fathom
Independent Thinking

A game theory approach to techno-economic competition

Andrew Brigden

Andrew Harris

28 February 2023

- AI and robotics have the potential to make human workers more productive or to render them redundant; which strategy should the US and China adopt for higher economic growth, and how will each superpower be impacted by their rival's choice?
- Using our proprietary techno-economic model, we consider how the payoffs of emerging technologies vary according to whether the two countries promote labour-replacing or labour-supporting technologies
- China's poor demographics are motivation for the country to pursue labour-replacing technologies — this will deliver faster growth, but at the cost of higher inequality
- The US has a choice — investment in labour-supporting technologies will deliver higher growth for the next ten years or so, but over longer horizons, a labour-replacing strategy will boost growth more
- We conclude that the US has a chance to achieve a 'good' technological rebalancing, if it can invest in both technologies and gradually pivot towards a labour-replacing strategy as workers reduce their hours voluntarily

The US and China have entered a new phase of techno-economic competition. The emerging technologies they prioritise and the quantity of resources they divert towards them will shape macroeconomic outcomes for decades. This note frames that competition in the context of two contrasting strategies — developing technologies that can replace labour, or technologies that support it. Obviously, the distinction between these two categories of technology is not always clear cut; however, dividing technological innovations broadly along these lines allows us to see the differing impacts of the two divergent strategies clearly.

Policymakers face a choice: should they promote labour-replacing or labour supporting technologies?

Fathom has developed a proprietary AI-Robot model (ARM) to test the quantitative impacts of targeting R&D spending towards either a labour-replacing or a labour-supporting strategy.[1] In this note, we examine the outcomes of the model for the US and China. Taking a game theory approach, we conclude that: a) the two countries will achieve the best economic outcome with opposing strategies, and b) this is the likeliest outcome. The optimal strategy for each country will not, of course, entirely be determined by the consequences for economic growth, but will also depend on policymakers' political priorities, both domestic and geopolitical. They will

1. The scenarios are calibrated by assuming that R&D spending as a share of GDP increases by 0.7% percentage points relative to a baseline scenario.

Continued

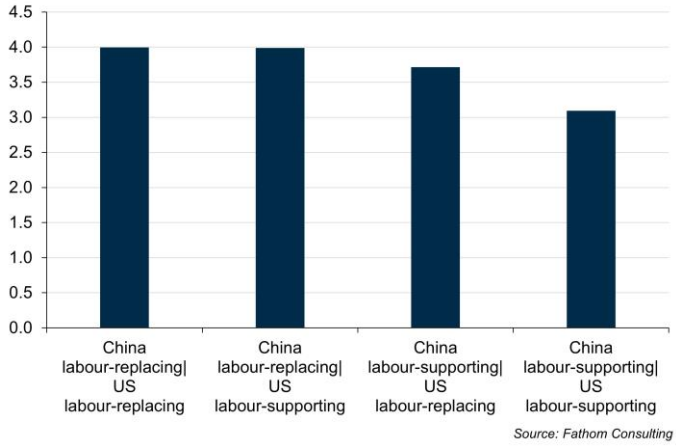
have to consider demographic trends, tolerable levels of inequality, international competition, and more. Even after accounting for these factors, we still think this is the likeliest outcome.

The optimal strategy for China

China has a clear incentive to pursue labour-replacing technologies. According to China's National Bureau of Statistics, in 2022 the country's population fell for the first time in six decades. This decline is set to continue: China's share of the global working-age population is set to halve by the end of the century. Labour-replacing technologies could offset the burden of labour shortages. Our model shows that, by targeting R&D towards labour-replacing technologies, China could raise annual output by 4% by 2035. As shown in the chart below, a labour-supporting policy would still increase output, but by less than the labour-replacing strategy. This is true regardless of the policy adopted by the US. China remains a net importer of robotics, implying that countries such as Japan (which is a leading exporter of robotics) could stand to benefit from such a strategy, although they will be presented with a dilemma if the trend towards US-China bifurcation continues.

China GDP in 2035

Percentage changes relative to baseline

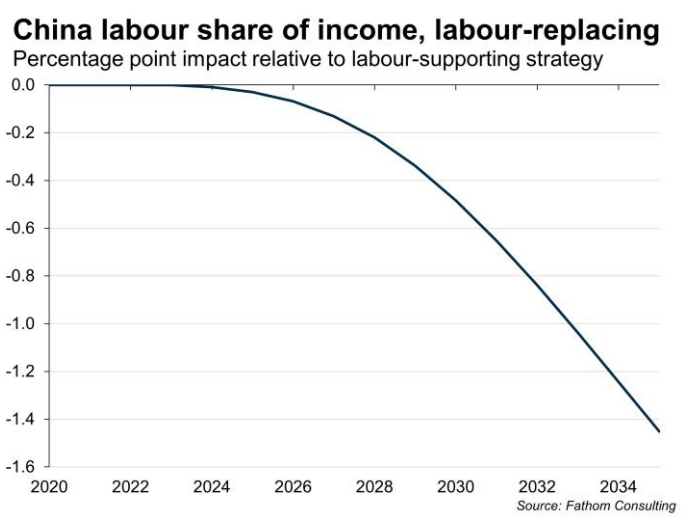


Source: Fathom Consulting

It is highly likely that China will adopt a labour-replacing strategy; policies such as Made in China 2025 suggest that China is already attempting to prioritise technologies that will deliver automation. However, Fathom views this as a 'bad' kind of technological rebalancing. While it might be necessary for China to maximise growth, this strategy would reduce the demand for human labour, weigh on wages, and increase inequality. We predict that the share of income accruing to workers would drop around 1.4 percentage points by 2035, as the chart below shows. In other words, what is best for China's economic output is not necessarily what is best for its workers.

A labour-replacing strategy will deliver the highest growth for China, but this will come at the expense of greater inequality

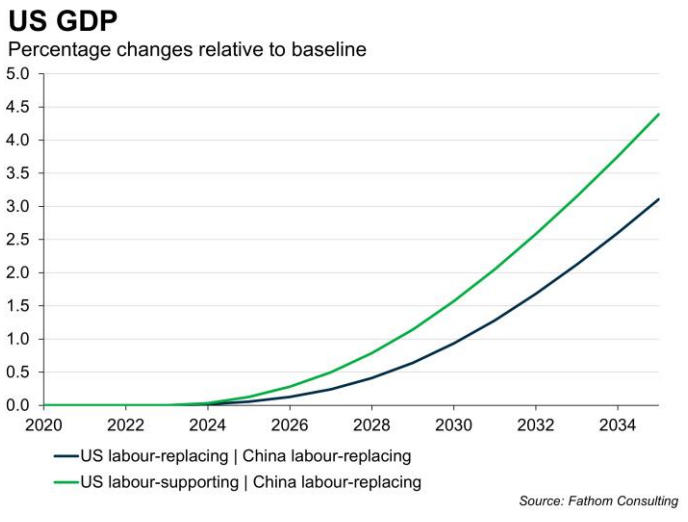
Continued



The optimal strategy for the US

For the US, greater investment in labour-supporting technologies would raise GDP, relative to a baseline scenario, by more than 4% in 2035. A labour-replacing strategy would only raise output by around 3% in the same timeframe. (Note: although this growth impact of a labour-replacing strategy is smaller, it still delivers higher growth than a business-as-usual scenario, albeit at the cost of greater inequality.)

In the US a labour-supporting strategy will maximise growth out to 2035

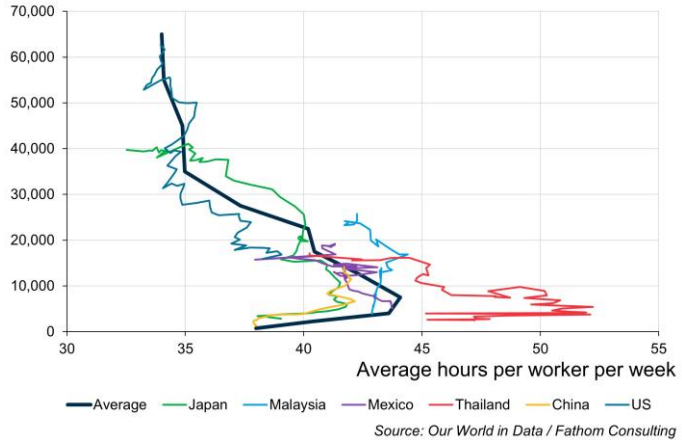


As discussed in a previous note, higher productivity (and therefore higher wages) in advanced economies have typically been associated with overall reductions in working hours.

Continued

Backward-bending labour supply curves

GDP per capita, USD, constant prices



Source: Our World in Data / Fathom Consulting

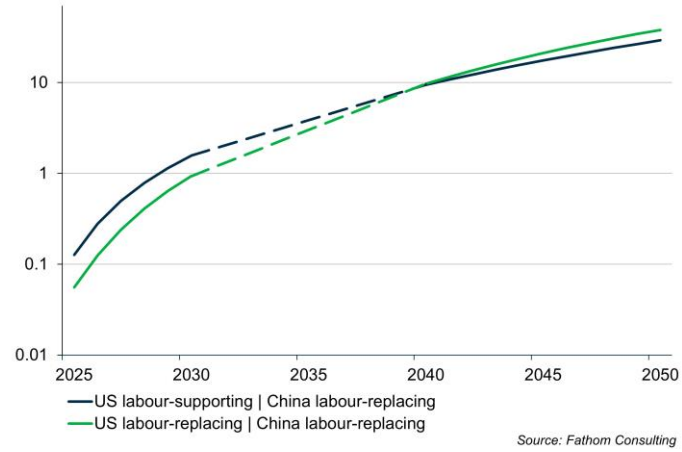
Therefore, if the US can deliver labour-supporting innovation and increase workers' wages in the process, workers are likely to voluntarily reduce the hours they work as the country has already reached the backward-bending portion of its labour supply curve, as the chart above shows. (For more, see the previous note in this series)

Beyond 2035, the relative payoffs of the two strategies flip for the US, and a labour-replacing strategy will deliver higher growth. This is because labour-replacing technologies, particularly robotics, are still at an early stage of development. When they reach maturity, a labour-replacing strategy will deliver the best returns as it relaxes the constraint that labour availability places on growth.

Beyond 2035, a labour-replacing strategy will deliver the highest growth for the US

US GDP impacts

Percentage changes relative to baseline, log scale

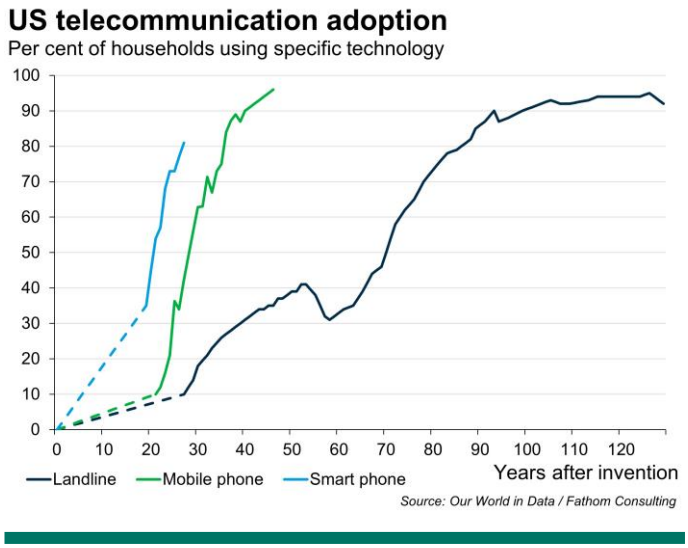


Source: Fathom Consulting

Once the capabilities of nascent technologies such as robotics reach maturity, there is evidence to suggest that their adoption will be rapid, with early adopters likely to benefit the

Continued

most. Technological diffusion typically follows an S-curve (that is to say, adoption is slow at first, before a sudden rapid increase, and then a dropping off as we approach saturation). There is reason to believe that this process is speeding up, as demonstrated by the chart below outlining technological adoption in the telecoms industry. So it is important to adopt new technologies early to maximise the benefits and not miss out against competitors.



The optimal strategy

As with any problem in game theory, each country's optimal strategy depends on the objectives of its policymakers. In China, it is likely that policymakers will prioritise economic growth over other objectives, while maintaining political control. So, in the trade-off between growth and inequality, it seems likely that they will place more weight on growth. In the US, that trade-off does not appear to exist, at least in the horizons that most policymakers care about, as higher growth can be achieved without ballooning inequality.

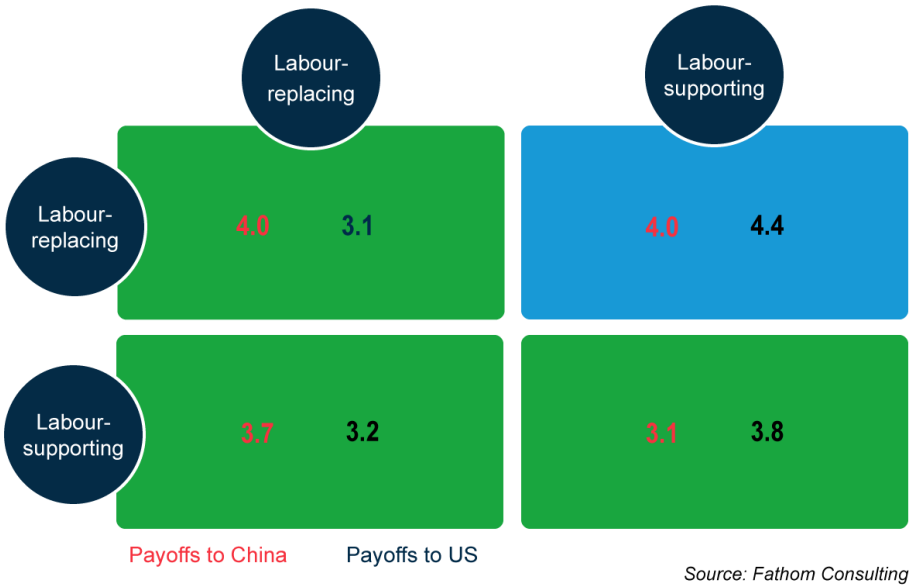
The likeliest outcome — China pursuing labour-replacing technologies and the US pursuing labour-supporting ones — is summarised in the matrix below. For both the US and China, the optimal outcomes individually are the same as the optimal outcomes strategically. In other words, there is a dominant choice for both nations, regardless of what approach the other adopts; game theorists call this a 'Nash equilibrium'.

The most likely scenario is that China will pursue labour-replacing technologies, while the US pursues labour-supporting technologies

Continued

Possible GDP payoffs in 2035

Percentage changes relative to baseline scenario



Source: Fathom Consulting

Orchestrating the pivot

Following a labour-supporting strategy is not without its risks. There is a possibility that the US will get left behind — in the same way as it was with 5G telecoms technology — if it neglects to simultaneously invest in labour-replacing technologies. Failing to do so could mean that it will find the field already occupied by its rival when it attempts to catch up.

Labour-replacing technologies will matter to the US, not simply because they will be needed if workers decide to reduce their hours, but also because some examples (e.g., drone technology) are likely to have applications in other fields too (e.g., warfare). Recent US administrations and their allies have shown increasing distaste for importing such technologies from the US's main geostrategic rival, a trend that is likely to continue in the coming years.

To reduce this risk, we conclude that the US should invest in both kinds of technologies, and increasingly pivot to labour-replacing innovations as the labour-supply curve bends backwards and workers voluntarily seek to reduce their hours.

If this is managed correctly, we would describe this as a 'good' kind of technological rebalancing — i.e., one where involuntary unemployment is avoided, living standards are increased, and the US can still compete with China on labour-replacing technologies. This will not be easy: going too fast on labour-replacing technologies risks involuntary unemployment, while going too slowly risks the loss of workers without a means of replacing them.

The US will need to shift between strategies; the transition will present risks and must be managed carefully

Continued

Regardless of which strategy they adopt, all countries will have to navigate the social and political consequences of the fourth industrial revolution. The reduced demand for human labour is likely to lead to rising inequality and, with it, social upheaval. Individual governments must find a way to navigate this issue. Ideas such as paying citizens a universal basic income have been invoked as possible solutions.

Welcome to the machine

A comparative assessment of the USA and China to 2035, focusing on the role of technology in the economy

This note is the fifth in a series highlighting the findings of *Welcome to the Machine*, Fathom's recent report on techno-economic competition between the United States and China to 2035.

Read more from this series or read the report in full

Further reading

Automation: this time could be different

Measuring the AI sector

Automation could offset China's demographic problem

Introducing 'Welcome to the machine'

Fathom Consulting
47 Bevenden Street
London
N1 6BH
Tel: +44 (0)20 7796 9561

Contact information
andrew.brigden@fathom-consulting.com
www.fathom-consulting.com