development of the fulfilment centres and their efficiency”

Innovation in the Warehouse

Problem Definition	Well Defined	Break through Innovation Purchase of Kiva	Sustaining Innovation Amazon Picking Challenge
	Not Well Defined	Basic Research Amazon Challenge awards	Disruptive Innovation Canvas Technology
		Not Well Defined	Well Defined
		Domain Definition	

(Satell, 2017)

“So placing these innovations into the Satell matrix we can note that they are looking to all 4 types of innovation defined by Satell.”

How amazon grabbed the opportunity

- Warehouse technology and expansion was further invested in as a reaction to the forecasted growth (MWPVL, 2022)
- The use of automation and robotics has allowed for fulfillment centre expansion which was rocketed with the purchase of Kiva in 2012 (Amazon, 2014; Amazon, 2011)
- Kiva is rebranded to “Amazon Robotics” in 2014 (Gonzalez, C., 2017), prevented previous customers from using Kiva tech (LeCavalier, J. 2019)
- Kiva was fully implemented by 2014 and is estimated to have cut click-to-ship times from 60-90mins to 15mins (Bogue, R. 2016)

“Warehouse expansion in both technology, staffing and magnitude was significant for Amazon and this development was boosted once interest in automation was honed with the purchase of Kiva in 2012.

With this Amazon eventually rebranded Kiva to “Amazon Robotics” and limited the sales to existing customers.

Kiva technology has been a great addition to the warehouse cutting click-to-ship times from 60-90mins to 15mins”

Was this move successful?

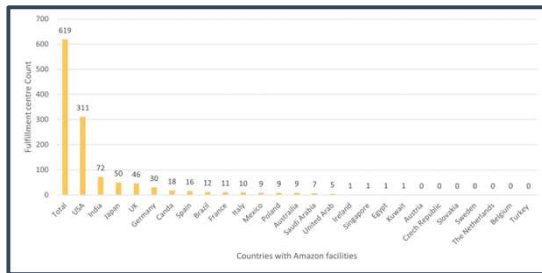


Figure: Current number of Fulfilment Centres (MWPVL, 2022)

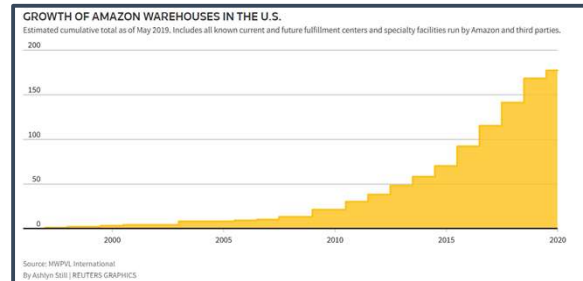


Figure: Cumulative warehouse numbers in the US since 1995 (MWPVL, 2022)

“Since 2009 Amazon has developed:

619 Total fulfilment centres

And experienced:

A 3470% increase in annual gross profit

A 130% increase in annual average stock price

A 6517% increase in annual employee count

An 1803% increase in annual operating expenses

These represent Amazon as a whole but would not be possible without Amazon’s investment into it’s fulfilment centres” - MacroTrends, (2022)

Internal Structure and Management Processes

Mark Davies - 2225058

Management processes

- Jeff Bezos CEO and Chairman; S team sets goals for strategy, shapes company culture and handles crises
- Rapid growth through acquisition and diversification
- Acquisition and innovation rates require “high-velocity decision making” (Bezos, J 2016)
- Adopt Forcing Functions (Bhatnagar and Gupta, 2021)
- Executives not paid according to team size or budget; important initiatives given modest staff resource
- “two-pizza teams” work on one focused project
- Prime Now- Launched 111 days after conception

Around 100 acquisitions and around 100 investments

S team consists of heads of divisions and areas – up to 30 people

“high-velocity decision making”

Make decisions with around 70% of the information

Quickly recognise if you’re wrong

Disagree and commit

Recognise misalignment issues early escalate immediately

- Forcing functions
 - Guidelines, restrictions, requirements or commitments that “force” an outcome without management of all details.
 - 2 pizza team – no exec team, should be fed more than 2 pizza. Average 4 people
- Senior executives are in “Executive mode”. They do not administer or oversee.

Management processes

- Patent strategy gives insight to management philosophy behind development
- Examples, which seem to plan for a smoother integration of variable capital (people) in fixed capital (machinery), guaranteeing worker's subordination to the ever-increasing proportion of machinery in the workplace. (Delfanti and Frey 2021)
- "Purposeful Darwinism" consistent with iterative and compounding improvements (Jassy, A 2022)

Patent strategy gives insight to philosophy behind development

Workers are unlikely to disappear from the warehouse floor anytime soon but will increasingly be used for training robots, maintenance and for extending the reach of machinery to increasing levels of automation (Delfanti and Frey 2021)

Examples, which seem to plan for a smoother integration of variable capital (people) in fixed capital (machinery), guaranteeing worker's subordination to the ever-increasing proportion of machinery in the workplace. (Delfanti and Frey 2021)

Dirigible delivering popcorn and drinks at sports stadia

Docking stations for drones

Increased worker surveillance

Visors and wearables

Humanly extended automation

Jassy took over in July 2021

Internal structures

- Hierarchical structure; senior leadership team. Non-unionised
- Controversy due to high productivity data driven standards
- Informal breaks allowed, 30-minute lunch breaks, 30-minute “Time off Task” (Moseman, 2022) break in normal schedule
 - Coaching for less productive, rotational programmes
- Associate compensation: £10.50/hr, pension, private health cover, life assurance, staff discounts, sign-on bonus, one-off bonuses (BBC, 2022)
- Amazon worker ‘almost fired’ after tracking device said he was too slow (Bristol Post, 2022)

Hierarchical structure; senior leadership team. Non-unionised
Informal breaks allowed, 30-minute lunch breaks, 30-minute break in normal schedule;
coaching for less productive, rotational programmes, wearables that alarm dangerous
movements, improved shoes, body mechanics

- Time off Task (Moseman, 2022)
- Metric used to monitor staff productivity
- Slightly – perhaps deliberately - vague measure used for toilet breaks and personal tasks
- “if you’re going to the bathroom, you’d better make it quick”

Algorithms monitoring individual productivity targets

Too many minutes ‘Time off task’

Internal structures

- Algorithms monitoring individual productivity targets
- Physical stress replaced by mental stress from productivity standards (Guendelsberger, 2019)
- Scan gun becomes digital manager allocating new tasks and counting seconds remaining to complete task
- Tension between:
 - Management: lean teams driving forward guided by boundaries
 - Shop floor: highly automated rule and data driven robotic productivity

- Not necessarily due to collisions but more to increased productivity requirements
- Tasks left to humans are the slowest therefore leading to productivity pressure

Leadership principles (Amazon, 2022)

Customer obsession

Innovative

Strong judgement

Always seeking to improve and insist on highest standards

Strive to be Earth's best employer

Success and scale bring broad responsibility

Amazon Technology Dependency

Michael Waite - 2134221

Amazon's Technology dependency with Acquisition of Kiva Robotics

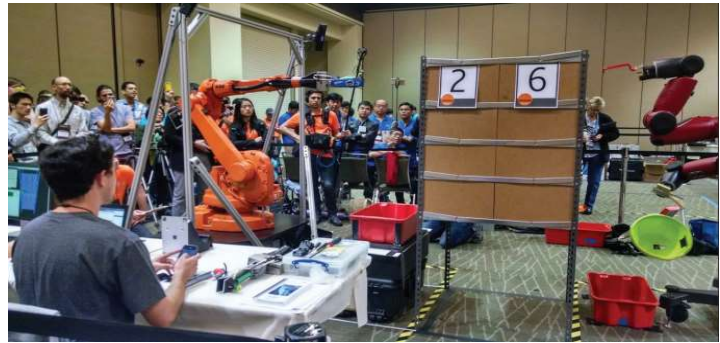


- In March 2012 Amazon makes a breakthrough innovation purchase of Kiva Robotics
- Amazon's press release introduced Kiva as "A leading innovator of Material Handling Technologies" and stated, "Kiva shares our passion for invention" (Amazon inc., 2012).
- So more than just a robot manufacturer, the innovative side of Kiva clearly caught the eye of Jeff Bezos

- In March 2012 Amazon gambled on one of the most transformative and radically changing Acquisitions Amazon has made with a breakthrough innovation purchase of Kiva Robotics
- Amazon's press release introduced Kiva as "A leading innovator of Material Handling Technologies" and stated, "Kiva shares our passion for invention". The key words here are innovator and invention when describing Kiva.
- So more than just a robot manufacturer, the innovative side of Kiva clearly caught the eye of Jeff Bezos

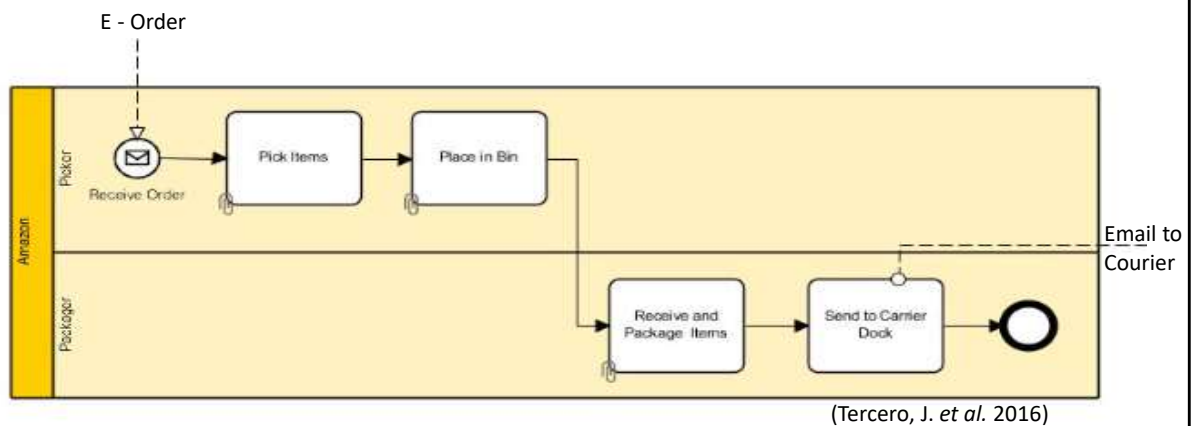
Sustaining innovation via competition

- Defined problem and defined domain Amazon Picking Challenge 2015
- 28 competitors in the challenge, \$26,000 prize and \$70,000 support grants (Wurman and Romano, 2016)
- \$100k outlay Amazon gained 28 independent innovative competitors, highly motivated in providing a solution to improving Amazon's picking capability!
- This encouraged rapid development of AI Machine Learning & Vision systems for adaptable systems



- In 2015 Amazon launched The Amazon Picking Challenge. This was clearly a sustaining innovation due to the problem and domain being defined
- 28 competitors entered competing for \$26,000 prize. Amazon also provided \$70,000 worth of support grants
- For under \$100,000 spend Amazon gained 28 independent competitors, highly motivated in solving the Picking Challenge Amazon had defined
- This encouraged rapid development of AI Machine Learning & Vision systems, since unlike conventional robot arms and palletizers with a single task, Amazon's picking tasks are rarely the same.

Amazon Fulfilment Centre Process



- A brief overview of Amazon's Fulfilment Centre Process
- There are two essential workstreams to Amazon's fulfilment process, Picker & Packager
- E Orders are received by the Picker who picks the items in the order
- These items are placed in an order 'bin' and moved on to the Packer
- The Packer receives the order 'bin' and packages with the most appropriate packing style
- The packed items are Palletized based on destination and sent to the Carrier Dock.
- When a full load is in place and email is sent to the Courier to collect.

Fulfilling the Process with Amazon Robotics Fleet

- Amazon has over 200,000 mobile robots working in its warehouse network
- Some of Amazon's Robots:

Picking, Packing Workstations

- Sparrow – Newest Picking robot using AI to handle unique items
- SmartPac – Envelope Package Wrapping
- CartonWrap – Boxes at 600-700 boxes/hr, 5x faster than previously done by humans

Palletizing Workstations

- Robin – Small Package Palletizing
- Cardinal – Large Package Palletizing

Transport Vehicles

- Hercules – Mobile Transfer robot
- Pegasus – Mobile Transfer robot
- Proteus – First Collaborative Autonomous Transfer Vehicle (ATV)



- Amazon has over 200,000 mobile robots working in its warehouse network.
- To highlight a few of these Robots

Picking, Packing Workstations

Sparrow is the newest addition to the Amazon Fleet and uses AI to handle unique items for picking

SmartPac & Cartonwrap are Envelope and Box packing machines; the CartonWrap at 600-700 boxes/hr is 5x faster than humans

Palletizing Workstations

Two types of palletizing workstations exist which are **Robin** for small envelope packages and **Cardinal** for Larger items

Finally there are Transport Vehicles

Amazon initially started transporting between workstations and inventory store with **Hercules** and **Pegasus** transfer robots. More recently though these are being replaced with the first Collaborative Autonomous Transfer Vehicle **Proteus**. Proteus allows humans to work safely alongside robots due to their high safety integrity. No guarding needed.

Amazon's Sparrow providing dexterity in picking individual products

- Until recently selecting inventory to be packaged (Picking) required Amazon's employees
- Sparrow is Amazon's newest picking robot that can detect, select and handle individual products and place them in an order 'bin'
- An order's items 'bin' is then sent for packing via Mobile Transfer Robots



(Brown, A.S. 2021)

Looking at a few of these in a little more detail.

Amazon's Sparrow replaces an operation that previously was exclusive to humans

Sparrow is Amazon's newest picking robot that can detect and handle individual products and place them in an order 'bin'

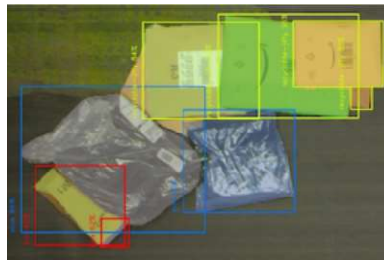
The order item's 'bin' is then sent for packing via Mobile Transfer Robots

Illustration of Amazon AI Machine Learning with Robin – Small Package Palletizer



In October 2021 the machine misses two black packages and one obscured one

By November 2021 The black packages are detected



but the obscured one is still missed

From February 2022 All packages are detected



(Brown, A.S. 2022)

- As an illustration of Amazon's AI development you can see in the image for October 2021 the machine misses two blank packages and one obscured one.
- By November 2021 the black packages are detected but the obscured one is still missed.
- By February 2022 All packages are detected

Disruptive Robotic innovation with Acquisition of Canvas Technology

- In 2019 Amazon displayed disruptive innovation by acquiring start up robotics company Canvas Technology
- Specialising in Canvas' own words as "End-to-end Autonomous Delivery of goods" (Moon, 2022), it enhances transfer between workstation and storage.
- Canvas Technology provides collaborative capability
- The autonomy capability provides the ability to expand robot technology into the Outbound Logistics part of its Value Chain



Proteus – Amazon's first collaborative ATV (Autonomous Transfer Vehicle), (Moon, 2022)

- In 2019 Amazon displayed disruptive innovation by acquiring start up robotics company Canvas Technology where the domain of transport robots was known but the problem was not clearly defined
- Specialising in Canvas' own words as "End-to-end Autonomous Delivery of goods", it enhances transfer between workstation and storage.
- Canvas Technologies collaborative capability provides the ability for workers to work alongside Robots, providing a safer workplace
- The autonomy capability also allows Amazon the ability to expand robot technology into the Outbound Logistics part of its Value Chain

Considerations of the Outcome of the Innovation

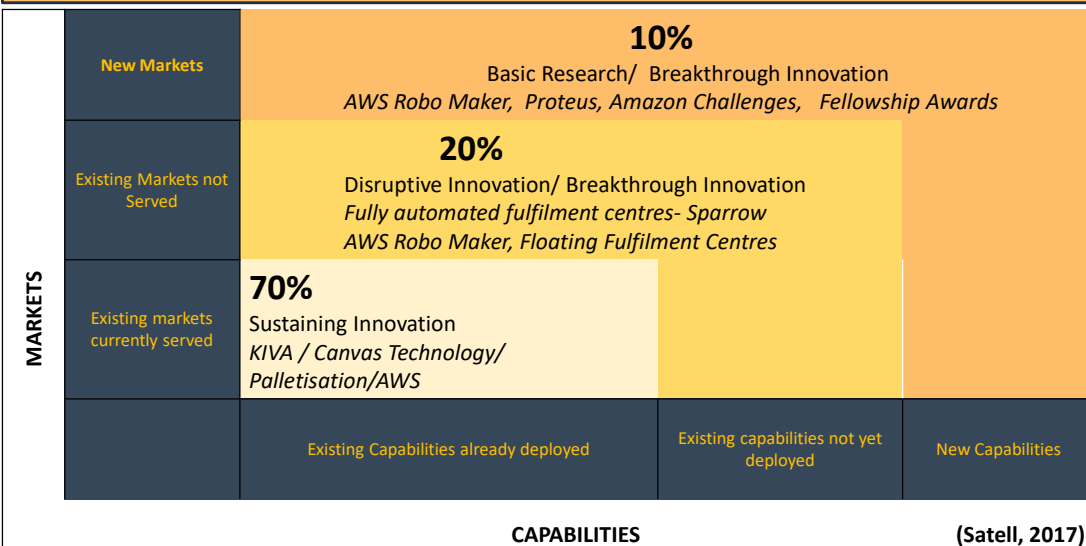
Gillian Laurie- 2222543

Satell Innovation Matrix

Problem Definition	Well Defined	Break through Innovation Purchase of Kiva Proteus	Sustaining Innovation Amazon Picking Challenge Sparrow robot AI Carton Wrap Robin/ cardinal Hercules/ Pegasus
	Not Well Defined	Basic Research Amazon Grand Challenges Fellowship Awards Medical Fields	Disruptive Innovation Canvas Technology AWS
		Not Well Defined	Well Defined
		Domain Definition	

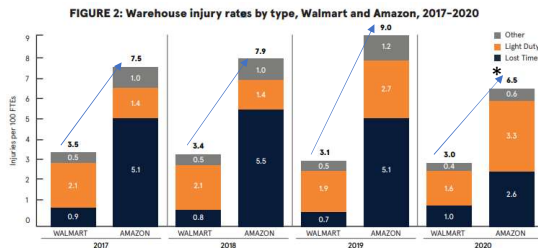
(Satell, 2017)

Three Horizons of Innovation for Amazon



we can also look at this in a different ways
 AWS is their route to market for so many of their innovations.

Health & Safety consideration



There has been reports of 80% higher than competitors (BBC, 2021)

- 2019 saw Amazon having a Injury & Illness Rate (IIR) double to market average (SOC, 2021)
- With potential of 42% of employees surveyed reporting some pain or injury from work activities (SOC, 2021)
- *2020 saw COVID restrictions which lowered the IIR

Positive H&S considerations

- Robo Tech Vests – reduced the need to record planned area of work
- Canvas technology reduced the need for these vests totally!
- Kiva - Reduced fatigue from excessive walking of colleagues
- Cardinal – Amazon (2021) robotic to lift heavy parcels to reduce employees strain injuries
- Wellness programs introduced to reduce injuries from static work

SOC Strategic Organising Centre

In 2020, for every 100 Amazon warehouse workers there were 5.9 serious injuries requiring the worker to either miss work entirely (lost time) or be placed on light or restricted duty (light duty). This rate is nearly 80 percent higher than the serious injury rate for all other employers in the warehousing industry in 2020. . **In 2020 Amazon workers who experienced lost time injuries were forced off work for an average of 46.3 days – more than a month and a half.** That is a week longer than the average recovery time for workers injured in the general warehouse industry and more than two weeks longer than the recovery time for the average worker who suffered a lost time injury.

. More than 4 in 10 (42%) respondents reported having experienced pain or injury from their job that caused them to miss work. Moreover, this suggests that the injury reports which Amazon submits to OSHA may be undercounting the number of injuries affecting Amazon workers.

Injuries are reported mainly as Repetitive strain Injury (RSI) – due to twisting, repetitive movement, bending

Amazon Says:

We want to develop technology with an end goal in mind of empowering our associates to perform their activities better and safer. If we don't integrate seamlessly end-to-end, then people will not use our technology."

Capability Consideration

- Workers capability requirements changed as products brought to individual, not individual to source product

"Companies may use technology in ways that decrease the skill requirements of jobs in order to reduce training times and turnover costs. This could create adverse effects on workers, such as wage stagnation and job insecurity." (Handel, 2022)

"Amazon Released Warehouse Robot Sparrow and It Could Wipe Out Jobs" (Varanasi, 2022)

- Upskilling 2025 – Training the workforce to perform new roles
- Use of AWS roles
- Amazon Fellowships (Amazon Science ,2022)

Amazon 2025 \$700M to upskill 100,00 employees

Funding for college tuition/ Prepaid fees/ Limitless learning/ fast starts

Move from entry roles to cloud based computing services for customers

Surge2IT - self paced learning. Lead to \$10K increase in salary.

Amazon now sponsoring Fellowships in USA to develop more Machine learning and AI

700 new categories of jobs that now exist within the company—all because of the technology we've introduced into our operations

Productivity consideration

Robots were able to pick 4 times faster than humans

Amazon now has over 350,000 robots deployed worldwide (The Economist, 2022) with 200,000 in fulfilment centres

Measures of 'time to task' for humans

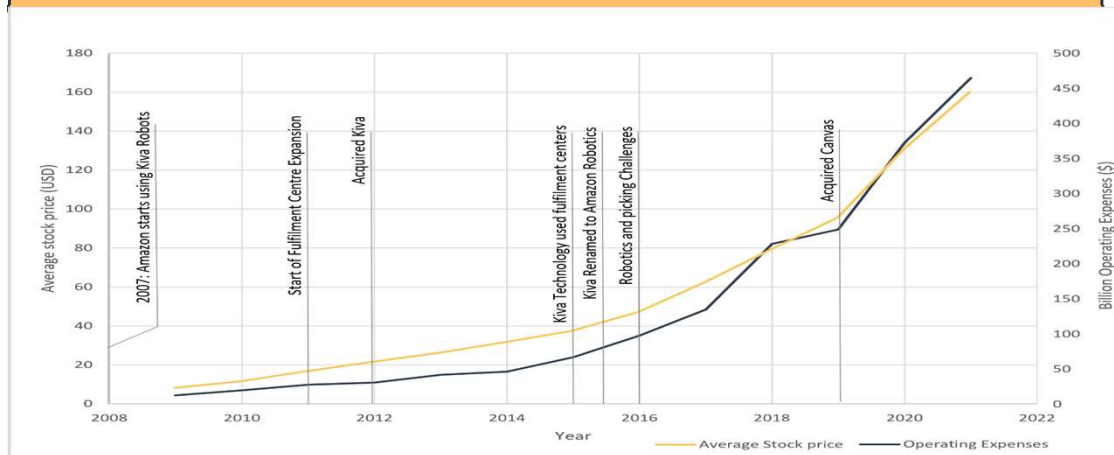
How does the worker keep up. Although they walk less, now the metrics have changed and human power has to compete to robotics targets

Removal of the wrist measurements, but still managed against the system. Then management processes for 'coaching to improve'. Or as been discussed earlier (BBC, PM 2022) As the computer sets the algorithm , does that define the standard for humans to work at??

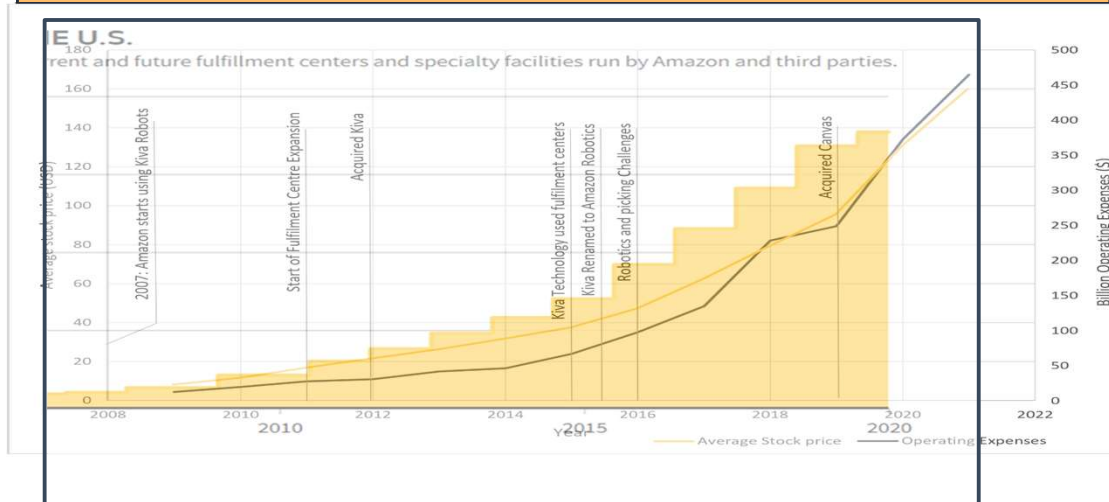
Financial consideration



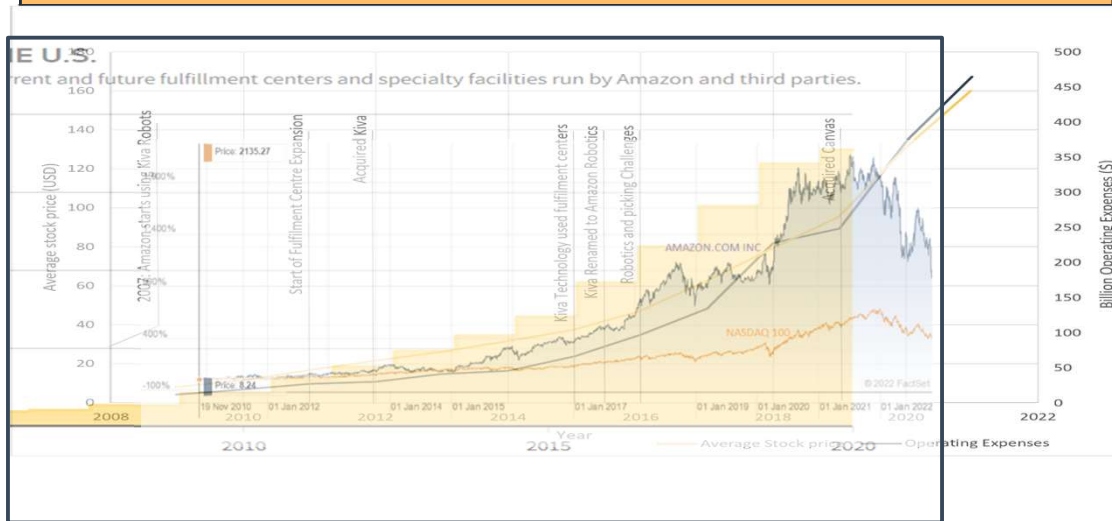
Innovations



Innovation and deployment consideration



Financial consideration

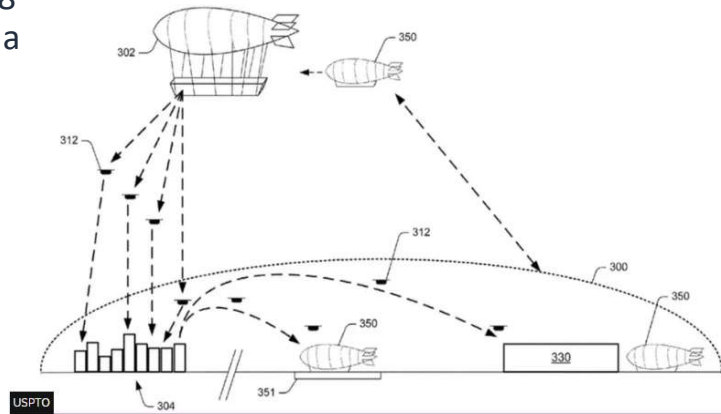


From this we can consider that there is a clear correlation between the innovation of robotics within the fulfilment centres, the rollout of all new centres being robotic and the profitability of the company.

2019 saw a slight impact with negative publicity of H&S in robotic centres, and the steep rise in 2020-2022 was clearly due to the external factors relating to COVID.

A Glimpse of the Future for Amazon's Fulfilment Centres...?

- In 2016 and amended in 2018 and 2019 Amazon published a Patent for an Airbourne Fulfilment Centre (AFC)



(Patent No# 9305280)

- In 2016 and amended in 2018 and 2019 Amazon published a Patent for an Airbourne Fulfilment Centre (AFC), multiple organisations filed 102 related patents since 2018 to 2022
- These floating warehouses would contain robots and workers just as current fulfilment centres
- Inbound logistics and human transport is provided by smaller shuttle Airships
- Unmanned aerial vehicles (UAVs) would be deployed for the AFCs outbound logistics deliveries
- After payload release the unladen drones would return to a shuttle and be returned with the next inbound shipment

Amazon Grand Challenge Team for Research

- Amazon's Grand Challenge Team
 - Amazon's top-secret research facility working toward pioneering solutions.
 - Amazon brings together knowledge from different fields to try to collaboratively solve a Grand Challenge problem allowing alternative perspectives through diversity to find the best solution
-
- this could be the future using sustaining innovation combined with the low-cost break throughs and acquisitions to drive the future

Questions



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