Putting a price tag on the hidden chemistry of recycled iron

The engine block in your car, the brake disc that stops it, the housing around its gearbox — all of these are most likely made of grey cast iron, one of the oldest and most widely used materials in manufacturing. What few people realise is that the iron made today is quietly different from the iron made a generation ago. To reduce waste and protect the environment, modern foundries melt large amounts of recycled scrap metal. This is good for the planet, but it carries an invisible side effect.

Recycled scrap brings traces of other metals with it: copper from old motors, tin from solder, chromium and nickel from stainless steel. These elements never fully burn off in the furnace. They build up, batch after batch, like sediment. Each new casting still passes its official quality check — the chemistry is "within limits" — yet the material has slowly drifted away from what it used to be.

This thesis asks a question that sits in a gap between three professions who rarely talk to each other — the metallurgist who studies the iron, the machining engineer who cuts it into shape, and the manager who decides what to buy. The question is simple: when iron quietly drifts like this, how much does it actually cost the factory that machines it into a finished part?

To answer this, the project built a computer model of a small factory line with three machines — one that mills a flat face, one that drills holes, and one that does the final precision shaping. Five different "types" of iron were sent through this simulated line: one clean reference batch, and four others representing the different ways real iron drifts. The model didn't just count how many parts came out — it calculated the true cost of each finished part, including the time the machines spend, the cutting tools that wear out, the raw casting, and any defective parts thrown away.

The central result is surprisingly clear-cut. When iron has slowly accumulated residual metals from recycled scrap, it costs about 10% more to machine each part than clean iron — even when a skilled operator does everything right and adjusts the cutting speed to compensate. For a part that costs around 80 euros to make, that is roughly 8 euros of extra cost that simply cannot be avoided on the factory floor.

By contrast, iron with small local impurities like sulphur and phosphorus turned out to cost only about 1 euro more per part — eight times less. This was unexpected. It means that two material problems often lumped together as "bad iron" are in fact completely different in their economic weight, and they hurt the factory through completely different routes. The residual-metal problem chokes the factory's output and drives up machine time; the local-impurity problem mostly just wears out tools a little faster.

The model in this thesis is not meant to predict the exact bill for any one factory. Its value is the method itself: a transparent way to trace a tiny shift in a material's chemistry all the way through to its effect on cost. As the world recycles more and leans further into circular materials, the small drifts hidden inside everyday metal will only grow in importance — and learning to put a price on them is the first step toward managing them wisely.