ECONOMIC BULLETIN

Productivity of New Zealand agriculture.

28 May 2024 | **Paul Clark**, Industry Economist | +64 9 336 5656 | +64 21 713 704 | paul.clark@westpac.co.nz

Keeping ahead of the pack – pushing agriculture to new heights.

- **Lifting productivity in agriculture is crucial if New Zealand is to deliver on the Government's goal of doubling exports over the next 10 years.**
- **It is also important to farmers. As price takers, their standard of living is closely tied to their ability to minimise unit costs of production.**
- **While agricultural productivity in New Zealand easily outperforms other sectors of the economy, growth has been slowing despite ongoing investment in mechanisation and more recently, new digital technologies.**
- **Investing in new technologies is a necessary, but not by itself a sufficient condition for lifting productivity growth. That requires a change in farming practice.**
- **Ideally that means embracing smart farming. i.e. the use of connected digital technologies, such as sensors, robotics, internet of things, and artificial intelligence, amongst others, to enable farmers to automate and deliver greater precision in farming processes.**
- **While there are challenges to adoption, it's likely that smart farming will find favour with many farmers in New Zealand. Indeed, we expect the sector to continue its long-standing tradition of being at the forefront of new developments in the agricultural space.**

What's the problem?

New Zealand productivity performance is relatively poor compared to its OECD peers.[1] According to the now defunct Productivity Commission, New Zealanders work more hours per week than their peers, but only produce 68% of what their OECD counterparts do. Put simply, we work longer and harder, but generally not smarter.

Things are slightly different for agriculture. Deregulation and the removal of protectionist subsidies in the mid-1980s was the catalyst for a period of sustained efficiency and productivity gains that other sectors of the economy could only dream of. Mechanisation and innovation, supported by investment research and development was key to both. So too, the big swing towards dairy conversions a decade or so later. That helped to lift productivity not just in dairy, which benefitted from greater economies of scale, but also in lamb and beef due to the adoption of improved on-farm land management practices, advanced genetics for animals, and better-quality pasture.

However, since the turn of the century, productivity growth has slowed. On farm efficiencies and productivity gains have continued, but they have come at an ever-slower pace. That's not great news for living standards or the wellbeing of New Zealand's farmers and growers.

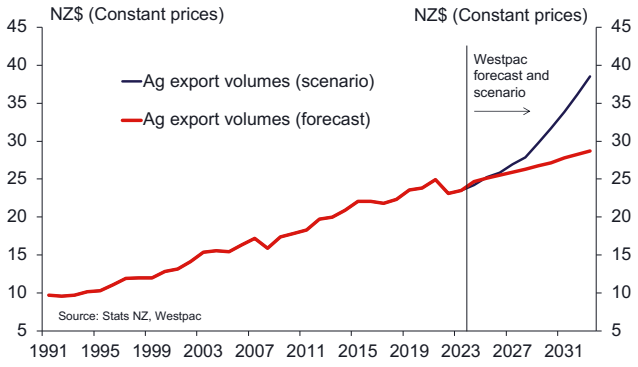
The question then is, how might the agricultural sector regain its productivity mojo? Put slightly differently, what needs to be done to boost productivity growth in the sector?

Answering that question will be key to delivering on the Government's goal of doubling exports by value over the next 10 years. New Zealand exports between 85% to 90% of its dairy, meat, fruit, and vegetable production in any given year. Depending on what constitutes an agricultural product, we estimate the sector contributes about 60% to New Zealand's merchandise exports.

1 New Zealand productivity among worst in OECD - Productivity Commission report | RNZ News

To achieve this doubling, we estimate that agricultural export volumes would have to increase by a whopping 63% over the next decade. If we then assume that sheep, beef, and dairy cattle stock levels continue to track at current levels, and that the land available for pasture and horticulture remains largely constant, which is entirely plausible given historic trends, then productivity would have to rise by a similar magnitude. That seems unlikely. Even in its heyday in the 1980s, agricultural productivity "only" rose by about 40%, slowing to 30% a decade thereafter.

Figure 1: Targeted export volumes - agriculture



Why does it matter?

At a micro level, the ability to produce more outputs for a given level of inputs should mean lower unit costs of production, improved profitability, and better returns to the factors of production in the form of higher returns on capital and increased real wages for workers. That's important, especially in agriculture where farmers are typically price takers, whose living standards/quality of life/wellbeing is in large part tied to their ability to control on-farm production costs. Most farmers in New Zealand are small-to-medium sized enterprises, over half of which are owner operated. They sit along the likes of state owned Landcorp, which operates a nationwide portfolio of farms.

The same is true at a macro-level. In simple terms, higher productivity implies that the economy can produce and consume increasingly more goods and services for a given level of inputs. It also helps keep a lid on inflation by reducing the need for supply constrained factor inputs, notably labour and capital, to deliver a given level of output.

As already mentioned, a stronger productivity performance in agriculture can be expected to lead to a stronger export performance. That's important – foreign earnings from exports are key to supporting consumption and investment through imports. Similarly, New Zealand's current account deficit is already very high and does not look set to significantly improve. A boost to exports would help improve the sustainability of our current account with benefits for all.

Increasing productivity also has other benefits. It's essential, for example, if New Zealand is to address some of the big challenges that it faces. That includes a rapidly aging population. As the ratio of non-workers to workers continues to increase, productivity in the workforce will be essential to sustain and grow output levels. It also includes producing enough food for a growing population. Productivity growth has allowed food to become more abundant and cheaper even as the world's population has increased.

So, what is productivity?

On the face of it, productivity is a straightforward concept – a volume of output divided by a volume of input. The more output than can be delivered from said level of input, the more productive a sector, industry, or indeed, farmer is deemed to be. Operational efficiency is closely related and is measured in the same way but differs in that it looks to minimise the volume of input for a given volume of output.

Scratch below the surface though and things get a lot trickier. Much of that has to do with what constitutes an input and an output, as well as the different ways in which these can be measured. Some measures are more accurate than others and can throw up vastly different productivity estimates.

In essence there are three key measures of productivity, namely capital, labour, and multi-factor productivity (MFP). The first two are partial measures, which measure output per unit of a specific factor input. Capital, typically in the form of land, livestock, machinery and equipment, and labour, in the form or workers, are usually the largest input factors used in the agricultural production process, so merit specific attention. MFP is different because it's about measuring output per unit of combined labour and capital input. There are also additional measures of productivity, such as total factor productivity (TFP), which is often used interchangeably with MFP, although strictly speaking it should include additional input factors, such as energy and materials used in the production process.

It's also important to distinguish between short- and long-term drivers of productivity.

Long-term estimates of productivity reflect changes in farm business scale and management practices, as well as technological progress. Increases in farm size, for example, have proven to be a core driver of productivity growth, because it allows fixed costs such as management skill and machinery ownership to generate more output.

That said, benefits from economies of scale are context-dependent and depend on relative input factor prices, on topography, as well as supporting infrastructure (for example, quality roads to move input and output volumes).

Average farm size.

- **Agricultural land area has trended lower over time, from a high of 152k sq km in 1981 to 102k sq km in 2021.**
- **The number of farms operating in New Zealand has fallen from almost 74k in 2000 to 49k in 2023.**
- **The size of the average farm holding in New Zealand has increased from 213ha in 1989 to 271ha in 2019. Cropping farms are usually significantly larger than their meat producing counterparts.**
- **The average US farm is 188ha, while in Ireland that number is just 33ha. That pales into comparison with Australian farms that average 4331 ha.**

Source: Stats NZ, ABS, USDA, Statista

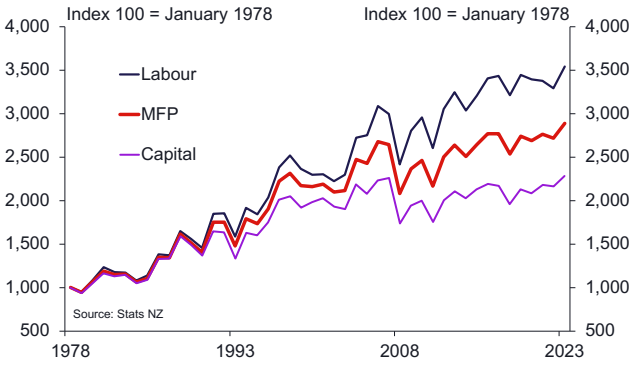
The average size of farms in New Zealand has trended higher in recent decades, while the number of holdings has decreased. A lot of that has had to do with the consolidation of smaller "family" owned dairy farms, with similar dynamics evident in the red meat space. The conversion of farmland into forestry in recent years, as well as a fall in cattle and sheep numbers, will also have contributed to this trend.

By contrast, short-term estimates of productivity are influenced by seasonal conditions, the vagaries of the weather and other temporary factors, including the availability of labour when it is time to harvest.

How has agricultural productivity tracked?

Data from Stats NZ shows that productivity in New Zealand's agricultural sector has grown across the three key measures. MFP grew by 189% between 1978 and 2023, while labour productivity, calculated as sector value add divided by hours paid, increased by a whopping 254%. Capital productivity, measured as output per unit of services provided by capital assets increased by 128% over the same period.

Figure 2: Productivity in the agricultural sector



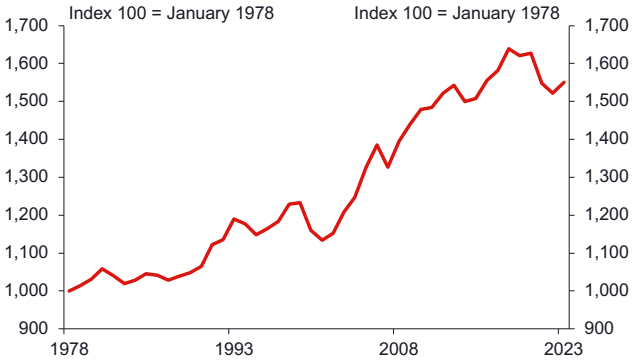
What is also evident from the published figures is that the growth trajectory of productivity has eased. Following market reforms, which included the phasing out of price supports and elimination of subsidies on factor inputs, MFP grew by an average 5.6% per annum between 1985 and 1999, slowing to just 1.4% between 2000 and 2009. Much of the earlier gains came from increasing economies of scale, greater mechanisation, and changes in land use. Productivity growth in agriculture has since averaged 1.7% per annum between 2010 and 2023.

Slower productivity growth since the turn of the century has been less evident in labour productivity, which has shown sustained growth over a long period of time, with the direction of travel only recently having moderated. By contrast, the trajectory of capital productivity has been largely flat since the mid-1990s.

A lot of that has to do with the availability of land for agricultural production, and the ecological limits that determine what can be farmed and how much can be produced from it. Highly productive land typically has a good climate, suitable soil conditions, and is less vulnerable to erosion. It also has good drainage and is generally flat or gently sloping.

The slowdown in capital productivity is likely to reflect a) the extent to which actual levels of production from this land have edged ever closer to ecological limits; and b) diminishing marginal returns generated from ongoing investment in mechanisation (and new technologies).

Figure 3: Capital-to-labour ratio in the agricultural sector



At the farm level.

An MPI report in 2017 estimated that returns on investment made to convert a beef and sheep farm into dairy typically take up to 4 years to fully materialise. That figure extends out to 6 years when converting pastoral land into kiwifruit orchards. That suggests that while gains may accrue longer term, during the early stages of conversion, when production processes are subject to disruption, there can be a loss of productivity.

Source: MPI (2017)

Weak capital productivity gains are also likely to reflect more technical issues. Increased mechanisation, for example, has raised the share of capital in the production mix, resulting in a higher capital- to-labour ratio. That is particularly true for dairy farms, where the adoption of new technologies has been far greater than in beef and lamb farms. The recent downturn in the capital-to-labour

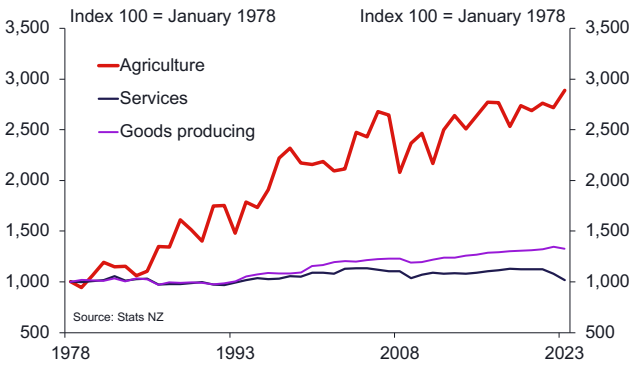
ratio reflects a hold on capital investment during Covid and a smallish pick up in sector employment.

How does the agricultural sector compare?

Despite a slowing trajectory, productivity growth in the agricultural sector stands head and shoulders above other sectors in the New Zealand economy. As mentioned, MFP in the agriculture sector rose by 189% between 1978 until 2023. Compare that to MFP in the fast-expanding services sector, which grew by 33% over the same period and a paltry 2% increase recorded for the goods producing sector, which includes manufacturing and construction. The contraction in manufacturing production seen over the last year or so has been a key contributor in this regard. The bottom line is, farmers are better at maximising output for given level of inputs than their counterparts in other sectors.

That said, agricultural productivity growth has been far more volatile than in other sectors. Much of that can be put down to the short-term drivers referred to above, i.e. seasonal conditions and the vagaries of the weather. Examples include last year's abnormal storm events, and the disruptions to apple production caused by cyclone Gabrielle in key growing areas. While a fall in output does not necessarily imply a decline in productivity, the fact that about 60% of factor inputs used to produce those apples are fixed, and does not vary with production, certainly does.

Figure 4: Multi-factor productivity by sector



Agricultural productivity growth in New Zealand is not that dissimilar to other high-income countries. Indeed, according to the USDA, most high-income countries exhibited stronger growth prior to the turn of the century, followed by a period of slower growth thereafter.

The pace of that growth though differs by country. USDA data, for example, suggests that TFP for agriculture in New Zealand grew by an annual average 1% between 1962 and 1999, falling to an annual average of 0.1% from 2000 onwards. That is a little bit lower than Australia, which saw TFP growing by an average 1.7% before the turn of the century and 0.9% thereafter. It's also lower than the 1.3% and 1% annual average growth achieved by high-income countries more generally.

There are various reasons why growth rates differ by country. Some of it has to do with statistical base effects. Countries that have already achieved high levels of agricultural productivity and are already close to their ecological limits, find it difficult to post large gains. That many explain, why for example, why middle- income countries typically show much larger agricultural productivity gains than their high-income counterparts.

Some it also has to do with the fact that in countries like New Zealand, much of the high quality land available for farming has already been fully utilised. Further productivity gains from this land can still be made by adopting new digital technologies, but the reality is that in most of these countries, the biggest gains are likely to come from better utilising low quality marginal land.

Other factors that might explain differences in growth include the rate of adoption of productivity enhancing technologies. Historically New Zealand has been quick to embrace technologies that improve animal and pasture genetics, stocking rates, production per head, production per hectare, as well as processing and supply chain efficiencies. It has also a well-earned reputation for employing highly innovative farming practices. Whether that remains the case given the exponential growth in new digital technologies is a moot point.

Then, of course, there is the impact of climate change. Climate variability is not only changing what is being a produced, but increasingly where it is being produced. Broader concerns about climate change and environmental sustainability, as well as the actions taken by governments to address these, also loom large.

What is needed to give productivity a boost?

The question then is what can be done to steepen the productivity growth trajectory of New Zealand agriculture. As price takers, achieving higher productivity gains are important if farmers are to achieve lower unit costs of production that result in better profitability, higher standards of living and improved wellbeing.

Typically, these gains can be achieved by changing the combination of factor inputs used to deliver outputs. This is about changing the volume or quantity of different inputs in the production mix to deliver maximum greatest output gains. In the case of agriculture, that's reflected in the already mentioned increase in the capital-to-labour ratio, evidenced in large part by the adoption of new machinery without a concomitant increase in the workers.

Gains, however, can also be achieved by changing the quality of factor inputs used in the production process.

In the case of labour, that is about improving the skills and competencies of the workforce. On the job learning has always been a feature of agriculture. Education is also becoming increasingly important as farmers seek to bridge their lack of understanding of how digital

technologies can deliver smarter and faster operations that not only make their lives easier, but also more productive. Assuming they have access to suitable equipment, higher skilled workers are typically able to do higher value-added work than their semi- and lower skilled counterparts, and as such are deemed to be more productive.

For capital, it's about improving the capabilities of machinery, plant, and equipment as well as land, and livestock. One way of doing that, for example, would be to remove the ban on genetically modified organisms (GMO). The introduction of GMO globally has significantly increased crop yields, allowing more food to be produced from a given piece of land. That said, introducing GMO is contentious, raising several ethical, political, economic, environmental, and social concerns that would have to fully considered when contemplating whether New Zealand should move in that direction. To that end, a rigorous cost benefit analysis that accounts for any externalities would be required.

In terms of ramping up capabilities, agri-tech looms large. According to its Industry transformation plan,[2] the agri-tech industry refers to manufacturers, biotech and digital technology firms that create products, services, intellectual property, and supply chain solutions for the broader agricultural sector.

From the viewpoint of farmers, agri-tech is about the on-farm application of digital technologies and tools. Specifically, it's about farmers and growers using cutting edge-technologies and data driven approaches to optimise logistics and on-farm efficiencies, increase yields, reduce unit costs, and boost sustainability. This represents a paradigm shift from past practice, where the focus has tended be on investing in farm machinery that embodied the latest technology. That still is important, but it is not the sole focus.

Agri-tech in New Zealand.

It's a big industry. According to Agritech New Zealand, there are between 700 to 900 firms in the agri-tech sector, generating revenues of between $2bn to $3bn per year.

According to Technology Investment Network (TIN), the top 22 agri-tech firms in New Zealand, which includes the likes of the Gallagher Group, Livestock Improvement Corporation (LIC) and TOMRA Fresh Foods, generated about $1.6bn in revenues in 2021. Most of that was concentrated in data analytics, post-harvest management and animal and crop health. The sector is also home for many new startups.

Source: Agritech New Zealand, TIN

According to Agritech New Zealand's Baseline of Digital Adoption in Primary Industries report published in 2022,[3] the use of technology by farmers and growers in New Zealand compares favourably with that of many other countries that have a large agricultural base. The report also suggests that most farmers in New Zealand are, to varying degrees, open to the adoption of new technology, and as in most industries, there is also a sizeable group of enthusiastic adopters.

That said, the same report also suggests that digital technology adoption in agriculture lags other sectors in the economy, and points to a significant proportion of farmers/growers in New Zealand who see little value in using digital technologies and are more likely to cling to the tried and trusted. That said, while many of these farmers have little understanding of these new technologies and what they can offer, they are still open to their third-party service providers using them.

Importantly, the report goes on to suggest that adoption of digital technologies should be considered in the context of changes in farming practices. Adopting technology is one thing, but making it work in a way that maximises productivity is quite another.

Smart farming is key to maximising productivity gains.

Smart farming looms large in this regard. Otherwise known as farming 4.0, smart farming refers to the use of connected digital technologies or agri-tech that enables the real-time monitoring, measurement, and analysis of on-farm performance, as well as the optimisation of farming practice.

Examples include the use of sensors, drones with infrared technology, and RFID for livestock biometrics, to monitor the health of individual livestock in real time. Similarly, humidity and soil sensors allow for the ongoing monitoring of soil conditions, while drone and satellite imagery are useful for large-scale measurement of moisture, temperature, and nutrient levels. Digital technologies are also used to monitor the day-to-day care, management, production, nutrition, selective breeding and raising of livestock, as well as the growing and harvesting of crops and fruit.

Smart farming also encompasses the ability to turn real-time data generated from these monitoring activities into actions. In the first instance that requires big data capabilities and access to cloud computing. In the second, it requires a data analytics capability that moves beyond just describing and diagnosing what has already happened – that can already be done on simple spreadsheets, to predicting and even prescribing what will happen in the future. Better forecasts in turn lead to improved activity planning and optimised farming practices.

2 Growing innovative industries in New Zealand: Agritech industry transformation plan – June 2023 (mbie.govt.nz)
3 Primary industries digital adoption report released (fertiliser.org.nz)

Smart farming.

Benefits.

- Improved efficiencies
- Increased productivity gains
- Lower unit costs of production
- Increased production
- Improved accuracy and financial forecasting
- Improved sustainability
- Lower use of natural resources, including pesticides and chemical fertilisers

Drawbacks.

- Can increase use of non- chemical fertilisers
- Reduced requirement for labour, lowering wages

Source: Agricultural recruitment specialists, Monarch Tractors

Smart farming technologies though extends further still. Sensors, artificial intelligence (AI), augmented reality (AR), robotics process automation (RPA), and the Internet of Things (IoT) are increasingly being used together to automate farming practices, such as soil maintenance, weeding, fruit picking and post-harvest packing, crop planting and harvesting, irrigation, feeding, and milking. Examples include robots that pick apples and kiwifruit, increasing level of automation in kiwifruit packhouses, automatic milking systems and heat detection in dairy cattle to enhance reproductive performance.

Farmers that adopt these technologies, don't operate in isolation. Smart farmers typically operate within ecosystems of connected suppliers, buyers and other stakeholders that operate at each point in the food value chain, including technology partners as well as research and development service providers. That in turn encourages greater operational agility and increased resilience to unforeseen events – a critical success factor for any price-taking farmer.

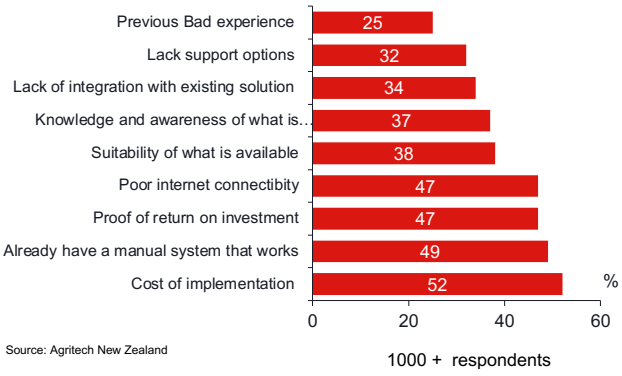
That is in addition to progress in other areas. Cutting edge genomics, DNA sequencing and precise genome editing technologies, for example, have long been used to improve the resilience of crops. Now they are being used to increase resilience to climate change. As far as livestock is concerned, genomics are being used to predict milk yields, the ease with which future generations will reproduce and susceptibility to disease. In conjunction with data analytics that allows for better decision making on breeding options, which in turn makes livestock more productive and profitable.

But that is just the start. Farmers are also tapping into natural sustainable alternatives to chemical drugs to reduce their impact on the natural environment. Increasingly they are using microbes to enhance crop and animal growth, suppress pathogens and improve the soil health. They are also using engineered micro-organisms to provide specific functions, such as improving soil health, reducing fertilizer use and increasing crop yields.

Barriers to adoption

While smart farming may seem to be the way forward for delivering productivity gains, adopting it can prove challenging.

Figure 5: Significant barriers to adopting digital technology



Some farmers don't see the benefits of digital technology and are happy to stick to their tried and trusted approaches to farming. In some cases that is by design. For most though it reflects a lack of knowledge about what digital technologies can offer in terms of agricultural productivity gains.

Education is key to addressing this deficiency. One option might be to create innovation ecosystems that facilitate knowledge transfer not just between farmers, but also with the agricultural science community (primarily universities and Crown research institutes), the government, and agricultural professionals (such as those that operate within the agri-tech sector).

A common request from farmers is that they need more research before they adopt new technologies. However, in many cases that research will already have been undertaken, but often remains in academic circles and/or is in a format that is difficult for farmers to comprehend. What is needed here are new and different forms of communication between the agricultural science community and farmers. One option might be open-source platforms that provide research material in an accessible format.

There are other obstacles. The big one of course is cost. Adoption of smart farming technologies often involves significant upfront investment, which can be prohibitive, especially when returns on that investment are uncertain or take time to materialise. Indeed, most farmers require some proof of return on investment before taking the plunge and will typically follow the lead of others that have done so. Financial solution providers that can provide services that ease the burden of having to make this upfront investment are likely to have role

here. One particular area might be where farmers are looking to invest in smart technologies that enhance the sustainability of their operations and reduce emissions.

There is also the cost and complexity associated with integrating smart farming technologies with existing systems. Compatibility issues are commonplace, can cause major disruptions to existing operations, and represent a significant barrier to adoption. With smart farming relying heavily on data, many farmers are also concerned about data sharing and privacy.

And that is before considering the skills and competencies needed to operate in digital world. A key constraint to adoption is a lack of wherewithal, with digital skills and capabilities typically in short supply. Although not specific to agriculture, this lack of digital awareness is likely to become more acute as the pace of technology continues to quicken.

That said, New Zealand's farmers have a long tradition of innovation and leading the way in new farming practices. While the obstacles to adopting smart farming are real, there is no reason why they cannot continue this tradition.

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