27 and Ewe: Evaluating the Case and Appetite for Genotyping the NZ Commercial Sheep Flock

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Executive Summary

Genomics remains underutilised in the New Zealand sheep sector, with adoption historically confined to stud breeders. This project explores the potential for genotyping commercial ewe flocks, not as a silver bullet for a single problem, but as a multi-benefit tool to achieve stacked benefits to improve productivity, resilience, welfare, and market positioning.

Using a mixed-methods approach (literature review, semi-structured interviews, and a national survey of commercial sheep farmers), findings indicate that while there is appetite and early signs of justification for genotyping a proportion of the commercial ewe flock, market failure and preventative costs exist, resulting in underinvestment at the farmer level.

Genotyping is more than a technical upgrade; it is a strategic lever for industry transformation. It enables cumulative genetic gain, earlier and more accurate selection and supports traceability and biosecurity. However, adoption is constrained by cost, infrastructure, and stakeholder alignment. International models such as Ireland's ICBF and Australia's MERINOSELECT demonstrate the value of coordinated investment, robust reference populations, and farmer-led governance.

Analysis of survey and interview responses using the ESC (Environment–Strategy–Capability) gap framework highlights gaps in value-chain communication, data governance and practical logistics. Bridging these gaps will require not only technological innovation, but also ethical governance, workforce capability development, and inclusive extension strategies. Based on survey responses, farmers are confident in genotyping delivering on productivity and animal health gains but remain cautious about market premiums and the lack of direct, short-term return on investment

Recommendations that are more specific to the uptake of genomics by commercial sheep farmers are:

1. Do case studies on lower cost options and potential benefits (e.g. flock sample profiling, parentage-only genotyping) and build a farmer-friendly customisable ROI calculator. This could be done by B+LNZ and/or as part of a post-graduate student project and would ideally be done in the next 12 months.
2. Prioritise farmer pain point traits (e.g health traits – starting with parasite tolerance and facial eczema) for both reference population development/expansion and as an extension pathway. This would ideally be a focus over the next 3-5 years. B+LNZ are an obvious enabler of expanding relevant reference populations and also co-designing and developing extension resources alongside farmers, private consultants and other trusted advisors.
3. Co-design validation tools (e.g. scorecards) for market-valued traits with processors, banks & farmers within the next two years.
4. Genomics providers to co-design and develop farmer-ready tools, packages and systems; bundle sampling kits, services and staged or subscription payment options, so farmers receive usable decision tools, rather than having to wrangle data.
5. Explore co-investment models (government + industry) to correct market failure and incentivize adoption in the next 12 months.

Explore co-investment models (government + industry) to correct market failure and incentivize adoption. Freeing access to genotypes and phenotypes has the potential to disrupt traditional ram breeding models, raising equity concerns for phenotype contributors. Governance frameworks must ensure fair reward and prevent fragmentation. With a

shrinking national flock, unity and critical mass are essential to maintain competitiveness and confidence.

With coordinated investment, fair governance and practical tools, genotyping has the potential to strengthen profitability, resilience and market confidence.

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Introduction

Genotyping is the process of reading an animal's DNA, typically from a small tissue sample such as an ear notch. It can be used to determine parentage and identify the presence or absence of specific genetic markers. Genomic selection analyses thousands of DNA markers to predict an animal's genetic potential more accurately than traditional methods, producing genomic breeding values (gBVs) that enable earlier and more informed breeding decisions. (Martinez, Abanto, Dias, Olate, Nunez, Diaz, Sepūlveda, Paz & Quiñones, 2025). Since its introduction in 2001, genomic selection has been widely adopted globally, accelerating genetic progress and reducing reliance on traditional trait measurement (Burrow & Goddard, 2023). Tools like Sheep Genetics Australia's Flock Profile now allow farmers to benchmark their flocks using average EBVs, even without individual performance records.

Genomic technologies are increasingly recognised as transformative tools in livestock industries, offering opportunities to enhance genetic gain, traceability, disease resilience, and market alignment. Yet in New Zealand, genomics remains underutilised in the sheep sector. The commercial ewe flock and its progeny, which are central to the national breeding pyramid, have not been systematically genotyped, despite the availability of these technologies for over a decade.

What makes genotyping powerful is its timing, as it can be done before an animal reaches maturity, allowing farmers to make early informed decisions about which animals to keep, breed, or sell, based on genetic merit, not just appearance or pedigree.

Despite these advances, uptake of genotyping and Electronic Identification (EID) in New Zealand's commercial sheep sector remains low. New Zealand's sheep industry, though shrinking, remains a cornerstone of the national economy (Johnson, Newman, McRae, van der Weerden, Brown & Scobie, 2021). The decline from 57.9 million sheep in 1990 to 23.6 million in 2024 (StatsNZ, 2025) underscores the need for strategic, high-impact investment in innovation and any further decline in the scale of the sector may compromise the ability to invest in significant innovation at the industry level going forward. Increased application of genomics, including genotyping some or all of the commercial flock offers one such opportunity not just for genetic gain, but for improved market access, traceability, biosecurity, and trading confidence.

This report explores the feasibility, benefits, and barriers to scaling genotyping across the commercial sector.

Purpose

The aim of this report aims to inform strategic decision making in the New Zealand sheep industry by evaluation opportunities, risks and barriers associated with adopting genotyping and genomic selection of the New Zealand commercial sheep flock.

Research Questions

1. Is there a strategic case for genotyping the New Zealand commercial ewe flock?
    a. What is the level/appetite for stakeholder adoption?
    b. What are the potential opportunities?
    c. What are the potential risks and barriers?

Methodology

This project used a mixed-methods approach to evaluate both the technical feasibility and stakeholder appetite for genotyping. Data sources included a literature review, a national commercial farmer survey and semi-structured interviews with industry stakeholders. Mixed methods are recognised as a robust approach, allowing for triangulation of qualitative and quantitative data to enhance validity and depth of insight (Dawadi, Shrestha, & Giri, 2021; Dossett, Kaji, & Dimick, 2020).

The survey gathered core demographic data, before asking respondents to select from multiple choice and scenario-type question. There were also some long/open answer questions. The survey questions can be found in the Appendices section of this report. Responses were obtained from 65 farmers.

The interviews were semi-structured and 9 interviews were conducted, from a range of genetics experts, and other industry stakeholders including a rural banking professional, meat processor representative, and a commercial farmer.

Findings were synthesised using strategic analysis frameworks to identify themes, gaps and inform recommendations. Thematic analysis was used for qualitative interview data, to identify recurring patterns and themes, and is a method recognised for its systematic approach to coding and interpretation (Braun & Clarke, 2023). PESTEL Analysis was applied to evaluate external macro-environmental factors (Political, Economic, Social, Technological, Environmental) (Belsare, 2025). Finally, ESC (Environment-Strategy-Capability) Gap Analysis was used to assess alignment between current industry practices and desired industry practices, highlighting gaps and strategic priorities (Hubbard, Rice & Galvin, 2018).

Literature Review

Introduction

Genomic technologies have had significant impacts on livestock breeding globally, offering tools to accelerate genetic progress and improve resilience in production systems. At their core, these technologies use DNA information to predict genetic merit with greater accuracy than traditional pedigree and performance-based methods.

International experience shows that genomic selection is now embedded in many livestock breeding programs, supported by national reference populations and coordinated investment. These systems demonstrate how genomics can deliver cumulative genetic gain and align with market and regulatory demands for sustainability and welfare.

Despite these advances, adoption in New Zealand's commercial sheep sector remain limited. Understanding why requires examining technical principles, economic viability, governance models and extension strategies reported in the literature.

Opportunities

Genetic improvement

Genotyping provides a powerful lens through which commercial sheep farmers can assess the genetic merit of their flock and generate estimated breeding values, without needing an animal's own performance records (Banks, 2024). This allows earlier and more accurate selection, especially for traits that are low heritability, expressed late in life, or difficult/expensive to measure (van der Werf et al., 2014). Genotyping enables benchmarking of flock performance, helping farmers identify genetic variation and make more informed decisions about replacements and mating (Sheep Genetics, 2005).

Genetic improvement is both permanent and cumulative. Once superior genetics are introduced into a flock, they persist and compound over generations. In U.S. dairy cattle, genomic selection increased annual genetic gain by 50-100% for high-heritability traits (e.g., milk yield) and by 300-400% for low-heritability traits (e.g., somatic cell count and fertility) (García-Ruiz et al., 2016). In New Zealand, integrating commercial flock data into reference populations could materially boost genetic gain, especially for traits like facial eczema tolerance and internal parasite resistance (Banks, 2024).

In New Zealand's sheep sector, genetic improvement has traditionally relied on stud flocks, with limited flow of superior genetics into commercial populations. This creates an estimated genetic lag of 5–8 years between tiers. This estimation assumes that rams transferred from the nucleus to the commercial tier are the average of those born in the same year in the nucleus (Blair and Garrick, 2007). Santos et al. (2017) showed that implementing performance recording and genotyping in the multiplier tier reduced this lag by 2–3 years, accelerating the flow of genetic merit to commercial animals which can increase the rate of genetic gain across flocks and industry.

Genomic selection also helps avoid unintended consequences. A study on U.S. Holstein cattle revealed that decades of selection for milk yield inadvertently reduced fertility and immunity. Genomic analysis showed that regions selected for production were linked to negative effects on health traits (Misztal & Lourenco, 2024). Van der Werf et al. (2011) and Van Marle-Köster & Visser (2021) highlight that genomic selection enables breeders to monitor a broader range of traits, including welfare and longevity, reducing the risk of unbalanced selection.

Genotyping also allows commercial animals to contribute valuable phenotypic data to national breeding programs, strengthening genomic prediction models and improving breeding value accuracy.

Case Study: Parasite Resistance

Gastrointestinal nematodes (GINs) are a major health and productivity challenge in sheep farming globally, including New Zealand. Infected animals suffer from anaemia, weight loss, reduced growth, and in severe cases, death. Triple drench resistance, where parasites are resistant to all three major drench families, is now a reality on many New Zealand farms (Techion, 2024). A case study modelling the cost of drench resistance estimated potential losses of up to $96,390 per year for a hill country sheep and beef operation if resistance is left unaddressed (Beef + Lamb New Zealand, 2024).

Traditionally, breeding for parasite resistance has relied on phenotypic data such as faecal egg counts (FEC) conducted after parasite exposure. This process is labour-intensive, costly, and ethically complex when applied at scale (Notter, 2017). Genomic selection enables the development of genomic prediction equations using a reference population, a group of animals that are both genotyped and phenotyped for traits like FEC. Once these equations are established, genomic breeding values (GEBVs) can be calculated for other animals using only DNA data, without the need for repeated parasite challenges or FEC testing (Swan, 2012). This approach allows for earlier and more accurate selection. In practice, this means that a smaller number of animals, such as those in a central progeny test or reference flock, can be challenged and sampled to generate genomic prediction models. These models can then be applied to a much larger population of commercial and stud animals, enabling selection for parasite resistance without direct phenotyping (Weaver, Weeks, & Bielek, 2021).

However, genomic predictions are only as accurate as the reference population they are based on. Maintaining and updating this population is essential to ensure prediction accuracy over time, especially as genetic relationships between reference and industry animals diverge (Swan, 2012). Additionally, parasite resistance is a polygenic trait with small individual marker effects, meaning that ongoing FEC recording may still be necessary to refine prediction models and validate breeding decisions (Notter, 2017).

Genomic selection also supports other hard or difficult to measure traits such as facial eczema (FE) tolerance, meat eating quality, feed use efficiency, ewe longevity, and methane emissions. Romney breeders farming in high-risk FE regions, have used RamGuard testing since the early 1980s. Their rate of genetic gain in FE tolerance nearly doubled after incorporating genomic selection into their breeding programs from 2012 onward, while also improving maternal traits (Amyes et al., 2018).

Food safety, security and market and consumer provenance

Genotyping and EID are key enablers of traceability, food safety, and market access. They support farm-to-fork tracking, disease response, and origin verification (Baird et al., 2021; FAO, 2022; McEwan et al., 2022). DNA-based traceability allows authorities to quickly identify and isolate contaminated products, reducing the spread of disease and economic fallout. For example, the USDA estimates that rapid traceability can reduce the economic impact of a disease outbreak by up to 90%. In New Zealand, where agricultural exports are central to the economy, such capabilities are critical for maintaining market access and public trust (USDA APHIS, 2025).

International markets increasingly require traceability as part of import protocols. Countries like Japan, South Korea, and the EU mandate traceability for red meat imports. Genomic traceability systems, such as Ireland's Irish Cattle Breeding Federation (ICBF), have demonstrated how verified genetic data can underpin market access and consumer trust (ICBF Annual Report, 2022; FAO, 2023). In New Zealand, integrating genotyping into traceability frameworks could help meet evolving trade requirements and differentiate products in premium markets (Banks et al., 2022; Teagasc, 2021). Genomics also detects food fraud and contamination, verifying species and ingredients in meat and dairy products (Laliotis et al., 2023; Zhao et al., 2025; Yang et al., 2022).

Consumer research suggests a willingness to pay premiums for meat with traceability attributes (Dickinson & Bailey, 2002). However, these studies typically assess traceability systems as a whole and do not isolate the impact of genotyping or EID specifically. Willingness to pay also varies by market and product type but increases significantly when traceability is bundled with other attributes such as humane treatment or verified health claims (Umberger et al., 2009).

Traceability adoption is limited by cost, integration challenges, and infrastructure gaps (FAO, 2022; Ministry for Primary Industries, 2023). Implementing traceability systems on farm incurs costs, particularly for commercial farmers. A U.S. study found that a national traceability program would require a 1.9–17.7% increase in beef demand to offset producer costs (Shear & Pendell, 2020). Genomics has the potential to provide food safety, security and market and consumer provenance as one of multiple benefits, thereby spreading the cost across those benefits. However, the rewards of providing this information is usually captured further along the value chain, despite the upfront investment required by the producer to produce genetically verified claims.

Biosecurity Applications

New Zealand's stringent biosecurity system is vital to protect exports and animal welfare. However, the sheep industry remains vulnerable to disease incursions, emerging pathogens, and endemic conditions that impact productivity, welfare, and trade.

Genotyping the commercial sheep flock offers a strategic tool to strengthen surveillance, enable early detection, and improve outbreak response. It improves disease tracking and supports population-level surveillance by identifying animals with natural resistance dynamics (McRae et al., 2021). It complements existing systems and provides deeper insight into disease. Ireland's integration of genomics into national cattle health programs, such as breeding for resistance to tuberculosis and liver fluke, demonstrates the potential of combining genetic profiles with health data to improve biosecurity outcomes (Irish Cattle Breeding Federation [ICBF], 2019). In New Zealand, genotyping aligns with MPI's strategic priorities for climate resilience and pest risk modelling (Meurisse, 2024), positioning the sheep sector to meet future trade and biosecurity expectations.

In the event of a disease incursion, genotyping enables rapid identification of at-risk animals, containment zones, and genetic carriers. It can also prioritise vaccination or culling strategies. This capability is especially valuable in New Zealand, where early containment is critical to protecting export markets and animal welfare (AgResearch, n.d.; FAO, 2022).

Decoupling of phenotyping from selection

Genomic selection has fundamentally reshaped livestock breeding programs by enabling the estimation of genetic merit using DNA data alone, provided a robust reference population exists (Meuwissen, Hayes, & Goddard, 2016). This innovation allows selection decisions to be made independently of an animal's own performance records or those of its relatives, marking a significant shift from traditional breeding approaches.

This shift allows breeding programs to be redesigned. Selection can occur earlier, and phenotyping efforts can be concentrated on reference populations rather than stud flocks (Banks, 2024; Swan, 2012). For New Zealand, this reduces the cost and labour of on-farm data collection, broadens access to genetic improvement, and supports national indexes for traits of economic and environmental importance.

However, this shift has the potential disrupt traditional stud breeding and business models, opening up the possibility of commercial farmers genotyping commercial ram lambs to use as sires, reducing the number of rams they purchase from stud breeders each year. This emphasises the importance for a strategic and ethical framework to be established to ensure equity and value return for those who have contributed phenotype data (Banks, 2024).

The decoupling of phenotyping from selection represents a paradigm shift in sheep breeding. It offers opportunities to reduce costs, improve selection accuracy, and democratize access to genetic improvement. However, Banks (2024) emphasises that decoupling phenotyping from selection requires strategic planning to ensure hard-to-measure traits are still measured. Maintaining reference populations is essential to keep genomic tools accurate.

Economic Viability

The economic viability of genotyping commercial sheep flocks depends on cost, genetic gain potential, access to associated premiums and strategic implementation. Simulation studies show that genotyping in the multiplier tier can significantly increase genetic gain and reduce genetic lag between stud and commercial tiers by up to two years (Santos et al., 2017). However, at 2017 pricing, breakeven was only achieved after 18–29 years unless genotyping costs dropped to NZD \$10–\$25/head, in which case breakeven occurred within 9–11 years. Current prices for parentage-only genotyping is in the range of \$10-20/lamb, with low-medium density genomic tests starting around \$34/head (Totogen, 2025; Zoetis, 2025)

Modelling studies show that genomic selection can be more profitable than traditional methods, especially when supported by phenotypic data and robust reference populations (Shumbusho et al., 2016). Their modelling showed that genomic selection could be up to 15% more profitable than classic selection approaches, provided a reference population was in place. In commercial Merino systems, Rose et al. (2023) demonstrated that genotyping could improve selection decisions and deliver measurable economic benefits, especially when used to inform replacement and culling strategies. However, they also noted that the cost-benefit ratio was highly sensitive to genotyping prices and the accuracy of selection, reinforcing the need for tactical implementation. Selection pressure on ewes is often limited, reducing the impact of genotyping unless replacement strategies are optimised (Santos et al., 2017). This may help explain the slow uptake of genotyping in commercial flocks, particularly where replacement rates are high and selection intensity is low.

Importantly, the benefits of genomic selection are non-linear. Genotyping a small proportion of animals can yield a large share of the potential gain. For example, genotyping the top 25% of male lambs in a Merino breeding program increased genetic gain by 13%, while genotyping 50% increased it by 18%, and genotyping all males increased it by 26% (Berry & Spangler, 2024). These diminishing returns suggest that optimal sampling thresholds exist, beyond which additional genotyping yields marginal gains.

Low-density SNP panels combined with imputation from high-density reference animals have emerged as a cost-effective strategy, maintaining prediction accuracy while reducing per-animal costs (Berry & Spangler, 2024). Smaller, cheaper SNP panels are used, then statistical imputation fills in the missing data by comparing these animals to a reference population that has been genotyped using high density panels. This method delivers nearly the same accuracy as full high-density genotyping, but at a significantly reduced cost, which could make large scale genomic programs more affordable and practical for commercial flocks. There is on-going work exploring other more cost-effective genomics strategies (Mohamed et al. 2025).

While full-flock genotyping is rarely justified by traceability alone (Banks et al., 2022), ancillary benefits such as genetic gain, improved selection accuracy, and enhanced management decisions strengthen the economic case. National schemes may be viable if broader industry benefits are considered, particularly if supported by fee schedule optimisation and throughput growth (Berry & Spangler, 2024). However, widespread adoption by commercial farmers and stud breeders will depend on continued reductions in genotyping costs, robust reference populations, and alignment with industry priorities.

Stakeholder Appetite

The success of genotyping New Zealand's commercial ewe flock depends not only on technical feasibility and economic viability, but also on stakeholder support and social license. Farmers, processors, banks, government agencies (e.g., MPI), and consumers all influence adoption.

Surveys and interviews reveal moderate to strong interest in genomic traceability, especially among processors and vertically integrated companies. Cost, complexity, and data ownership are key barriers (Banks et al., 2022).

Farmer attitudes toward genotyping are mixed. While some see it as a pathway to improved productivity and resilience, others remain cautious due to upfront costs, perceived complexity, and uncertainty about return on investment. Generational differences are evident, and younger farmers tend to be more open to genomic technologies, while older farmers often rely on traditional visual assessment and breeding methods. Cultural resistance to change and peer influence also shape decision-making, with many farmers prioritising short-term outcomes over long-term strategic investments (Van Eenennaam, 2025).

According to MPI's 2024 technical paper on Climate Change: Trade and Biosecurity (Meurisse, 2024), the agency emphasizes the importance of future-proofing New Zealand's readiness and response plans by integrating climate, trade, and pest risk modelling, and it could be argued that genotyping commercial sheep could contribute to that. In the Biological Emissions Reduction Science and Mātauranga Plan (April 2023), MPI identifies "low emission animal genetics" as one of the priority emissions mitigation solutions for acceleration

System Design and Governance

Equity and value-sharing are essential for the long-term sustainability of genomic systems in New Zealand's sheep industry. Stud breeders, who have historically contributed costly phenotypic data, must be fairly rewarded if their data is used to benefit the wider sector (Burrow & Goddard, 2023; Lee et al., 2021).

To address this imbalance, Banks (2024) and Berry and Spangler (2024) propose a levy-rebate model, where commercial farmers and breeders who do not contribute phenotypic data pay a per-head levy that is redistributed to those who do. This approach helps avoid free-rider risks and creates a fairer, more transparent ecosystem for data sharing. It also incentivizes high-quality data collection, which strengthens the national reference population and improves breeding value accuracy (Banks, 2024; Berry & Spangler, 2024).

Successful models for phenotype contribution include Central Progeny Tests (CPTs), processor feedback systems, and disease challenge studies (Lee et al., 2021). Despite the value of these contributions, concerns around data ownership and privacy remain a barrier. Farmers may be hesitant to share genetic data without clear agreements on who owns the data, how it will be used, and who benefits. Fears of corporate control or misuse of data can reduce trust in genomic programs (Johnsson, 2023). Ethical frameworks are essential to ensure fairness in genomic systems. These are discussed further in the Ethical Considerations section.

System design and governance must balance innovation with fairness. Genomic progress depends not only on technical capability, but also on ethical stewardship, inclusive participation, and transparent value-sharing mechanisms. Without these, the risk of fragmentation, mistrust, and inequity may undermine the potential of genotyping to transform the New Zealand sheep industry.

Funding Models

Implementing genotyping across New Zealand's commercial ewe flock requires significant investment, coordination, and long-term commitment. Three main funding models are discussed.

Industry-Led Investment

New Zealand has a strong tradition of farmer-led cooperatives. Livestock Improvement Corporation's (LIC) investment in dairy genomics demonstrates how scale and shared ownership can support reference populations and infrastructure (Spelman et al., 2020). In the sheep sector, Beef + Lamb NZ Genetics has led initiatives like Cool Sheep and Central Progeny Tests. However, industry-led models can face fragmentation, limited capital, and slow uptake without clear commercial incentives (Burrow et al., 2021).

Public-Private Partnerships (PPPs)

PPPs leverage government funding alongside industry expertise. Pastoral Genomics and DairyNZ's Industry Working Group recommend shared responsibility, national reference populations, and improved transparency. This model could be adapted for the sheep industry, with coordination between B+LNZ, MPI, breed societies, and service providers (DairyNZ, 2024).

Private Investment and Commercial Models

Private companies may invest in genotyping to develop proprietary breeding lines, genomic services, or traceability platforms. Commercial models can accelerate innovation by injecting capital, technical expertise, and market-driven incentives into breeding programs. In sectors like poultry and swine, private breeding companies have driven substantial productivity gains through focused investment and integration of genomic data into selection programs (Narrod & Fuglie, 2000).

However, while private investment can accelerate innovation, it raises concerns about data ownership, equity of benefit distribution, and market concentration. Commercial models may underinvest in traits that lack immediate market value but are important for long-term sustainability, such as climate resilience or animal welfare (Narrod & Fuglie, 2000; Bruford et al., 2015). Another major concern is the potential for market concentration, where a few firms dominate access to genomic tools and data, limiting competition and farmer choice (Narrod & Fuglie, 2000). This can lead to inequitable distribution of benefits, especially if proprietary platforms restrict access to breeding values or impose prohibitive costs on smaller producers

International experience suggests that private investment is most effective when built on publicly funded reference populations and open data infrastructure. Examples include France's meat sheep program and Australia's MERINOSELECT, both supported by national coordination and farmer-led governance (Raoul, Swan, & Elsen, 2018). A hybrid model, combining public funding, industry leadership, and private innovation, is likely the most effective path forward for New Zealand. It aligns with the country's collaborative innovation culture and ensures genomic tools remain accessible, equitable, and strategically aligned.

Data Management

Genomic selection relies on good data, not just DNA, but also information about animal performance, pedigree, and environment. For genotyping to deliver value in New Zealand's commercial sheep sector, this data must be well-organised, secure, and easy to use (Berry, 2023). Farmers are often hesitant to share genetic data without clear agreements on ownership, use, and benefit-sharing. International models recommend transparent data-sharing agreements and systems that reward contributors (Banks et al., 2022; Genomics Aotearoa, 2023).

Publicly available genomic and phenotypic data can drive innovation, equity, and efficiency in livestock breeding, but must be managed carefully to mitigate risks related to privacy, ownership, and commercial viability. Transparent governance, ethical oversight, and stakeholder engagement are essential to ensure that open data serves both scientific progress and the long-term sustainability of livestock industries (Zhao et al., 2024; Thorogood & Chokoshvili, 2023).

Workforce Capability

Successful implementation of genotyping in New Zealand's commercial sheep sector depends not only on infrastructure and investment, but also on workforce capability. While New Zealand has world-class genomic research institutions, capability gaps remain across the broader agricultural workforce. These gaps include limited genomic literacy among farmers and rural advisors, a shortage of trained geneticists and data scientists in the sheep sector, and a growing need for cross-disciplinary skills that combine genetics, data analytics, and farm systems knowledge (DairyNZ, 2024; Roby Dodd et al., 2023).

To address these challenges, initiatives such as postgraduate training, extension services, and industry internships are being developed. B+LNZ Genetics has invested in applied science pathways and farmer education to improve understanding of breeding tools and genomic technologies (B+LNZ Genetics, 2024). Internationally, programs like the U.S. Agricultural Genome to Phenome Initiative (AG2PI) and Genomic Literacy, Education and Engagement (GLEE) offer models for integrating education into national genomic strategies (Zimani et al., 2021; NHGRI, 2017) that involve targeted upskilling programs, co-designed with industry, and delivered through accessible formats such as field days, online modules, and peer-to-peer learning.

Ethical considerations also intersect with workforce capability. As genomic data becomes more central to breeding decisions, those involved in data collection, analysis, and interpretation must be trained in ethical governance, privacy protection, and responsible data use. This includes understanding consent protocols, data ownership rights, and the implications of genomic information for animal welfare and farm management (Kramer & Meijboom, 2022).

Ethical considerations

The expansion of livestock genotyping and genomic selection raises a range of ethical considerations that must be addressed to ensure responsible and inclusive implementation. One key issue is the potential disruption of existing industry structures. Genomic technologies can concentrate breeding power among a few elite operations or commercial providers, potentially marginalising smaller breeders and reducing diversity unless governance frameworks ensure equitable access (Kramer & Meijboom, 2022).

Data ownership and consent are also central. Farmers contributing genetic data may have limited control over its future use, especially if managed by commercial platforms. Transparent consent processes and clear data-use agreements are essential to maintain trust (Thorogood & Chokoshvili, 2023). Dynamic consent models, used in human genomics, may offer a pathway for livestock systems (Zimani et al., 2021).

Animal welfare must also be considered. While genomic selection can improve traits like disease resistance and longevity, it may also intensify selection for productivity traits that compromise health. Ethical breeding programs must balance productivity with welfare outcomes and avoid perpetuating traits that reduce resilience (Ishii, 2017; Nuffield Council on Bioethics, 2021).

Genetic diversity is at risk when genomic selection favours a narrow set of traits or relies heavily on a limited number of sires. Reduced diversity can undermine long-term resilience to disease, climate change, and market shifts. Conservation of genetic resources, including rare breeds and diverse genotypes, is essential for future adaptability and should be integrated into national breeding strategies (Bruford et al., 2015). Public gene banks and open-access genomic databases can support this goal but require sustained investment and coordination.

Public perception plays a significant role in shaping the acceptability of livestock genomics. While genomic selection is generally viewed as an extension of traditional breeding, gene editing and other advanced technologies often face scepticism due to concerns about unnaturalness, food safety, and ethical boundaries (Ishii, 2017). Transparent communication, stakeholder engagement, and education are essential to build public trust and ensure that genomic innovations align with societal expectations (Zimani et al., 2021).

Ethical frameworks for livestock genomics emphasise transparency in data use, informed consent from contributors, equitable benefit sharing, and respect for cultural values—particularly in Māori farming systems (Genomics Aotearoa, 2023; OECD, 2021). These principles are critical to building trust and ensuring inclusive participation in genomic programs.

Extension and Adoption

The adoption of genotyping and genomic selection by sheep farmers in New Zealand is influenced by a complex interplay of technical, economic, and social factors. One of the key barriers is limited genomic literacy among farmers and rural advisors, which affects their ability to interpret breeding values and integrate genomic tools into decision-making. Extension services play a critical role in bridging this gap by translating complex genetic information into practical, farm-level insights. Programs led by Beef + Lamb New Zealand Genetics have begun to address this need through workshops, field days, and online resources that explain genomic principles and demonstrate their economic value (AgResearch, 2023).

Farmer adoption is also shaped by trust in the technology and its providers. Studies show that farmers are more likely to adopt genomic tools when they are co-developed with industry, supported by peer networks, and embedded within existing breeding frameworks (Burrow et al., 2021).

Social and psychological factors, such as risk aversion, perceived complexity, and resistance to change can also play a role. As Agnew (2024) notes, the biggest barrier to technology adoption on farms is often not cost, but human readiness for change. Extension strategies must therefore go beyond information delivery to include relationship-building, peer learning, and long-term support. Farmer-led innovation groups and participatory breeding programs have shown promise in increasing engagement and uptake of genomic tools (Burrow et al., 2021).

The adoption of genotyping and genomic selection in sheep farming has traditionally relied on information-transfer models of extension, where advisors deliver technical knowledge through workshops, factsheets, and presentations. While these methods have value, they often assume that farmers must understand the science behind a tool to use it effectively. However, emerging evidence suggest that farmers can extract value from genomic technologies without needing to fully grasp the underlying genetics, much like how they use smartphones or AI-driven apps without understanding the algorithms. Tool-based approaches, such as decision-support platforms or mobile dashboards, offer an alternative pathway to adoption by simplifying complexity and embedding genomic insights directly into farm management workflows (Van Eenennaam, 2025; Addorisio et al., 2025). These tools can translate genomic data into actionable recommendations, such as which ewe lambs to retain or which rams to mate, using intuitive interfaces and visual cues. Compared to traditional extension, tool-based approaches may be more scalable, especially in extensive systems where time and access to advisors are limited.

A hybrid model combining digital tools with facilitated workshops and ongoing advisor support may be the most effective approach. This respects farmer expertise while enabling broader adoption of genomic technologies.

Conclusion

The literature supports a strategic case for genotyping New Zealand's commercial ewe flock, particularly through targeted approaches such as sire genotyping, flock profiling, and integration with national breeding programs. Genomic selection offers cumulative and permanent genetic gain, improved selection for hard-to-measure traits, and enhanced traceability, biosecurity, and climate resilience.

However, the adoption of genotyping is constrained by cost, infrastructure, and stakeholder alignment. Key challenges include fragmented data systems, limited genomic literacy, concerns around data ownership, and the need for equitable reward systems for phenotype contributors. International models such as Ireland's ICBF and Australia's MERINOSELECT demonstrate the value of coordinated investment, robust reference populations, and farmer-led governance.

Currently the cost associated with genotyping commercial sheep is cost prohibitive and no single benefit is likely to offset the cost of genotyping commercial sheep. However, as markets and technology evolve it is possible that the accumulated impact of multiple benefits may result in a compelling case for the strategic genotyping of commercial sheep in New Zealand.

Extension and adoption strategies must go beyond technical education to include practical tools, peer learning, and trust-building. Genomic technologies should be positioned not as replacements for farmer expertise, but as tools that enhance decision-making and resilience.

The literature highlights that genotyping is not a silver bullet, but a strategic lever for industry transformation. Its success will depend on inclusive system design, ethical governance, and sustained investment in infrastructure, capability, and farmer engagement.

Findings and Discussion

Survey Results

Demographics/Background

A total of 65 responses from 11 different regions were received from a survey that was distributed via personal and professional social media and email networks. The majority (75.4%) were commercial sheep farmers, with the remainder made up of sheep stud breeders and genetics specialists. 73.8% of respondents farmed 2000 sheep or more and received over half of their income from their sheep enterprise. 87.7% of respondents were aged 45 years old or older.

Interestingly, 50.8% of respondents did not currently have EID tags in sheep but were open to the idea, and another 44.6% had EID tags in some or all of their sheep. This percentage was higher than I anticipated and may reflect a self-selecting cohort of survey participants who already have an interest in genetics and the potential of EID tags, or it may in fact represent the sector.

Internal parasites, survival, growth, body condition score, and reproduction were the most frequently selected traits that respondents wanted to improve over the next ten years (Figure 1).

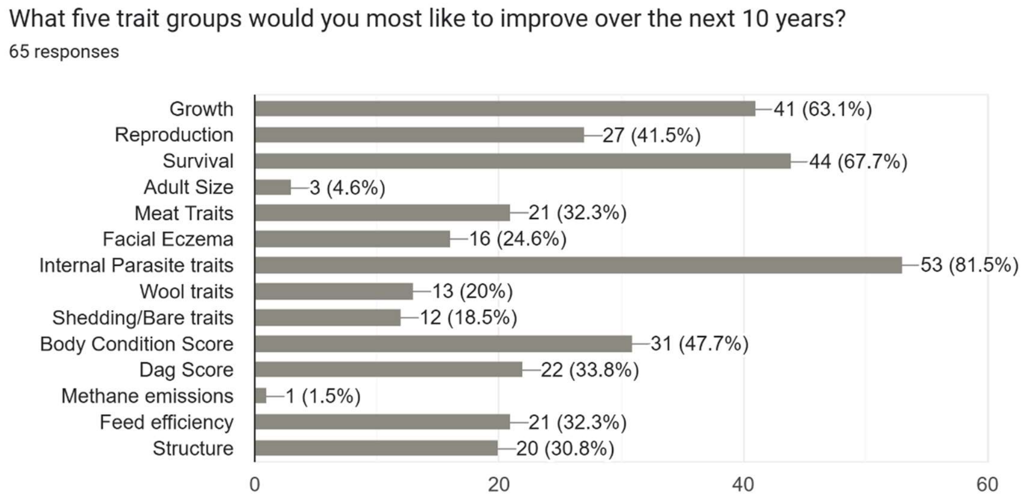

Figure 1. Five trait groups survey respondents would most like to improve over the next 10 years.

Potential Benefits

Respondents were most confident of the likelihood of genotyping commercial sheep to improve farm productivity and profitabilty and genetic improvement in animal health and wellbeing and genetic improvement in traits that reduce labour and improve ease of management. This suggests that farmers are most confident in direct, farm-level benefits that improve operational efficiency and genetic gain, rather than those dependent on external parties, such as processors. Respondents had the lowest confidence in genotyping commercial sheep improving social license to farm, and improving market access and premiums.

"Massive opportunity for farmers to make a considerable amount more profit with less work."

Potential Barriers

The most commonly selected barrier to adoption was "Cost" (83.1%). This was followed by uncertainty about "Return on investment" (47.7%) and "Doubts about market premiums" (40%) (Figure 2).

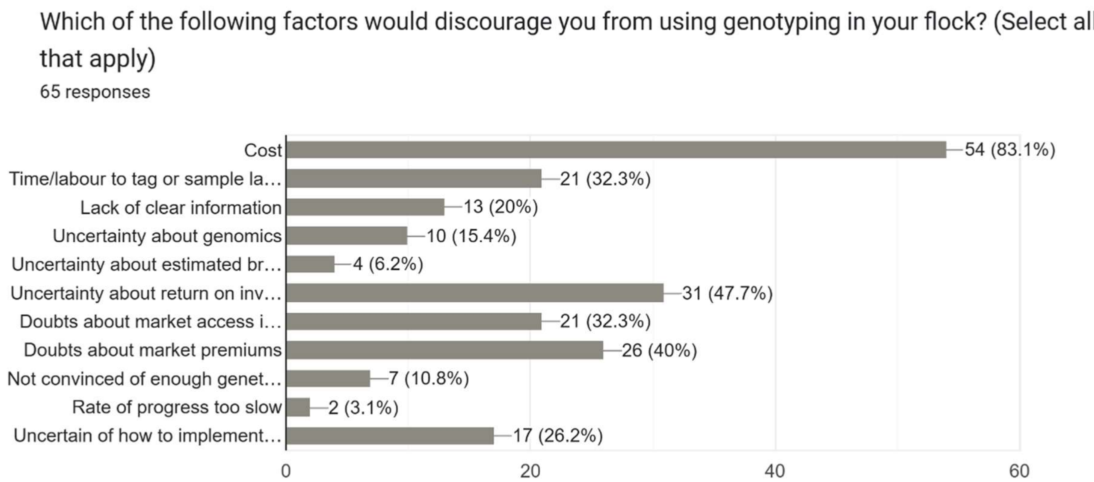

Figure 2. Factors likely to discourage survey respondents from genotyping their flock

An opportunity was provided for respondents to detail other factors that would discourage them from genotyping their commercial sheep. These responses reinforce that technical feasibility alone is not enough. Based on analysis of the survey responses, the following themes emerged suggesting what respondents considered would be required for genotyping to succeed in commercial sheep farming. This includes direct quotes relating to some of those themes:

1. Tag reliability and practical challenges
2. Cost and cashflow constraints
3. Labour and time requirements
4. Workforce capability and data literacy/burden
5. Farm scale and system fit
6. Knowledge and confidence gaps
7. Philosophical and strategic reservations

   "Could distract from the real profit drivers… too many people look for genetic solutions to management problems."

8. Trust in genomic prediction and governance

   "Genomics may become overly commercialised and locked out by proprietary rights and intellectual property."

Preferred models

Respondents were most interested in low-moderate cost genomic service models, with 84.4% or respondents selecting the low or moderate options that gave access to genomic breeding values for 3 or 5 traits, respectively.

When presented with the option of genotyping all, 50% or 5-10% of their replacement ewe lambs, 53.1% selected the moderate cost (50% of replacements) option.

Confidence in genomic data

41.5% of respondents would value a ram that has only been assessed using DNA/genomic data for facial eczema equally to a ram from a stud that also tested animals for facial eczema (phenoyting). 35.4% or respondents would need more information to decide (Figure 3).

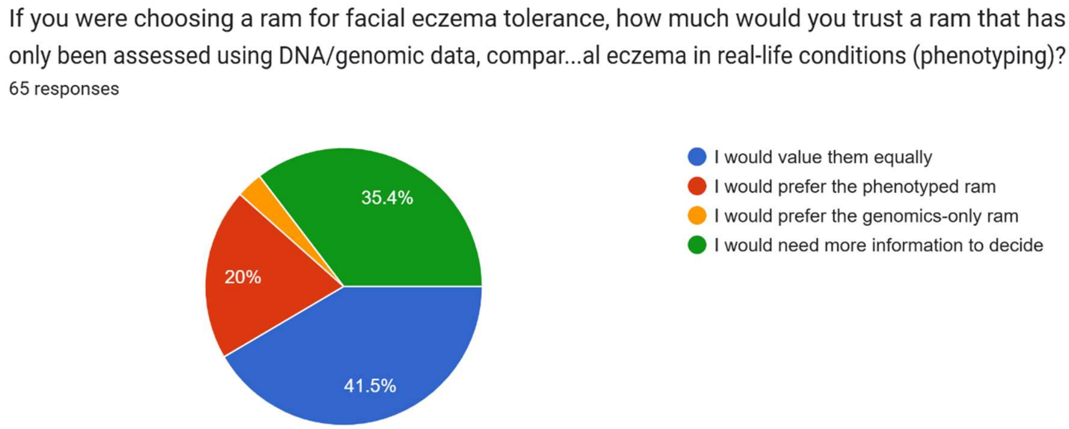

Figure 3. Summary of respondent responses to preference of buying a ram that has only been genotyped or has been genotyped and has phenotypic data recorded for that trait.

When asked a similar question about purchasing ram hoggets with a focus of selecting for lower faecal egg counts, 50% of respondents would consider a ram that had a phenotype for faecal egg count under a parasite challenge to be worth $200 more than a ram hogget that only had a genomic breeding value, but no associated phenotype (Figure 4).

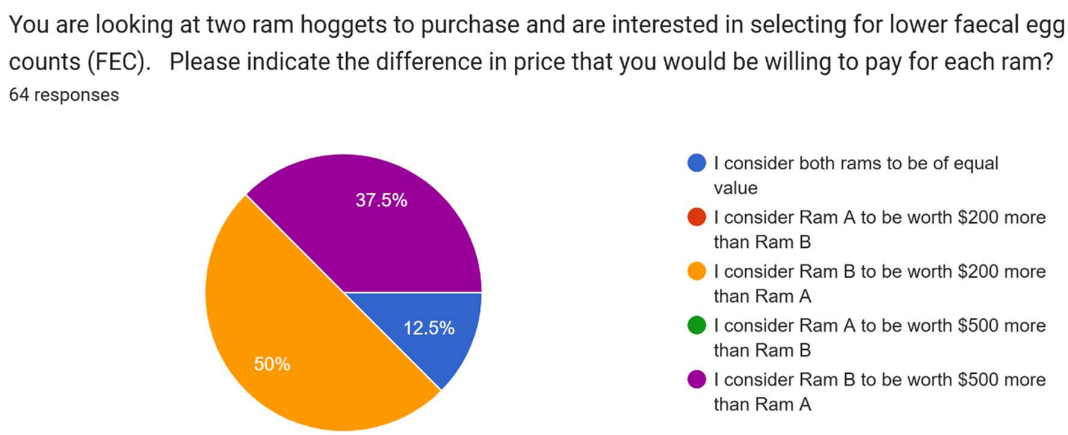

Figure 4. Summary of survey responses asking how farmers would value a ram that has both genomic and phenotype information or genomics only information.

When asked to explain their responses, a key theme to emerge was the belief that phenotypic data adds validation, transparency and credibility to genomics predictions

> "I use and believe in EBVs but testing in a real farm or challenge situation gives assurance."

When asked how confident they would feel using breeding values to select replacements, even it if meant choosing animals that don't look like usual picks (but significant structural issues had been culled), 65.1% of respondents said they would feel "somewhat confident – I'd use gBVs but still rely on visual checks" (Figure 5).

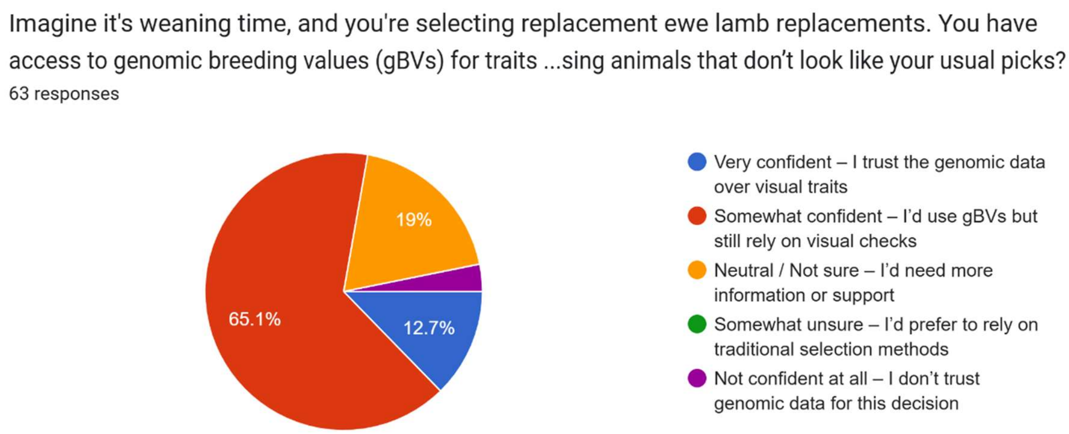

Figure 5. Summary of survey responses asking how confident farmers would be to select ewe hogget replacements on genomic data (after major structural culls have been removed)

When asked how confident they felt about investing in long-term genetic gain, 90.9% of respondents felt either somewhat or very confident. Many respondents expressed a belief in cumulative, permanent genetic gain.

"You never regret better genetics. The only thing is to be certain you're selecting for the right things."

Others cited positive results from previous genetic investments, reinforcing that experience builds confidence, especially when results are visible.

"Just look at the NZ sheep flock's performance over the last 30 years — the gains have been huge."

Some expressed an interest, but the cost and ROI were deemed prohibitive.

"Somewhat confident; however, sheep & beef farming needs to be profitable enough to afford an 'extra' investment."

Several responses emphasised that genetics must complement good management, reflecting a necessarily holistic mindset where genetic gain is one part of a broader farm strategy.

"…Could be a lot more money to be made by better management of ewe flocks. But we still need someone to lead the way for sure."

Support Needs for Genotyping Decision-Making

The key themes to emerge from the survey responses regarding support needed to aid decision making regarding genotyping were:

1. Clear economic justification
2. Accessible information and education

3. Practical demonstration and peer support
4. Simplified tools and interfaces
5. Sampling logistics and cost reduction
6. Confidence/validation of genomic data

Investment strategy

When asked if genotyping should be an individual farm decision or part of a wider industry strategy, 76.9% of respondents selected individual farm decision.

The key reasons given for this were:

1. Respect for farmer autonomy
2. Concerns about mandates and top-down pressure
3. Cost and ROI uncertainty
4. Need for validation and evidence

"Let each farmer decide what best suits them."

Of those who selected that genotyping should be part of a wider industry strategy, their rationale was largely around making more progress by working together. There were also some responses that supported a hybrid approach of industry investment, but individual farmer opt-in.

When asked what role processors, industry bodies or government should play in supporting adoption if genotyping and EID tags were shown to deliver benefits for the wider sheep industry and NZ, there were a range of responses. Respondents generally supported the involvement of these groups and suggested the following:

- Financial support and subsidies
- Mixed views on premiums and market incentives – most responses supported this, but some felt that processors could not/should not invest time or energy away from core business currently
- Education, promotion and extension
- Validation and evidence
- Respect for farmer autonomy
- Mixed views on government involvement – 2 out of 52 responses were opposed or strongly opposed to government involvement.

When invited to share thoughts on wider issues regarding sheep farming and genotyping, the following themes emerged:

- Optimism about potential of genotyping/genomics
- Cost and accessibility concerns reiterated
- Importance of validation and balanced breeding and management
- Strategic role of genetics in industry resilience
- Need for leadership and practical support, but a farmer-led rather than a top-down approach.
- Desire for clear information, easy-to-use tools and practical examples to help decision making

Other ideas that emerged but with less consensus included

- Uncertainty about sheep industry future in New Zealand

- Concern from stud breeders

  "…a general lack of profitability within our industry over time probably curbs the confidence for significant investments to be made."

Interview Analysis

Thematic Analysis

A total of 9 interviews were conducted, comprising four genetic specialists, two industry leaders, one processor, one genomics service provider and a rural banking specialist. These interviews generated a valuable and insightful dataset. A mindmap was created, to outline the key themes and sub-themes that emerged from the interviews.

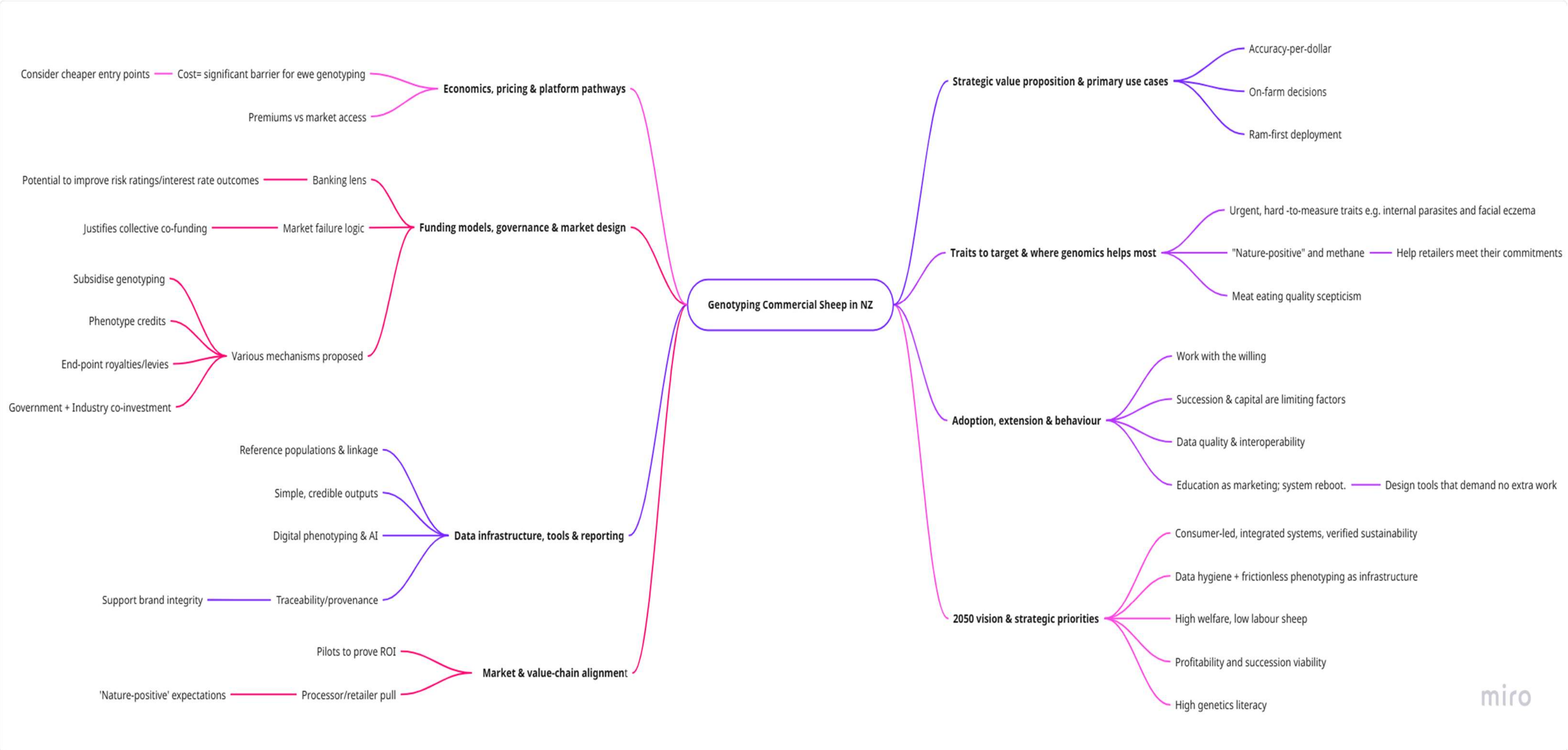

Figure 6. Thematic analysis of semi-structured interview responses

Combined Survey and Interview Analysis

PESTEL Analysis

Understanding the case and appetite for genotyping in New Zealand's commercial sheep sector requires more than technical and economic evaluation. External factors such as policy settings, market signals, social attitudes, technology trends, environmental pressures, and legal frameworks all influence the feasibility and timing of change.

The PESTEL framework (Political, Economic, Social, Technological, Environmental, Legal) provides a structured lens to examine these macro-level drivers and constraints (Belsare, 2025). Applying this analysis helps identify opportunities and risks beyond the farm gate, ensuring recommendations are aligned with industry priorities and external realities.

P — Political

- **Align with national priorities.** Several interviewees suggested linking genotyping to MPI's climate resilience and biosecurity strategies, positioning genomics as a tool for trade-readiness. New Zealand's methane reduction targets and retailers' Scope 3 commitments cause strong external drivers for low-emissions genetics.
- **Trade diplomacy & market access.** International retailer commitments to climate and nature-positive sourcing are shaping premiums for methane-aware, traceable, welfare-aligned products. Sustainability credentials increasingly influence export negotiations; failure to adapt could erode NZ's competitive position.
- **Facilitate value-chain communication.** It became apparent during the interview process that there were significant communication gaps between stakeholders along the sheep meat supply chain, offering an opportunity for improved outcomes via greater communication and alignment. This related to topics such as trait priorities, incentives, and the 'readiness' of various parts of the chain to respond to market signals.
- **Government co-funding appetite.**
    - Public–private co-funding is justified by market failure - phenotyping/genomic infrastructure yields public/industry good (Scope-3 compliance, trade-readiness), while individual farmers cover the direct costs and adoption risk. Time-bound government investment and governance (accuracy/reporting standards) can correct under-investment.
    - Models like AgriZero show willingness for public-private partnerships, but reliance on subsidies risks short-term thinking and outcomes if exit strategies aren't clear.

"Retailers have made Scope 3 emissions commitments… we can reward farmers who prove their carbon emissions." - Processor

"We capture GHG numbers for all of our clients—deer, sheep, dairy. If you had credible information that reduces GHG numbers, that's going to have an overall impact on your credit rating." - Rural Banking Specialist

E — Economic

- **Cost barrier.** ROI clarity and payback periods are critical for adoption. Current genotyping prices are prohibitive for whole-flock adoption; ROI improves only when multi-trait value is stacked (productivity + sustainability + welfare) along the supply chain. Banks indicated willingness to finance if profitability and risk reduction were evident, but genetic potential doesn't influence stock valuations. Funding models discussed included industry levies and co-investment from processors and service providers.

- **Cost-effective entry points are critical for adoption**. Accuracy-per-dollar matters for adoption, meaning "how much more accurate are selection decisions per dollar invested?". Parentage-only, flock sample profiling or low-density panels with imputation may be useful, lower cost entry points for commercial farmers.

- **Succession & capital constraints**. In the survey, farmers report high confidence in long-term genetic gain, but up-front spend and payback timing remain practical constraints, particularly as sheep farmers face succession issues and capital constraints.

- **Phenotyping reimbursement is essential**. Levy/credit models were advocated for by genetic specialists to sustain hard or expensive to measure trait phenotyping and to prevent free-riding. This still allows for individual farm decision-making, but if pursued would mean those that choose to use genotyping work within a levy/credit model to access genomic data.

- **Stacked value.** Genotyping commercial sheep is not a silver bullet to solve one particular issue, but rather offers multiple, stacked benefits to a range of issues and opportunities. Nature-positive market credentials (health, welfare, traceability) expand the economic case beyond farm-level gains.

- **Positive externalities from phenotyping/genomic evaluations create under-investment at farm level**. Premiums may commoditise, turning credentials into market-access tickets rather than price uplifts. Mechanisms (e.g. phenotype funds, end-point royalties, processor-aligned incentives) are needed to internalise value.

"We've got to be relentless about going after the value pockets or we won't give customers a reason to buy our product." - Industry Leader/Farmer #1

"We need to see a financial return on our investment." - Survey respondent

S — Social

- **Autonomy.** Farmers value autonomy and resist mandates.

- **Divergent mindsets exist along the supply chain** – the farmer survey shows strong interest in parasite tolerance, and productivity traits, and weak interest in methane. This indicates a disconnect between farmer priorities and the priorities of other supply chain stakeholders, such as banks, processors and retailers.

- **Succession and workforce capability** were raised as broader sector challenges.

- **Education gap.** EBVs and genomics remain intimidating. Complexity and lack of confidence were noted as barriers. Some interviewees recommend extension is tool-led with practical scorecards and peer case studies over theory-heavy workshops.
- **Demographic realities.** Majority of respondents are 45 years old or older, and time-poor, with succession issues looming. Adoption strategies must respect workload and minimize complexity.

"Farmers don't want to be dictated to - voluntary adoption is critical." - International Genetics Specialist #2

T — Technological

- **Data hygiene & infrastructure.** Accurate EID, parentage, and phenotype-genotype linkage are prerequisites; poor data quality undermines ROI
- **Platform innovation.** Low-density chips + imputation and genotyping-by-sequencing could cut costs, but validation, and interoperability are critical.
- **Digital phenotyping**: Cameras, drones, and wearables promise low-labour data capture; still early-stage and cost-heavy.
- **Risk of fragmentation**: Competing private systems without common standards could confuse farmers and slow sector-wide genetic gain.
- **Need for simple, farmer-friendly tools.** Interviewees and survey respondents stressed the need for simple, farmer-friendly tools

"We couldn't find reliable software that could share information with other platforms." — Survey respondent

"How the hell do you identify your high performers? You can't do it at mob level - you've got to do it at individual level." – Industry leader/farmer

E — Environmental

- **Nature-positive credentials offer stacked value**
  - Combining health, welfare, and traceability improvements via genotyping creates credible farm-level marketing credentials for processors and retailers to extract premiums and market access while also aligning with farmer priorities.
  - Addressing farmer pain points also contributes to the nature-positive narrative desired by the consumer/market, e.g. Selecting for parasite resistance reduces chemical use; FE tolerance improves resilience to climate-linked disease.
- **Integrated systems lens**. Some interviewees advocated for diversified, low-input systems where genomics underpins sustainability.

"Nature-positive credentials will be a ticket to trade." - Industry Leader #1

L — Legal / Ethical

- **Data governance and consent critical.** Interviewees stressed the need for explicit agreements on ownership, access, and benefit-sharing. IP rights over reference populations and genomic data need transparent frameworks; lack of clarity could deter private investment and/or erode stud breeder confidence.
- **Voluntary adoption with ethical stewardship**. Survey sentiment resists compulsion; transparency and choice are key to social license.
- **Fair reimbursement**. Royalty/reimbursement frameworks and guardrails for genomic-only predictions are needed to protect phenotyping and avoid fragmentation.

"Risk to studs if commercial farmers can breed their own rams without gathering raw data." - Survey respondent

"We're developing a mechanism, so genotype-only users pay more, and that money funds reference populations - fair reward for phenotype contributors." - International Genetics Specialist #2

Environment – Strategy – Capability Gap Analysis

The ESC (Environment- Strategy- Capabilities) Gap Analysis framework provides a structured approach to evaluate the alignment between the sheep industry's current state and its desired future state regarding genomic integration. This analysis identifies gaps across three dimensions (Hubbard, Rice & Galvin, 2018):

- **Environment:** External factors shaping industry priorities, including market signals, regulatory pressures, and sustainability expectations.
- **Strategy:** The sector's plans and actions to leverage genomics for productivity, resilience, and market positioning.
- **Capabilities:** The technical, financial, and human resources required to implement these strategies effectively.

By mapping current practices against desired outcomes, the ESC gap analysis highlights where investment, coordination and capability development are needed to enable informed, scalable adoption of genotyping in New Zealand's commercial sheep sector.

Table 1. Environment – Strategy – Capability Gap Analysis

Area	Current State	Desired State	Gaps	Priority Actions
Environment	Fragmented value-chain communication; limited alignment on trait priorities, incentives and tools. Suggestion of market failure.	Coordinated roadmap linking genomic adoption to national priorities (climate resilience, biosecurity, trade-readiness). Clear market signals for nature-positive traits supported by genomic credentials.	Misalignment between farmer pain points and retailer sustainability drivers; unclear link to finance benefits. Market failure - collective benefits not fully captured by individual farmers → underinvestment.	Convene multi-stakeholder forums; publish sector roadmap; integrate genomics into sustainability and trade strategies. Align processor-bank incentives. Pilot processor programs using genomic scorecards for health, welfare, and emissions traits. Explore co-investment models (government + industry) to correct market failure and incentivize adoption. Reframe sustainability traits; publish ROI case studies; co-design bank & processor-ready sustainability & other 'selling point' scorecards.
Strategy	Strong preference for voluntary, farmer-led adoption; lead with pain points (parasites, FE).	Phased strategy: flock sample profile → parentage-only → low-density + imputation ramp → expanded trait coverage.	No clear adoption roadmap; risk of ad hoc uptake	Develop staged implementation plan; lead with pain-point traits (parasites, FE); publish ROI models.
	Limited guardrails for disruptive use cases (e.g., ram-hogget genomic predictions).	Ethical framework with minimum accuracy standards and disclosure requirements.	Potential for increased rate of genetic gain but also a risk of undermining stud breeder value and sector cohesion.	Co-design governance guardrails; embed transparency in genomic service agreements.
Capability	Reference populations exist but lack breadth and depth.	Multi-breed reference population backbone with regular accuracy/linkage reporting.	Insufficient phenotyping for hard-to-measure traits; risk of prediction decay.	Expand reference populations; implement levy/credit funding for phenotyping; publish accuracy dashboards.
	Limited farmer-facing tools; data friction in sampling and portal usability.	Simple decision-support tools (Cull/Mate lists, trait scorecards, ROI calculators).	Complexity and time burden deter adoption.	Develop farmer-ready packages; bundle sampling kits, services and staged or subscription payment options; train advisors.
	Workforce capability gaps in genomic literacy and advisory support.	Skilled advisor network and farmer education programs integrated with tool-led extension.	Shortage of trained advisors; limited genomic literacy among farmers.	Deliver structured advisor training; co-design extension programs with industry; embed peer case studies.

Further Discussion

The multi-analyses of survey and interview findings and the literature review have allowed key themes to be identified in the context of wider macro-environmental drivers and constraints. This process highlighted current gaps, and opportunities for action.

One theme requiring deeper discussion is the misalignment between farmers and other sector stakeholders regarding the prioritisation of reducing methane emissions. A strong focus for a number of large retailers (including McDonalds, Sainsbury's, Tesco) is their commitment to achieving Scope 3 emissions reductions by 2030. Scope 3 emissions encompass all indirect greenhouse gas (GHG) emissions that occur in a company's value chain, including raw material production and purchased goods (such as meat and fibre). These often represent the majority of a company's total emissions (GHG Protocol, 2023). Leading retailers have set targets to reduce forest, land and agriculture emissions by 30-39% by 2030. These targets are important for sheep farmers because processors and retailers increasingly require verified farm-level data to demonstrate progress towards Scope 3 goals. Meeting these expectations is becoming a prerequisite for market access and participation in premium programs linked to sustainability.

For some farmers, however, reducing methane emissions remains a contentious issue and may be considered to be politically or ideologically driven. This perception creates tension with personal values and introduces uncertainty, as policy shifts under changing governments could alter targets and incentives before investments deliver returns. Farmers also express concern that aggressive methane reduction targets could undermine profitability and threaten rural communities (RNZ, 2025). Some argue that reducing livestock numbers to meet methane targets risks compromising food production and global food security (Rural News Group, 2025). Additionally, many farmers are unconvinced of a clear link between selecting for lower methane-emitting animals and improved profit and worry that including methane in breeding objectives may slow genetic gain in other areas or create unintended consequences. This was reflected in survey results, where only one respondent selected methane as a priority trait for the next decade.

With Scope 3 target timelines approaching, the conversation around methane emissions is not going away. Messaging should frame climate traits as part of a broader package, such as reduced chemical use through improved parasite and disease tolerance, improved feed efficiency, and improved welfare and productivity outcomes. Genetics requires a balanced approach and breeding objective, and improving productivity and efficiency is recognised as a tool to improve both profitability reduced emissions intensity. Farmers are already contributing to nature-positive outcomes, including biodiversity initiatives, and genomics offers an opportunity to validate methane performance while driving gains in other high-value traits.

Gaps in communication across the supply chain were evident in several interviews, sometimes explicitly and other times through what was left unsaid. This disconnect highlights fragmented information flow and limited transparency between research, service providers, processors, bankers, farmers and other stakeholders. These gaps risk slowing adoption and undermining confidence in innovation, and issues around trust, regardless of whether the communication gaps are intentional or unintentional. The opportunity lies in creating stronger alignment of goals, tools, and strategy across the value chain. Without a shared understanding of timelines, capabilities, and market signals, the sector risks inefficiencies and missed opportunities, such as tools to address animal health and social license issues. A coordinated communication framework, supported by regular cross-sector forums, shared technology roadmaps, and clear messaging could help ensure effective and impactful investment and innovation development for the sheep sector. This could be addressed by either stronger returns at the farmgate, or perhaps more likely in the short term, investment in addressing the market failure which is covered in more detail later in this discussion section.

An interesting point was raised while interviewing the rural banking specialist. Currently banks do not attribute any financial value to genetic merit of livestock, regardless of livestock class. This means an animal with superior genetic potential for lambing, growth, or parasite resistance is valued the same as one with poorer genetic merit. While this simplifies financial analysis, genomics' ability to quantify genetic value raises questions about whether this approach should evolve to recognise livestock genetic potential in future lending and livestock trading models. Whilst there is evidence of higher breeding worth dairy cows attracting a premium in the trade-stock market, this is less common in the NZ sheep industry currently, which presents an opportunity for higher genetic merit sheep to be recognised and valued on the trading market.

Despite extensive exploration of adoption themes, this project does not fully quantify the answer to the research question: "Is there a case for genotyping commercial sheep in New Zealand?" On-farm genetic gain is relatively straightforward to model and aligns with farmer confidence in genotyping benefits but depends on individual breeding objectives and trait priorities. Beyond the farm gate, financial benefits remain difficult to model as market premiums are untested. A practical next step would be developing a simple, customisable ROI calculator for farmers to estimate payback periods based on flock size, breed, and trait selection.

The concept of market failure was referred to by several of the interviewees in regard to genomics in New Zealand sheep flocks. Market failure is defined as occurring when a free market fails to allocate resources efficiently, resulting in outcomes that are not socially optimal or economically efficient. This tends to occur when private incentives do not fully align with society's broader interests and economists typically identify market failure in situations where externalities exist (e.g. costs or benefits spill over to third parties), public goods are undersupplied, information asymmetry distorts decision making and/or market power disrupts competitive pricing (NSW Department of Industry, 2017). When a farmer genotypes their flock, the data improves the accuracy of national breeding evaluations and benefits the wider sheep industry through genetic progress, productivity gains, sustainability outcomes and better animal health. However, these collective benefits are not fully captured by the individual farmer, so there is less private incentive to invest (NSW Department of Industry, 2017). As we can see in the current state of the use of genotyping and genomics in New Zealand sheep, this results in underinvestment relative to what would be optimum for the industry as a whole. Market failure often draws investment from governments and industry bodies, at times resulting in a commercialisation pathway at the conclusion of the investment. An example market failure investment is the 'Resilient Dairy: Innovative Breeding for a Sustainable Future' programme that was led by the Livestock Improvement Corporation (LIC). It was co-funded by MPI and Dairy NZ and has invested in genomic science and diagnostics for dairy cattle to improve health, productivity, environmental resilience and sustainability of the dairy herd (LIC. 2023). With the outputs of this sheep genotyping project suggesting confidence in the value of genetics along the supply chain, but obvious signs of market failure, it would suggest that targeted investment into sheep genomics by government and industry bodies may be justified.

Conclusions

This project set out to evaluate the case and appetite for genotyping the New Zealand commercial ewe flock, and to identify the conditions under which it could deliver meaningful value to farmers, and the wider sector. Evidence from literature, interviews, and surveys indicates that while genotyping is not yet widely adopted, it offers strategic potential when applied to high-impact traits and supported by enabling infrastructure. Genotyping is also not a standalone solution, it is a lever that can accelerate cumulative and permanent genetic gain, particularly for hard-to-measure traits such as parasite resistance, facial eczema tolerance, feed efficiency and ewe longevity. These improvements underpin productivity, resilience, and animal health while contributing to nature-positive credentials increasingly demanded by global markets.

Adoption, however, faces significant constraints. High costs, fragmented data systems, and concerns about equity and data ownership limit uptake. Farmers remain cautious, prioritising immediate cash flow over less tangible and harder to quantify long-term genetic gain, and express a preference for voluntary, farmer-led approaches supported by practical tools, including evidence of return on investment and once adopted, simple decision support tools.

There is evidence of market failure. Genotyping generates public and industry benefits, including improved national evaluations, faster genetic progress, and sustainability outcomes but these spillovers are not fully captured by individual farmers, resulting in underinvestment. Precedents such as the co-funded 'Resilient Dairy: Innovative Breeding for a Sustainable Future' programme illustrate that targeted co-investment and governance can accelerate genomic infrastructure while maintaining commercial pathways. For the New Zealand sheep sector similar interventions, standardised accuracy and reporting dashboards, and clear guardrails for data use, will be essential to unlock the full potential of genomics

While no single benefit currently offsets the significant cost of genotyping commercial sheep, the combined value of multiple benefits, when supported by robust reference populations, coordinated investment, and lower cost entry points could tip the balance in favour of adoption. International examples such as Ireland's ICBF and Australia's MERINOSELECT demonstrate that coordinated, inclusive, and well-governed genomic systems can deliver transformational outcomes. For New Zealand to realise similar benefits, it must invest in infrastructure, workforce capability, and trust-building, while ensuring fair reward for phenotype contributors and maintaining farmer autonomy.

The evidence is clear that phenotyping is the engine room of long-term value. Without sustained measurement of hard-to-measure traits (e.g. FE, FEC, feed efficiency, ewe longevity, MEQ and methane), genomic predictions will lose accuracy and trust. Interviews converged on the need for a levy/credit mechanism tied to genomic use so that users help fund the phenotypes they consume, preventing free-riding and ensuring that recorded studs and reference flocks remain viable.

From a capability standpoint, the building blocks exist but require focus. A direct focus and investment is required into reference populations across breeds, traits and environments. Tools and logistics are of great importance to commercial farmers, particularly those that remove practical barriers, such as sampling service providers. The governance and ethical settings also need attention. Data governance and consent frameworks must be explicit about ownership, access, and benefit-sharing to support participation across commercial and stud contexts and to avoid fragmentation or proprietary lock-in concerns.

Whilst there is not currently a commercially viable case for genotyping entire commercial ewe flocks in New Zealand, there is significant potential for greater value to be extracted from genomics, and for lower cost entry points to be explored. In addition to on-farm genetic gain benefits, genomics offers a pathway to secure market access and possibly premiums, while delivering enduring gains in efficiency, biosecurity and sustainability. Realising this potential will require coordinated action across government, industry bodies, processors, and farmers.

Recommendations and next steps

A review exploring how genomics can be better utilised in the New Zealand sheep sector is currently being undertaken by an industry body. This work would likely address some of the key recommendations from this report that include developing a cross-sector vision and genomics roadmap, improving communication and transparency along the supply chain, expanding reference populations, further investigating the feasibility of establishing a phenotype funding mechanism and strengthening governance and data ethics. This work would likely be led by industry bodies and would be ongoing over the next decade.

Recommendations that are more specific to the uptake of genomics by commercial sheep farmers are:

1. Do case studies on lower cost options and potential benefits (e.g. flock sample profiling, parentage-only genotyping) and build a farmer-friendly customisable ROI calculator. This could be done by B+LNZ and/or as part of a post-graduate student project and would ideally be done in the next 12 months.
2. Prioritise farmer pain point traits (e.g health traits – starting with parasite tolerance and facial eczema) for both reference population development/expansion and as an extension pathway. This would ideally be a focus over the next 3-5 years. B+LNZ are an obvious enabler of expanding relevant reference populations and also co-designing and developing extension resources alongside farmers, private consultants and other trusted advisors.
3. Co-design validation tools (e.g. scorecards) for market-valued traits with processors, banks & farmers within the next two years.
4. Genomics providers to co-design and develop farmer-ready tools, packages and systems; bundle sampling kits, services and staged or subscription payment options, so farmers receive usable decision tools, rather than having to wrangle data.
5. Explore co-investment models (government + industry) to correct market failure and incentivize adoption.

Limitations of this study

There were several limitations of this study. Firstly, the sample size for both survey respondents (68) and interviewees (9) were relatively small, and did not represent all voices in the industry. The survey in particular, is likely to contain bias as participants were self-selecting. It was shared via personal and professional email and social media networks, but it is likely that those who responded had an interest in the topic of sheep genetics, which may have biased the results and resulted in survey results that were disproportionately positive regarding confidence in genetics, the use of EID tags and appetite for genotyping than may actually exist amongst the wider commercial sheep farming population of New Zealand.

A cost: benefit analysis or ROI calculator is the other obvious limitation and is an obvious next step beyond this project.

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Acknowledgement of use of AI tools:

I used Microsoft Co-pilot and ChatGpt AI tools, mainly for identifying interview and survey themes and to help with the editing process. I also asked it questions, in a similar way to doing a google search as I was working through the literature review when I came across new concepts. I used many, many prompts.

Appendices

Survey questions

1. What best describes your role in the sheep farming industry?
    a. Mark only one oval. - Commercial sheep farmer - Stud breeder - Other (please specify)
2. How many ewes are in your flock? * - Fewer than 500; - 500–1,999; - 2,000–3,999; - 4,000 or more
3. What percentage of your farm's total income comes from sheep? Mark only one oval. Less than 25%; 25–49%; 50–74%; 75–100%
4. What region do you farm in?. Dropdown Mark only one oval. Northland/Auckland; Waikato; Bay of Plenty; Gisborne; Hawke's Bay; Taranaki; Manawatu-Whanganui; Wairarapa/Wellington; Tasman/Marlborough/Nelson; West Coast; Canterbury; Otago; Southland
5. Which age group do you belong to? Under 30; 30-44; 45-59; 60 and over
6. What is your role in making decisions about genetics or breeding on your farm or in your organisation? Mark only one oval. I make most or all of the decisions; I contribute to decisions as part of a team; I am not involved in these decisions
7. Do you use EID tags in your sheep flock currently? Yes – all sheep have EID; Yes – some sheep have EID; No – but I'm open to using EID; No – not interested in using EID
8. What five trait groups would you most like to improve over the next 10 years? Trait Priorities Check all that apply. Growth; Reproduction; Survival; Adult Size; Meat Traits; Facial Eczema; Internal Parasite traits; Wool traits; Shedding/Bare traits; Body Condition Score; Dag Score; Methane emissions; Feed efficiency; Structure
9. Perceptions of Genomics Benefits. If commercial sheep farms used both EID tags and genotyping, how likely do you think each of the following benefits would happen — either on your farm or more broadly in the industry? * Very likely; Somewhat likely; Somewhat unlikely; Very unlikely.
    a. Processors paying for genomically validated traits (e.g. meat quality, methane)
    b. Genetic improvement in traits that reduce labour and improve ease of management
    c. Genetic improvement in animal health and wellbeing
    d. Biosecurity and traceability – on-farm benefits
    e. Biosecurity and traceability – trade/export benefits Improved market access
    f. Processors paying for genomically validated traits (e.g. meat quality, methane)
    g. Genetic improvement in traits that reduce labour and improve ease of management
    h. Genetic improvement in animal health and wellbeing
    i. Biosecurity and traceability – on-farm benefits
    j. Biosecurity and traceability – trade/export benefits
    k. Improved market access
    l. Potential for market premiums
    m. Supporting social license to farm Improved farm productivity
    n. Improved farm profitability market premiums

o. Supporting social license to farm
p. Improved farm productivity
q. Improved farm profitability

10. If you think there would be any other benefits, please detail?
11. Which of the following factors would discourage you from using genotyping in your flock? (Select all that apply)
    a. Cost
    b. Time/labour to tag or sample lambs
    c. Lack of clear information
    d. Uncertainty about genomics
    e. Uncertainty about estimated breeding values (EBVs)
    f. Uncertainty about return on investment
    g. Doubts about market access improvements
    h. Doubts about market premiums
    i. Not convinced of enough genetic gain
    j. Rate of progress too slow
    k. Uncertain of how to implement the information
12. If there are other factors that would discourage you, please detail?
13. If genotyping could improve key traits in your flock, which option would you prefer? Mark only one oval.

    Option A: $40/ewe lamb – access to all available traits
    Option B: $25/ewe lamb – access to 5 key traits
    Option C: $10/ewe lamb – access to 3 key
14. If you were to consider genotyping your flock, which of the following options would you prefer?

    Mark only one oval.
    Option A: Higher cost: $40 per ewe lamb; Genomic breeding values for all traits; All potential replacement ewe lambs genotyped; Fast genetic improvement in your top priority traits
    Option B: Moderate cost: $25 per ewe lamb; Half of replacements genotyped: 50%; Genomic breeding values for 5 key traits; Steady genetic improvement in your top traits
    Option C: Lower cost: $10 per ewe lamb; Small mob sample genotyped: 5-10%; Flock level genetic profile only (no individual ewe data)
    eczema in real-life conditions (phenotyping)?
15. If you were choosing a ram for facial eczema tolerance, how much would you trust a ram that has only been assessed using DNA/genomic data, compared to a ram from a stud that has also tested animals for facial eczema in real-life conditions (phenotyping)?
16. You are looking at two ram hoggets to purchase and are interested in selecting for lower faecal egg counts (FEC). Please indicate the difference in price that you would be willing to pay for each ram?
17. Please explain your response to the previous question?
18. You have access to genomic breeding values (gBVs) for traits like growth, survival, parasite resistance, and facial eczema tolerance. The lambs are tagged with EID and sorted into draft lines based on their gBVs. You have culled out ewe lambs with significant structural issues, but you notice that some lambs with strong gBVs for your priority traits are smaller or less visually appealing than others. How confident would you feel using genomic breeding values to select replacements, even if it means choosing animals that don't look like your usual picks?

19. How confident do you feel about investing in long-term genetic gain?
20. Please provide more detail?
21. What practical challenges would you face in implementing genotyping on your farm?
22. What are the tools, support, or information that would help you make a decision about genotyping?
23. Do you think genotyping should be an individual farm decision, or part of a wider industry strategy?
24. Why?
25. If genotyping and EID tags were shown to deliver benefits for the wider sheep industry and New Zealand as a whole, what role do you think processors, industry bodies, or government should play in supporting adoption?
26. Is there anything else you'd like to share about genotyping, sheep genetics, breeding, or the future of sheep farming in New Zealand?

Semi-structured interview questions

The following questions were asked to all interviewees:

1. What opportunities do you see from genotyping the commercial ewe flock?
2. What are the biggest risks, downsides or barriers to adoption?
3. How should genomics and related infrastructure (e.g. reference populations) be funded?
4. Which traits would you consider genotyping to offer the most value to industry?
5. It you had $10m+ to address an issue or unlock an opportunity in NZ sheep industry by 2050 – what issue or opportunity would you address and how?

In addition, questions specific to a person's role or area of expertise were also asked:

Processor: Could genotyping support premium product claim and would you consider offering premiums or incentives for genotyped animals?

Rural Banking Specialist: Could verified genetic merit or sustainability credentials help farmers negotiate better loan terms or interest rates?

Genetics specialist/genomics providers: What would a fair and sustainable model look like?; What would it take to lift adoption of genetics and genomics among commercial farmers?; What role could data infrastructure or digital tools play in enabling these?