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A2_3 Maximising Income

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Abstract

This paper looks at the income mechanic of the video game Starcraft II. We look at the optimum number of workers to have mining at one mineral patch at any one time. This optimum number depends on the type of minerals being mined, but is ~2.4 for blue mineral patches, and 2.5 for gold mineral patches.

Introduction

Starcraft II is a real-time strategy (RTS) video game developed by Blizzard Entertainment. Despite only having been released 7 months ago, it has already established itself as one of the leading e-sports (electronic sports), with regular tournaments held around the world [1] [2] [3]. Players mine resources (either minerals or vespene gas) using workers or 'harvesters', and then use these resources to build their armies up, before attacking the opposing player, hoping to wipe out their army and win the game. The resources these players collect can play a major part in the game. Some players opt for a low income game (few workers), hoping to take out their opponent before they can mass up a substantial army, while others may attempt to play a heavy 'macro' game, where the aim is to mine vast quantities of resources and overpower their opponent with the sheer number of units they can produce.

Striking a balance between the number of workers and army units can be a deciding factor in the outcome of the game as they share the same supply limit (the total number of units allowed). Too many workers and the army will be too small, too few workers, and there will not be enough resources to buy units. We have looked into finding the optimum number of workers to have in any one mineral 'patch' (a mineral 'field' is made up of patches of minerals) at a time to give the highest income (minerals per minute), as only one worker can mine from a mineral patch at a time.

Investigation

There are two kinds of minerals in Starcraft II, blue minerals, which return 5 minerals per trip, and gold minerals (also referred to as high-yield minerals) which return 7 minerals per trip. The blue mineral fields contain 8 mineral patches, while the gold mineral fields contain 6 patches. To collect the income for a given number of workers, the workers were placed next to the mineral field and given the order to mine. After one minute, they were stopped and the number of minerals collected was recorded. For errors, the number of minerals the workers had mined from the field but not returned was used. These results are shown in Fig. 1.

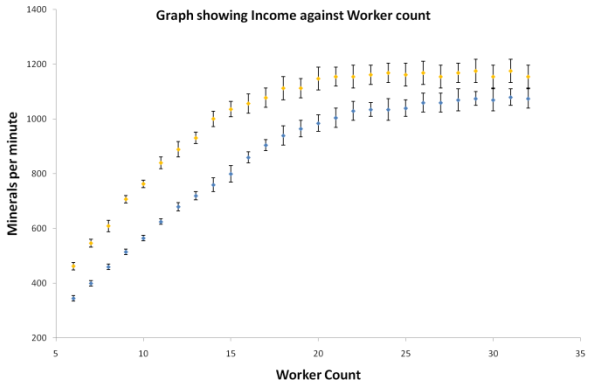

Fig. 1. Graph showing the income against the worker count for blue minerals (the blue points) and for gold minerals (the gold points).

Finding the optimum number of workers per field allows us to find the optimum number per patch using Eq. (1),

$$w = \frac{W}{N}, \qquad (1)$$

where w is the optimum number of workers per patch, W is the optimum number of workers per field and N is the number of mineral patches.

Fig. 1 appears to show that past a certain number of workers, the income does not increase, but plateaus. This is down to the fact that only one worker can mine from a mineral patch at a time, so building more workers than is necessary forces them to move between mineral patches until they can mine one, effectively meaning that they cost more than they return. From Fig. 1, the optimum number of workers would appear to be ~24 for blue minerals and ~20 for gold minerals.

However if we consider the cost of the workers against the return they provide (the income minus the worker cost*), we can get a more accurate result (see Fig. 2).

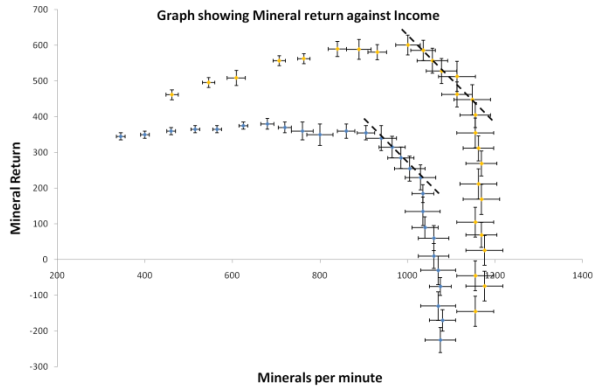

Fig. 2. Graph showing the mineral return provided by workers against the income for blue minerals (the blue points) and gold minerals (the gold points). The dashed lines indicate a gradient of -1.

It can be seen that with worker counts of >27 (>29 for gold minerals), the return is actually negative (this does not mean the income is negative). The optimum number of workers will occur at the point that the gradient of the graph in Fig. 2 becomes less than -1. For the blue minerals this occurs at 19 workers, while for the gold it occurs at 15 workers. Using Eq. (1), this means that the optimum number of workers per patch is ~2.4 for blue minerals and 2.5 for gold minerals.

*The player initially starts with 6 workers so only extra workers built affect the worker cost.

Discussion

The values of ~2.4 and 2.5 workers, although statistically valid, should only really be considered guidelines when playing the game as a number of other factors come into play, the largest of these being what race the player plays as. Starcraft II consists of three races, Terran, Protoss and Zerg, which all play very differently. Terran can call down a special worker which can mine mineral patches at the same time as the other workers, and returns 30 minerals per trip instead of 5 (42 on gold minerals). This means a Terran player may not need as many workers to keep up with the income as the other races. Zerg however, effectively lose a worker every time they want to construct a building, so it could be beneficial to build extra workers early, despite getting less return for a short period.

Another factor that affects the optimum number is the maps that the game is played on. Current mineral fields may change in the future to consist of more or less patches to help vary the game. For example, the gold fields may change to consist of 8 patches as well. If this does occur, it would be simple to scale up the results for the blue minerals using Eq. (2),

$$I_{gold} = I_{blue}\,\frac{M_{gold}}{M_{blue}}, \qquad (2)$$

where I_i is the income for the respective mineral fields and M_i is the minerals per trip for the respective mineral patches.

Conclusion

The optimum number of workers per mineral patch is dependant on the type of minerals being mined. For blue mineral patches it is ~2.4, and for gold mineral patches it is 2.5. However, this should be considered in conjunction with which race is being played (especially Terran), and with how the mineral fields are made up on the map.

References

[1] Korean competition, the GOMTV Star League (GSL): http://www.gomtv.net/

[2] North American competition, Major League Gaming: http://pro.majorleaguegaming.com/

[3] A European Gaming Festival, DreamHack: http://www.dreamhack.se/dhw10/event-scheduele/e-sports/starcraft-ii/