


PLM Road Map™ & PDT North America 2023
The Digital Thread in a Heterogeneous, Extended Enterprise Reality
 A call for PLM Professionals to share their knowledge & experience
 May 3 & 4

CIMdata eurostep



Dr. Patrick Hillberg,
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 Formerly Siemens PLM*

**THE PAST CENTURY HAS NOT PREPARED US FOR
THE NEXT DECADE**

For the past century, producers serving multiple geographies could choose to distribute factories worldwide, increase production capacity in a few regional factories, and ship products globally.

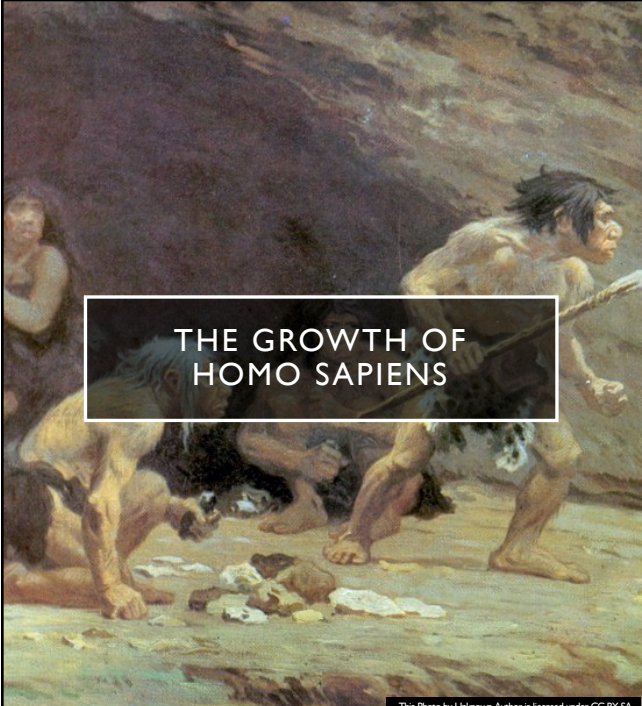
Their choice for the latter led to the globalization seen now, and decisions based on comparative wage advantages in the 1990s have evolved into economy-of-scale decisions reinforced through efficiency and advancing technology. Humans maximized the effectiveness of the global supply chain... until we didn't.

Digitalization may provide a solution to supply chain shocks and implies a substantial change in how we evaluate efficiency vs. resiliency in pursuit of societal value.

This session explores the use of Digital Twins and Threads to trade in locally manufactured virtual products rather than physical products to be shipped globally.

But the greatest challenge in this will be in developing a digital-capable workforce.

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**THE GROWTH OF
HOMO SAPIENS**

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NEW YORK TIMES BESTSELLER

"This gripping tale is both a history lesson and a warning about the future."
—Bill Gates

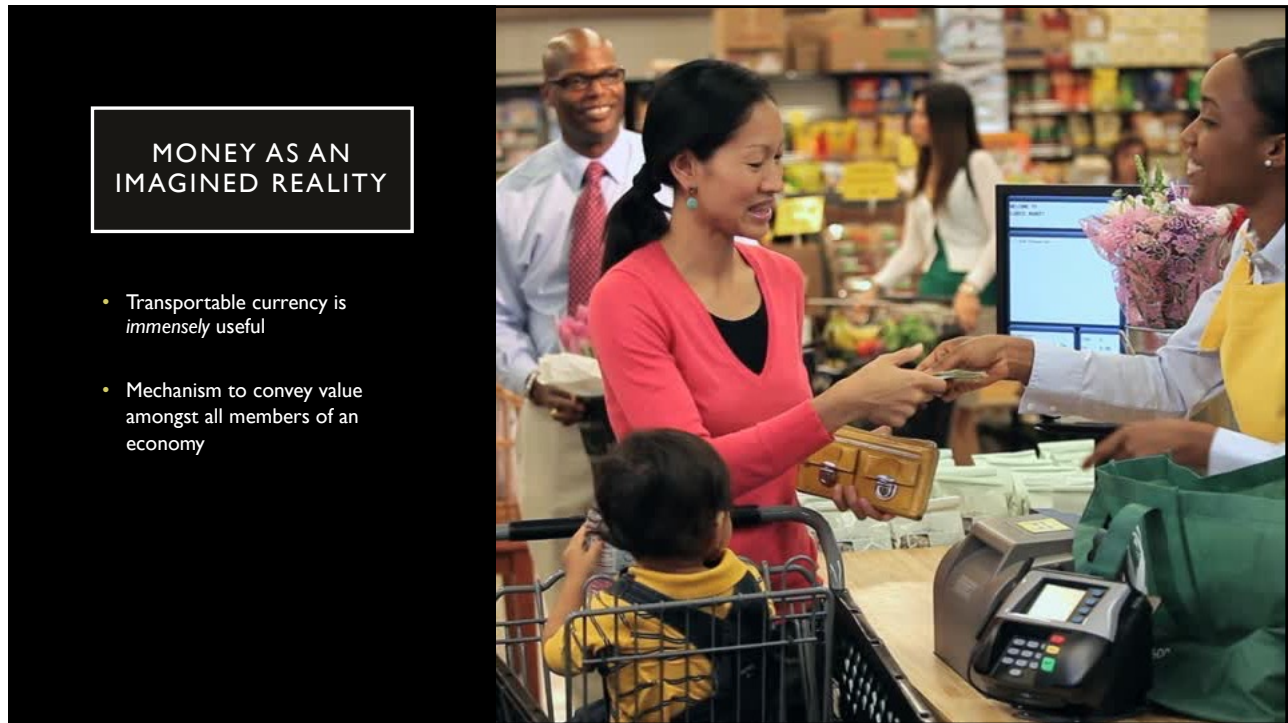
Yuval Noah Harari

Sapiens

A Brief History of Humankind

- Gossip (aka "Networking")
 - Societal means to share information on who is trustworthy
 - Up to ~150 people
- Imagined Realities
 - Socially accepted truths to which we all align, even if not objectively provable
 - Aka "shared beliefs"
 - Exert forces on the world through governments, constitutions, religions, and nearly all the "ism's"

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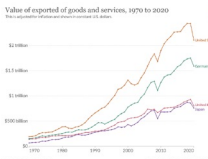
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GDP GROWTH AND TRADE

- Transportable currencies enable global trade
 - Trade increases efficiency and sustained GDP growth
 - Geographical Convenience became a strong predictor of GDP growth in the post-war period
- China's "Second Revolution" opened the country to world markets
 - 1999: Low-wage workers → **Comparative Advantage**
 - Exports (40x) and GDP per Capita (15x) from 1999-2021
 - Now: Comparative Advantage → **Scale Advantage**

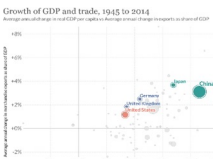
Value of exported goods and services, 1970 to 2020


The largest increase occurred in the 1990s.




Growth of GDP and trade, 1945 to 2014

Average annual change in total GDP per capita is 1.6% (range 0.5% to 2.6%); average annual change in trade is 4.2% (range 2.5% to 5.9%).





18 Apr 2012 14:00
of 12,124
200 Connections to 148,773
to 100,000
of 100,000
to 1,000,000
to 1,000,000







22 July 2012 18:00
of 124,771
200 Connections to 171,148
to 100,000
of 100,000
to 1,000,000
to 1,000,000

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2

Decision	Producer supplying two markets: (S_1 & S_2)
Build Factory local to S_2 ?	F_2 – cost to build “Factory-2” τ (τ au): Shipping cost per unit S_2 : Size of the alternate market
Indifference curve:	$F = (\tau)S_2$ If $F > (\tau)S_2$ Increase global shipping

THE NEW ECONOMIC GEOGRAPHY

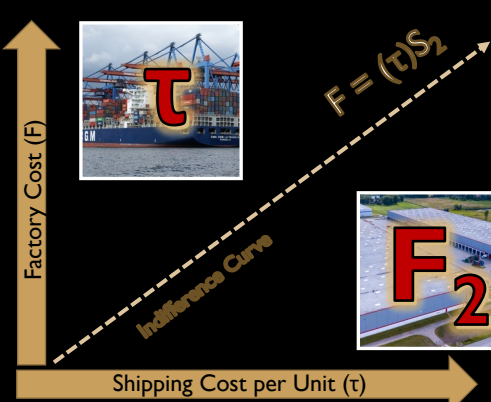





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THE NEW ECONOMIC GEOGRAPHY

Factory Cost (F)



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GLOBAL VALUE CHAINS 1980 – 2020

- Seaborn container trade grew 18x to \$14T
- But distributed factories more complicated than $F = (\tau)S_2$
 - Manufacturing is complex and knowledge-based
 - Requires learning across languages, cultures, and time zones
 - Factory cost $F \uparrow$; Shipping cost $\tau \downarrow$
- But shipping cost is not strictly monetary either
 - Long supply chains fraught with uncertainty and risk.

THE WALL STREET JOURNAL


GM to Halt Production at Several North American Plants Due to Chip Shortage

Affected vehicles include Chevrolet Traverse, Cadillac SUV models XT5 and XT6



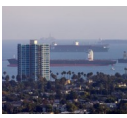
The New York Times

'Bottleneck Recession': Shortages Are Hurting Germany




INSIDER

Moody's: 'dark clouds ahead' for the global supply chain as 77% of the world's largest ports face backlogs



The Guardian

A 'perfect storm': supply chain crisis could blow world economy off course




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SYSTEMS THINKING: LIMITS TO GROWTH


Reinforcing Feedback:

- A change in the system makes a similar change more likely. E.g., a virus or an avalanche



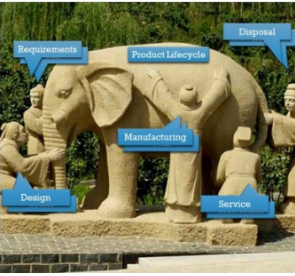
Balancing Feedback:

- A small change in the system makes that change less likely. E.g., sales volume vs. commodity prices



BLIND MEN AND THE ELEPHANT

- Have never seen an elephant before, so try to understand it by touching it
- But by decomposing the tasks, they fail to understand the "system".




Systemic Complexity

We must adopt Systems Thinking to manage complexity (if management is even possible). And nothing is more complex than climate change.

Thinking in Systems

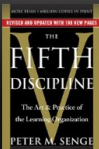
David H. Meadows



FIFTH DISCIPLINE

The Art and Practice of the Learning Organization

PETER M. SENGE



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SYSTEMS THINKING: LIMITS TO GROWTH

Middle-Ages:
Collaborative Farming

Technical Agriculture

Mass Production

But growth is limited by
the nature of that growth

Microbiologists Keep Finding Giant Viruses in Melting Permafrost
Researchers find several new species in a single soil sample.

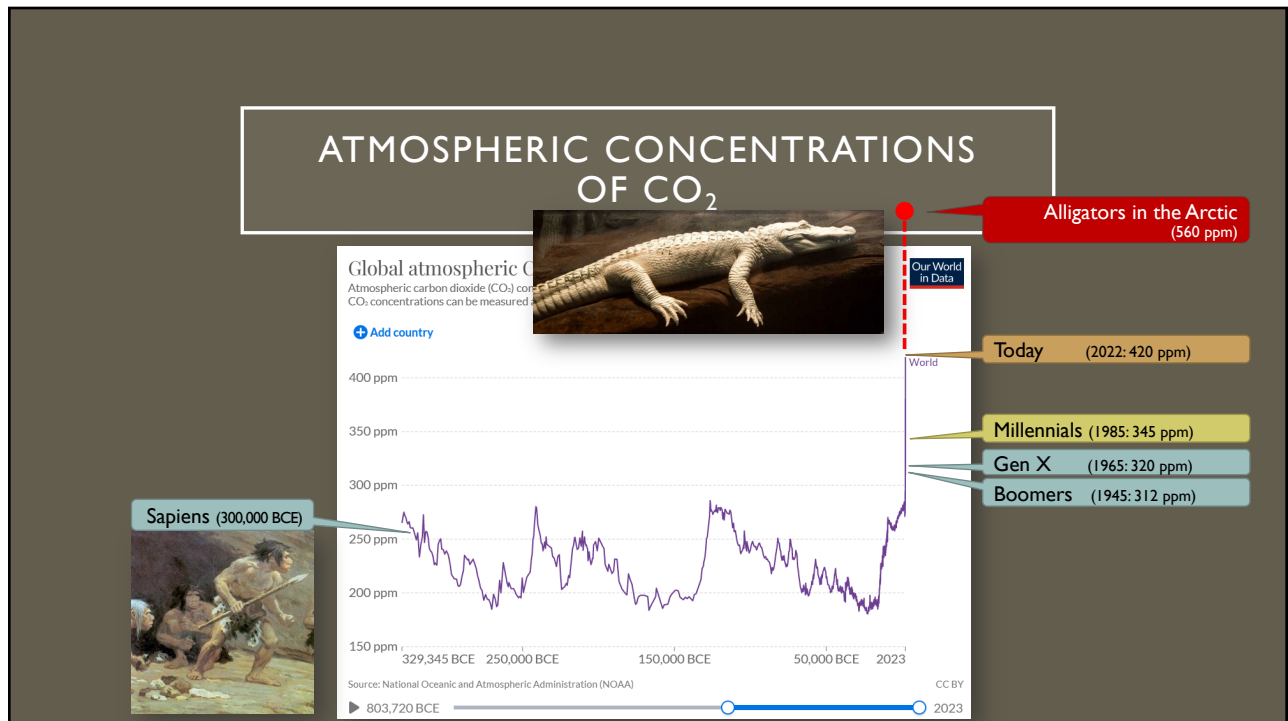


(Jenny E. Ross/Corbis)

By **Danny Lewis**
 SMITHSONIANMAG.COM
 SEPTEMBER 17, 2015

Smithsonian
MAGAZINE

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CAPITALISM AND EXTERNAL EFFECTS

- Capitalism (*an imagined reality*):
 - Private Property, Markets and Firms (selling products)
 - Malthusianism (1790): has not happened

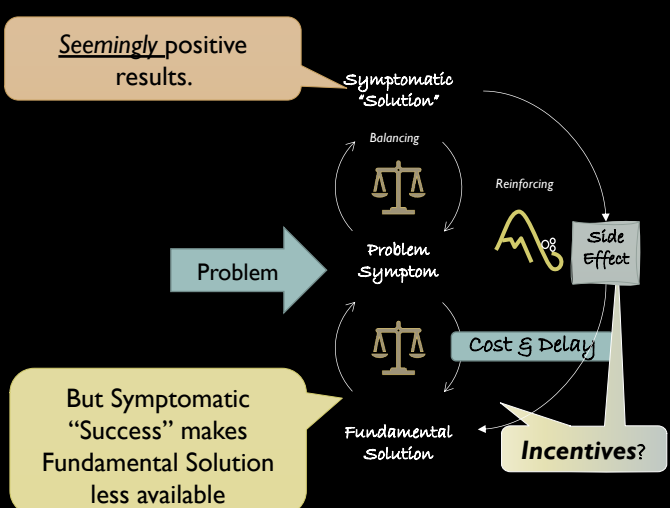
- Externalities
 - Impacts on those (positive or negative) who are not involved in the market contract
 - After 250 years, the “Climate Credit Card” is preparing its bill




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SHIFTING THE BURDEN

Seemingly positive results.





N95 Masks:

- Hospitals, etc. sought lower inventories
- 90% mask manufacturing moved overseas
- But low inventories not viable for Pandemic defense.

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UNCERTAINTY, SYSTEMIC RISK, AND NEW REALITIES

The diagram illustrates a cycle of risk and reality. On the left, 'Calculable Risk' is shown as a 'Symptomatic Solution' to a 'Problem Symptom', achieved through 'Balancing' (represented by a scale icon). This leads to a 'Fundamental Solution' and a 'New Reality'. On the right, 'Systemic Risk' is shown as a 'Reinforcing' 'side Effect' of 'Uncertainty', which also leads to a 'Fundamental Solution' and a 'New Reality'. A feedback loop labeled 'Reinforcing' connects the 'side Effect' back to the 'Problem Symptom'.

From *The Butterfly Defect*, by Goldin and Mariathasan

- Risk is quantifiable and predictable
- Uncertainty includes unexpected threats
- Systemic Risk is a breakdown in the entire system.
- Systemic Risks occur at Tipping Points, and are followed by some new objective reality

© Patrick Hillberg Ph.D.

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- So what will the earth actually look like


PBS Terra: What Will Earth Look Like When These 6 Tipping Points Hit?

TIPPING POINTS

- Current:
 - Coral Reef Collapse
- At 1.5°:
 - Melting Ice Sheets → 10m Sea Level rise
 - Permafrost → Carbon Sink to Source, Novel Diseases
- Now - 2° : AMOC
 - Atlantic Circulation stops Overturning → Europe Little Ice Age, → Sea Level rise in US NE
- By 2-3°:
 - Monsoons redirected → impacts food supply for 1B people
 - Amazon Rain Forest → Shift from Carbon Sink to Source

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“MANAGING
PRODUCT LIFECYCLES
FOR A SUSTAINABLE
FUTURE”



Case:
Do BEVs offer a Sustainable Business Model?

- Your auto company must meet the IPCC GHG reduction goals:
 - 45% by 2030, and Net Zero by 2050
 - Assume gas at \$100 per gallon

Supply

- Are supplies of BEV minerals and IC's available to meet the market need?
- What are the geopolitical aspects of the supply chain?

Demand

- What is the demand for BEVs at the expected price point?
- What are new possible business models?

Jobs to be Done?

- Is sustainability important?
- Other sustainable means to accomplish our transportation goals?

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“MANAGING
PRODUCT LIFECYCLES
FOR A SUSTAINABLE
FUTURE”



Batteries, Magnets and ICs
per Passenger Mile

Case:
Do BEVs offer a Sustainable Business Model?

Supply

Demand



2040 Sustainable Development Scenario

2020 Levels

U.S. Field Production of Crude Oil

Thousand Barrels per Day



1200 bbl in 1920 9600 bbl in 1970 50 years: 8x

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THE PAST CENTURY HAS NOT PREPARED US FOR THE NEXT DECADE

- Economic efficiency has been based on easy transport of physical products
 - At the expense of both resiliency and sustainability
- Must create economic models based on a new set of Imagined Realities
 - Market contracts must account for externalities
- Can we trade in virtual products, using Digital Factory Twins?

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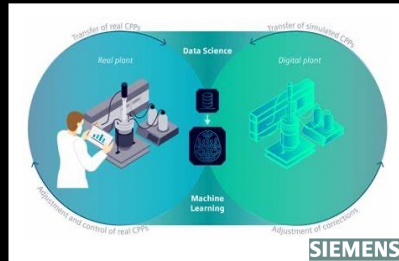
DIGITIZE TO LOCALIZE

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DISTRIBUTED VACCINE MANUFACTURE

- Vaccine Supply Chain
 - Since smallpox eradication in the 1960's, cold chain required from manufacturing to point of use
 - Traditional supply issues of interruptions, excess, and stock-outs
- RNA Vaccines
 - Production 1/100th to 1/1000th smaller than conventional production
 - Construction: one-twentieth the investment (\$20M). Half the time
 - Wide range of vaccines, produced 10x faster.



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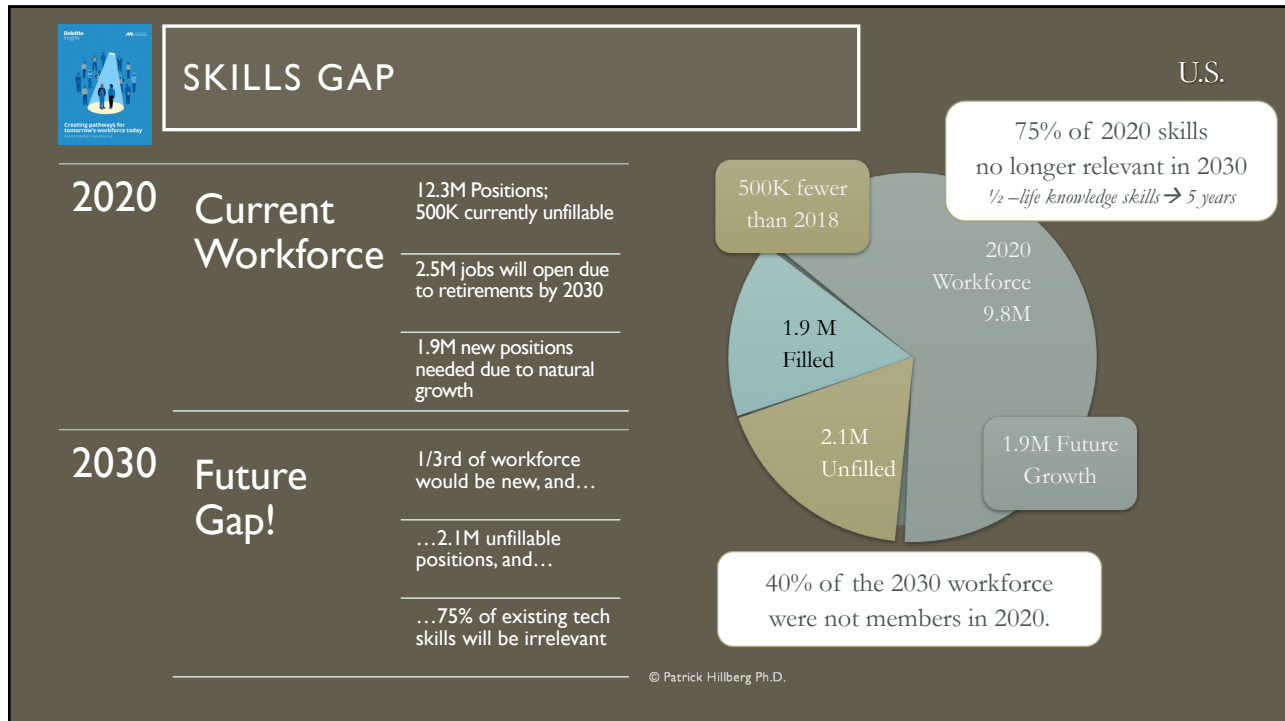


DEVELOPING A DIGITAL MANUFACTURING WORKFORCE

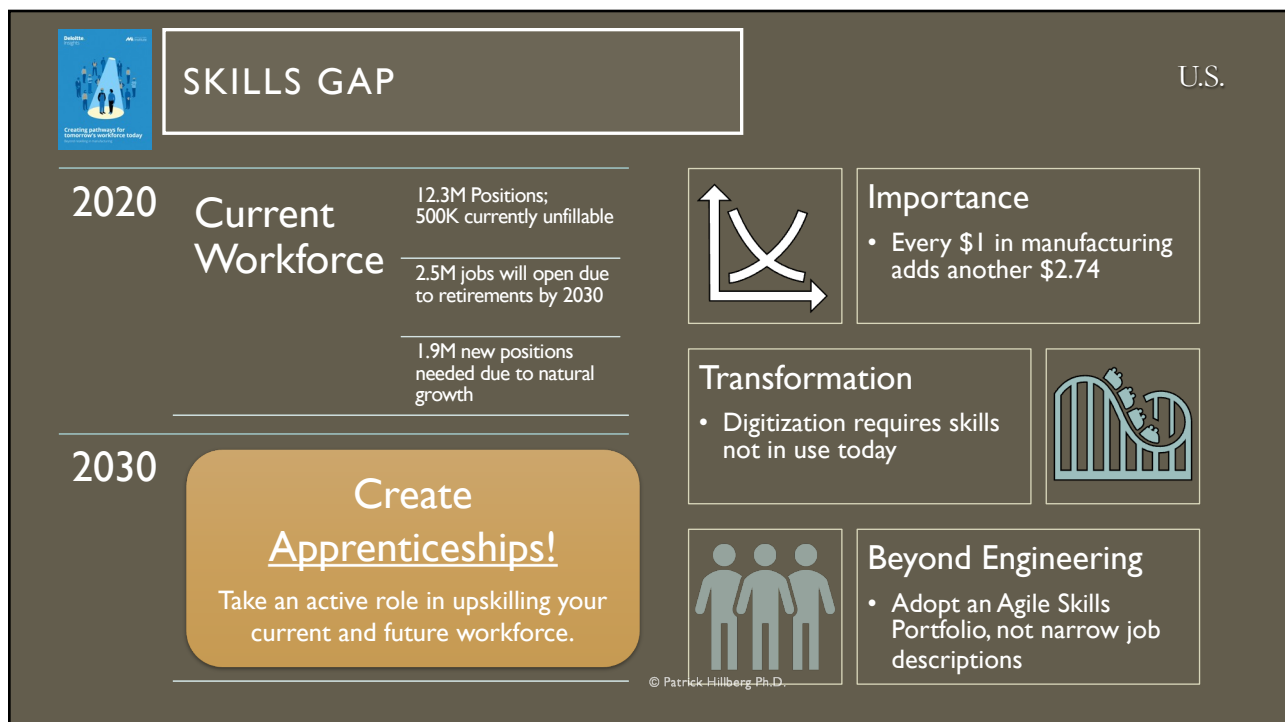
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THE PAST CENTURY HAS NOT PREPARED US FOR THE NEXT DECADE

What? Our measures of global efficiency do not account for negative externalities, and our growth is limited. We must emphasize resiliency and sustainability.

So What? Imagine a new Reality, and for Creative Destruction to impact century-old industries.

Now What? Trade virtual products for local manufacture. Drive continuous, learning within your organization.

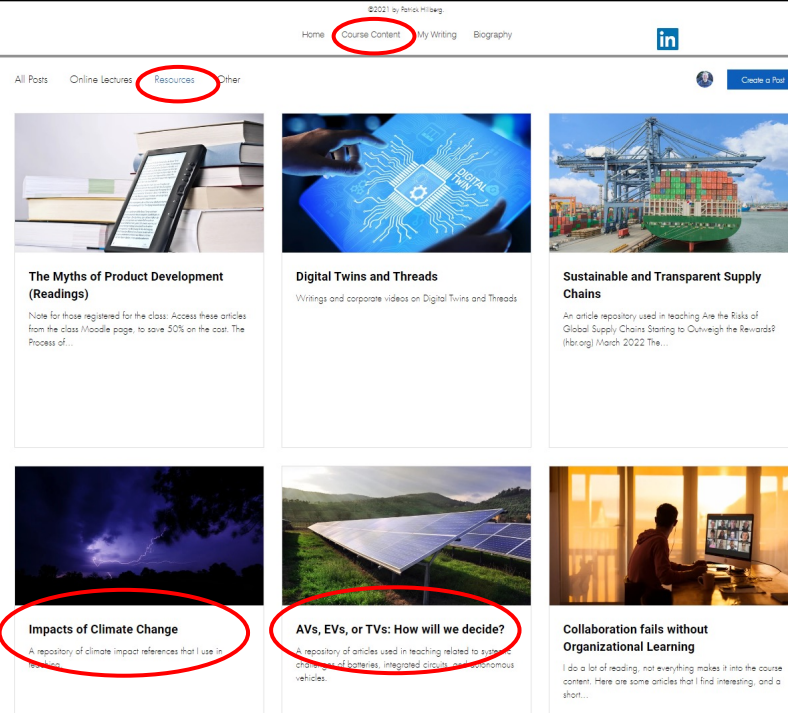


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SOURCES AND REFERENCES

See my website at
PatrickHillberg.com

Thank You!



The screenshot shows a website layout with a navigation bar at the top containing 'Home', 'Course Content', 'My Writing', and 'Biography'. Below the navigation bar are several article cards. The 'Resources' tab is highlighted in the navigation bar. Two article titles are circled in red: 'Impacts of Climate Change' and 'AVs, EVs, or TVs: How will we decide?'. The 'Impacts of Climate Change' article is described as a repository of climate impact references. The 'AVs, EVs, or TVs: How will we decide?' article is described as a repository of articles used in teaching related to automotive charging and batteries.

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