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Yule log(istics)

JUST HOW PRODUCTIVE IS SANTA?

Santa’s job of delivering presents to well-behaved children across the globe has never been a stroll in the North Pole. But an explosion in demand for his presents in recent years – combined with dwindling reindeer populations – has made it a serious sleigh-ride. Have satellite navigation, delivery drones and "click and collect" turned Santa into a retail revolutionary?

For most youngsters, excitement at the imminent arrival of Santa Claus is more than enough to induce a sleepless Christmas Eve. But the more business-minded of them may also be kept awake by some worrying questions about logistics. How on earth can Santa reach every town in the world in a single night, even with the aid of a flying sleigh and a team of highly-motivated reindeer? And if that was difficult enough in the past, isn’t it simply impossible in the highly-populated modern world?
The economists at Frontier have been worrying about this, too. In the technical jargon, Santa faces a "constrained optimisation problem". He has to deliver goodies to as many households as he can – all over the world – and has a fixed amount of time in which to do so – from late Christmas eve to Christmas morning. However, while the time constraint remains stubbornly fixed (using time zones to the limit, 33 hours\(^1\)) in the last half-century the number of children aged 14-or-under certainly has not: it's increased by more than 60%. What's more, population growth between 1960 and 2015 has been concentrated in areas a long way from Santa’s base in Lapland, as Figure 1 below illustrates.

**Figure 1. Population growth (in children aged 0-14 years)**

This is plainly not good news for Santa; not only does he have to make more deliveries, but he, Rudolph and the team have to make longer trips back to Lapland to re-stock the sleigh.

\(^1\) We assume that Santa can spend a maximum of 8 hours in any time-zone before he risks being spotted by waking children, but that he can take advantage of the rotation of the earth to extend his total delivery window. If he starts at Kiribati on the International Date Line and moves west, this would give him an extra hour when he moves into each of the next 25 (inhabited) time zones before he reaches the other side of the Date Line, and American Samoa. This should give Santa 33 hours in total (or 8+N in each N time-zones) – which is still not much!
The first and obvious option was of course to try to speed up the sleigh. But that's unlikely to have yielded much. Reliable data on advances in elite reindeer performance are hard to come by, so we've taken improvements in human athletic performance over the same period (plotted in Figure 2) as a proxy. Even this, however, may be too optimistic since while the human population has grown, reindeer numbers have been declining rapidly. So while the human talent pool has widened, Santa has an ever-smaller cadre of athletic sleigh-pullers from which to select his team. In any event, even our human proxy's speed gain pales into insignificance beside the growth in Santa's required mileage, as Figure 2 also shows.

**Figure 2. Increases in Santa's demand and reindeer speed since 1960**

![Graph showing increases in Santa's demand and reindeer speed since 1960](source: Frontier Economics)

The gap – let's call it the “Reindeer Residual” – is huge. So what has the strategy team in Santa's grotto been doing?

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2 As elite reindeer typically train using much of the same methods as the world's top marathon runners (including training at high antler-tude), we've used the evolution of the marathon world record as a proxy for increases in elite reindeer speed.

The first job (as always) is to complete the analysis. Frontier’s elves have modelled Santa’s task over time. Allowing for a reasonable “per child” delivery time, and a sleigh large enough for 5,000 deliveries between re-stocking, we find that if Santa was operating at his time limit of 33 hours in 1960, he’d now need more than 50 hours to make all of his deliveries, even with more Dashing and less Prancing by Rudolph and the team. The proof is in the (Christmas) pudding below, which shows that the need to travel all the way to and from Lapland to restock has been the key driver of Santa’s growing delivery challenge.

**Figure 3. Hours needed to deliver presents to all children**

![Graph showing hours needed to deliver presents to all children](image)

**Source:** Frontier Economics

**EXPLAINING THE REINDEER RESIDUAL**

So how is Santa continuing to deliver? We’re pretty confident that he hasn’t swapped his humble sleigh for a time-travelling DeLorean (or even tucked an electric bicycle motor under the seat). Frontier’s work with a range of other retail and distribution businesses working at the cutting edge of delivery logistics suggests a few other sources of improvement:

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4 More specifically, we have allowed a generous 0.01 milliseconds per delivery and a speed of 50 million km/hour in 1960 – reaching 55 million km/hour by 2014 thanks to the reindeer training improvements referred to above.

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• **Navigation.** Let’s start with the obvious. GPS devices have dropped to ten-a-penny since the launch of the first GPS satellite in 1978. Rather than using an old fashioned map and a trusted route, we are sure that Santa now relies on a high-tech device to optimise his route, provide turn-by-turn directions and avoid air traffic control congestion.

• **Regional distribution centres (RDCs).** Tradition has it, of course, that Santa operates out of his single site in Lapland. But is this really likely? Given the demand he faces, it would be only logical for Santa to have invested in a set of RDCs tactically placed around the world. We estimate that one strategically-placed RDC in Brazil could save Santa more than an hour for deliveries within Brazil alone. But why stop at one? Children: keep your eyes peeled for Santa RDCs with tell-tale signs (colourful lights, conical trees, Coca Cola lorries, etc.) when you are next on a dull trip down the motorway.

• **Click and collect.** In days gone by, poor Santa appears to have had no option but to hand-deliver every present himself – and apparently free of charge. Nudging parents to pick up the presents children have ordered from Santa online, at local outlets, may now be helping Santa to reduce the number of households that he actually has to visit on Christmas Eve. We estimate that even if Santa had only seen "click and collect" grow 5% a year since 2012 (which would be pretty unimpressive when compared with the growth rates achieved by some high street retailers), he would still have been able to reduce his travels by 379 million km by 2014. Of course, persuading parents to switch from home delivery to "click and collect" may be harder for a man who conveniently calls outside office hours (and in any case can let himself in via the chimney). But Santa could always try introducing a few incentives – such as a small delivery charge (perhaps in the form of a minimum brandy-and-carrot requirement). Alternatively, he could try to introduce a "click and collect" Claus into his delivery contract for the most remote families.

• **Changes in present preferences.** The Reindeer Residual assumes that a sleigh-load remains constant at 5,000 presents, and that the number of presents per child is also unchanged over time. But we know that children's letters to Santa are now asking for smaller presents (physically, that is - not financially) than previous generations did. We estimate that while Santa’s sleigh could only accommodate about 8 rocking horses and 400 big teddies in the mix, it can fit in over 7,000 Apple Watches or 10,000 selfie sticks, with a bulk order of iTunes voucher cards stuffed in the back pocket. This will have done wonders for Santa’s workload. A one-off 10% improvement in the total number of presents Santa can fit in his sleigh would reduce the time needed to complete deliveries by a sizeable 4.5 hours. Indeed, if Santa could have achieved a mere 1.25% improvement per year every year since
1960, this would have cancelled out almost all of the additional mileage required of him by population growth.

- **Quicker sleigh-loading.** Conveyor belts and robotic arms have largely replaced much of the traditional workforce of elves, although – happily – we understand that the displaced elf workforce has been almost entirely absorbed by the growing labour demands in the 'elf-and-safety industry (not to mention the large employers Messrs Tolkien and Rowling). Meanwhile it is rumoured that Santa has been recruiting highly-skilled IT engineers and a design team working on sleigh lookalike drones, expected to be used at an undisclosed location experimentally this Christmas. Whether this will take off, only time will tell.

The figure below – exclusively obtained by Frontier’s elves after piecing together photo-fits generated from some of Santa’s closest shaves with the time limit – illustrates how these changes have been reflected in Santa's changing appearance.

**Figure 4. Logistics in action or Logistics inaction?**
IS SANTA AS PRODUCTIVE AS HE SEEMS?

Given all these logistical advances, it could be argued that Santa's task has in fact been getting easier, not harder, over time. Perhaps Santa himself hasn't really been working harder, quicker or faster. Maybe he's cut down his route and outsourced his delivery job to stressed parents; surely he's bought himself a Satnav; certainly, he's been lucky that children have finally realised that good things come in small packages; and – most controversially – he will doubtless have sacked some loyal elves in favour of wage-free robots.

However, the game's not over: intense online competition is increasing children's expectations all the time. With next-day delivery a must, and same-day delivery for "click and collect" offered by some, Santa can expect children to be writing their requests closer and closer to Christmas. What's more, an increasing number of Santa's peers are offering the ability to cancel orders online, so he will have to keep pace or find himself at the bottom of the chimney with the wrong present. As for returns and exchanges, while everyone struggles to manage these, Santa will find his current January-October holiday unacceptable in modern trading conditions.

Are there any opportunities to match these challenges? Plenty. Other retailers, having seen stores and websites swamped on Black Friday, have now begun to try to spread the peak demand load. Similarly, Santa is rumoured to have been in talks to share his delivery network for other important seasonal deliveries – watch out for sooty Easter eggs this spring.

Well, there you go: it looks as if Santa has made some good logistical decisions along the way, but faces a lot more strategic issues to come. If he has quietly been innovating, it's still hard to see him as a paragon of productivity, when compared with many other retailers. Santa may still be blazing a trail through the skies on his sleigh, but in logistical terms he's no Christmas cracker.