Banker's Dozen: From Economics Paper to Playable Game
December 8, 2010

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Abstract

This is an account of an experiment in game adaptation. I describe the motivations behind and the results of several attempts to build a video game based on the ideas of an unusual economics paper – "The Theory of Interstellar Trade" by the Nobel Prize winning economist Paul Krugman.

I. Introduction

Game designers have often looked to other media for inspiration. Usually this means drawing from a fictional narrative text such as a novel, a comic book, or a feature film. This paper documents the the making of *Banker's Dozen*, an experimental video game that innovates by using an economics paper as its source material.

When I discovered "The Theory of Interstellar Trade", it immediately struck me as a potential source for adaptation. I thought that its unorthodox science fiction subject matter and wry sense of humor might allow me to trick players into practicing a bit of what the historian Thomas Carlyle maliciously termed "The Dismal Science".

Game design and economics are in many ways overlapping professions. Their practitioners share a common world view where human behavior is seen as mediated by systems of constraints and incentives, and where agents must make choices in order to accomplish their goals. To illustrate the affinity of economic ideas with the practice of game design and play, I offer a definition of economics that wouldn't be out of place in a game studies book.

"Economics is the study of infinite wants and finite means, the study of constrained choices. This is true for individuals and governments, families and nations."

-Russell Roberts, Professor of Economics at George Mason University and host of the popular podcast "Econtalk"

Continuity between these fields is an ongoing project. The development of game theory by John von Neumann, John Nash and others was one of the most significant revolutions in the study of economics in the 20th century. More recently we have seen the employment of economists by developers of massively multiplayer online games like E.V.E. Online. These massive virtual worlds have also been useful in facilitating the practice of experimental economics. If games can provide inspiration and assistance to economists, could economics do the same for game designers?

II. The Theory of Interstellar Trade

Paul Krugman wrote "The Theory of Interstellar Trade" in the late 1970s when he was *"an oppressed assistant professor, caught up in the academic rat race."* The paper is a humorous examination of the economic considerations that must be taken into account in practicing trade across great distances and high speeds. In the paper, Krugman calls his work *"a serious analysis of a ridiculous subject, which is of course the opposite of what is usual in economics."* The writing is liberally peppered with puns and absurdities. This passage from the introduction is I believe a fair representation of the tone and substance of the document:

"Many critics of conventional economics have argued, with considerable justification, that the assumptions underlying neoclassical theory bear little resemblance to the world we know. These critics have, however, been too quick to assert that this shows that mainstream economics can never be of any use. Recent progress in the technology of space travel, as well as the prospects of the use of space for energy production and colonization (O'Neill 1976) make this assertion doubtful; for they raise the distinct possibility that we may eventually discover or construct a world to which orthodox economic theory applies. It is obvious, then, that economists have a special interest in understanding, and, indeed, in promoting the development of an interstellar economy."

Krugman talks about two major features of interstellar trade. First, it would necessarily involve voyages that take a very long time (possibly one hundred years or more). Second, if this transit is going to be practical, the space ship making the voyage would have to be traveling at a significant fraction of the speed of light. The theory of special relativity (which has been subject to experiment and so far confirmed) says that time must pass more slowly as speed increases because the speed of light appears constant regardless of the speed of the observer. This means that in transactions where interstellar travel plays a part, we must consider the possibility that time is not constant between all interested parties.

Professor Krugman goes on to rigorously examine the central question of the paper - "how should interest charges on goods in transit be computed when the goods travel at close to the speed of light". Basically, this is a question of opportunity cost, or what the theoretical merchant is giving up in order to send these goods from one planet to another. The capital behind such a project could instead be invested elsewhere, so for a voyage to be worthwhile, its projected profits must be greater than other potential future cash flows.

Krugman eventually proves two theories. Of these only the first theorem is of interest to the game adaptation:

"First Fundamental Theorem of Interstellar Trade: When trade takes place between two planets in a common inertial frame, the interest costs on goods in transit should be calculated using time measured by clocks in the common frame, and not by clocks in the frames of trading spacecraft."

What Krugman refers to as the "common frame" means the rate of time on Earth, and on the other planet involved in the trade. (Krugman assumes that these planets are not traveling at a significant speed relative to each other.) This theorem has one corollary of interest to a game adaptation; because interest rates should be computed based on the Earth's inertial frame, a traveler will experience a higher relative rate of return on investment because less time will have passed for them.

III. Related Commentary and Literature

Krugman's paper spent many years in a state of obscurity, and was finally released in 2008. This would prove to be good timing as the author was by then a world famous economist who was (and is still) widely read by professional economists. This meant that in addition to the original text, I was able to draw upon a recent dialogue spawned when the paper surfaced two years ago. I was also pleased to find an unrelated but useful paper on the subject of relativity and finance. The paper, "Space-Time Finance" was written by Espen Gaarder Haug in 2004, before "The Theory of Interstellar Trade" had seen wide circulation.

My understanding of Krugman's work was aided enormously by the commentary of Tyler Cowen, Professor of Economics at George Mason University on his blog "Marginal Revolution". Cowen interpret's the effects of trade and relativity through their effects on time preference, and in doing so lays out what will become the basic scenario for all of my attempts at game adaptation:

"My own puzzling focuses on the determinants of real interest rates, given how time dilation changes the meaning of time preference. As you approach the speed of light you move into the future relative to more stationary observers. So can you not leave a penny in a savings account, take a very rapid spaceflight, and come back to earth "many years later" as a billionaire? Hardly any time has passed for you."

As readers not familiar with economics may have inferred from this passage, time preference is the value we place on having money sooner rather than later. When we decide to take out a loan, what we are doing is receiving some amount of money immediately, which we will pay a premium for in the future when the loan comes due. Cowen's scenario works because the theory of special relativity allows potential creditors to improve their returns if they can manipulate their time preference through acceleration and time dilation. Cowen continues his analysis by speculating on how this technology would affect other areas of the economy:

"In essence we are abolishing time preference, or at least allowing people to lower their time preference by spending money on fuel. I believe that in such worlds the real interest rate cannot exceed the costs at which more fuel can "propel you into the future through time dilation."

Cowen believes that if relativity were actively used as an investment strategy, traders are going to find themselves in a situation where they are basically paying for time with fuel. He continues along this line of thought, imagining some incredibly perverse outcomes:

"Whether the individual arbitrage conditions translate into economy-wide arbitrage conditions is a difficult puzzle. What if everyone gets into a fast spaceship? Do the savings accounts still bear positive interest? How does the price of robots enter into this equation?

Is monetary policy neutral in such a world, with time travelers arbitraging against any attempt by the Fed to shift real interest rates? Does the Fed have to subsidize the price of fuel to stimulate the economy? Does everyone just end up in the future?"

A world where everyone travels at high speeds for financial gain seems to be a reductio ad absurdum that falsifies Krugman's original theorem, which assumes that financial markets will be mostly based on slow moving planets rather than fast moving space ships. To decide which scenario is more likely is beyond the scope of this paper. My attempts at adaptation have instead been focused on translating these ideas into compelling game rules and procedures. In this I have been assisted by Espen Gaarder Haug's "Space-Time Finance", which suggests some additional avenues of exploration.

Haug's paper is a comprehensive exploration of relativity and finance. It would have been, on its own, sufficient inspiration for a game project, however I did not encounter “Space Time Finance” until I was well into the process of creating game prototypes. The most significant contribution of "Space Time Finance" to my project was its examination of general relativity. It turns out that both speed and gravity can cause time dilation effects. The author proposes a scenario where an investor orbits a black hole with a gravitational force ten times greater than Earth's sun. With this example, Haug shows that *"the annual return on the space station is an incredible 11,639%"*. He tempers this investment advice with some commentary on how difficult it would be for humans to survive in this extreme environment.

IV. Conceptual Design Overview

Starting with the scenario proposed by Cowen, of exchanging fuel for time, I imagined the game as a playable simulation of investment and spaceship navigation where the player attempts to travel as fast as possible without spending too much money on fuel. This configuration would remain constant in all of the *Banker's Dozen* prototypes.

While economic models tend to describe situations that reach a state of equilibrium, where there is one ideal course of action, a game must have several potentially attractive strategies to be of any interest to players. The noted game studies scholar Gonzalo Frasca once described a game as an activity where all choices are potentially attractive to the player. Activities with only one attractive option would be more accurately called "work". This imperative of heterogeneity meant that I needed to find incentives to prevent the player from turning the game into a simple math problem where they could buy as much fuel as possible and travel as fast as they could for the duration of the game, so long as they could return to earth. Some of these incentives against unrestricted use of high speed travel would be integral to the physics based mechanics of navigation, such as the possibility of running out of fuel in deep space. Others would open up new areas of gameplay, ultimately transforming the first prototype into a sort of management simulation.

V. Paper Prototype

The first playable version of *Banker's Dozen* was a turn based multiplayer paper prototype, administered by a game master. This version of the game had the most complicated set of rules and procedures of all of the prototypes. Players were asked to make choices about navigation, investment, communication, reputation, culture and business operations.

The navigation portion of this prototype grants the player a ship that they can move across a grid that depicts a play field with an area of roughly one hundred square light-years. This grid contains a stylized representation of Earth's sun and its closest neighbors. It is divided into squares, each representing one half light year in distance. Players can travel at either one or two squares per turn, which translates to speeds of 0.5c or ~.999c. While on earth it is possible to buy fuel, which must be expended any time one wishes to accelerate, decelerate or turn. If a player's ship is located on top of a star, they can turn their ship at reduced fuel cost, a rule which was meant to simulate the use of gravity to perform "slingshot" maneuvers in space. Earth is the only planet that players can visit. Players can potentially run out of fuel while away from home. If a player is unable to return to earth, they must withdraw from the game.

To simulate the relative dilation of time, players are issued a limited number of "birthdays" at the beginning of the game. Birthdays are a resource used to represent months and years of time passing. If a player is traveling at high speed, they discard fewer birthdays per turn. The game ends

when all of the players have expended all of their birthdays.

In the paper prototype, players make money primarily by speculating on different index-linked mutual funds. These funds are simulated though a deck of event cards drawn each turn. These securities each have different levels of risk and volatility.

Players can also make money through the buying and selling of rare items such as fine wine or endangered species, which they must carry aboard their ship to use the effects of time dilation as a preservative. Trading rare items is risky, but possibly more lucrative than investing in index-funds. Adding this type of cargo will increase the mass of the player's ship, forcing them to expend more fuel every time they perform a navigational maneuver. The price of rare items is controlled through the same event-card deck that drives the securities markets.

The mechanics of communication over vast interstellar distances is an important aspect of the paper prototype. We tend to think of electronic communication as instantaneous, but this is only because the messages we are sending are traveling the relatively short distance of thousands of miles. In reality, the radio, microwave and electrical transmissions we use to communicate travel at the speed of light. In contemporary society, players of online video games are probably the most affected by this limitation because they require low latency network connections. It is impossible to play a first person shooter over a satellite connection because the satellite is positioned far enough from the player that each data packet takes a noticeable fraction of a second to get from transmitter to receiver.

The effects of this communications latency phenomenon would be multiplied many times over in a game where players can travel many light years away from earth. I decided to simulate this non-instantaneous communication because of the interesting choices and trade-offs that it might provoke. Players traveling further from earth would theoretically be able to achieve better fuel economy because they would spend less time turning around. Players who stayed closer to earth would have more up-to-date information on the state of the market, and would be able to return to earth more easily in an emergency situation. Near-earth players would also be less likely to find themselves drifting through space, out of fuel and out of control.

Another important incentive system in this version of the game is the role of governments, taxes and reputation. Even the most casual observer of current events knows that when bankers and traders engage in behavior that comes across as fraudulent, malicious or unfair, there is often a public controversy over the matter, sometimes followed by the legislation of new commercial regulations. In societies experiencing extreme economic situations such as the Weimar Republic of the 1919-1933, economic disaster can even contribute to the breaking down of the state's monopoly on legal violence, culminating in a change of regime. In designing *Banker's Dozen*, I assumed that the use of time travel as a financial tool by an elite group of bankers could be viewed as inappropriate by the citizens of many nation states, and this could create situations where the player would find themselves being restricted or taxed if public opinion were to turn too far against them.

To simulate this system of reputation and regulation, the game has cards mixed into the event deck which can cause the player's assets to be taxed each turn. There are also event cards that prevent the player from buying and selling stock by radio transmission while in space. Players can restore their reputation and counteract negative regulatory forces by successfully completing a television-interview mini game. This mini game is a stylized form of debate where the player and the game master compete for audience approval by playing cards symbolizing different rhetorical techniques against each other.

Through the staffing mechanics, players can improve their performance in various areas of the game by hiring and paying three types of staff members. Quants are financial analysts that allow the player to "see into the future" by looking at cards in the event deck which have not yet been turned over. Players can also hire scientists to develop new technologies which may give them a competitive advantage, such as more efficient rocket engines and instantaneous communications devices. Marketing staff maintaining the player's reputation and prevent undesirable government regulations.

The sort of relativistic space travel depicted in the game would theoretically allow an astronaut-

banker to take trips that would be hundreds of years long from the point of view of an observer on Earth. Because someone from the 19th century would have certain disadvantages if they were transplanted into modern society, then it is reasonable to assume that our hypothetical banker might suffer similar disadvantages as they propel themselves into the future. I included a set of mechanics relating to the use of cultural knowledge as an attempt to address this situation. These rules and procedures are a set of consequences that the player must deal with if they stay away from Earth for an extended period of time. Players have a cultural affinity score which is decremented each turn, except when they are visiting earth. This score affects two areas of the game. In the first case, the contents of a player's deck of debate cards in the television interview game is based on their cultural affinity level. In the second case, players must interview their staff before hiring them. This process will determine if a potential employee is trustworthy or not, and a mendacious employee will eventually embezzle money from the player. The ability to conduct a revealing interview is directly linked to the player's cultural affinity score. Players can choose at any turn to restore some of their cultural affinity by watching television while in space, but in doing so they forfeit the opportunity to view the latest market information cards that have been drawn from the event deck.

VI. First Playtest

Development of the paper prototype game culminated in an informative, but inconclusive playtest. The testers enjoyed the setting of the game and were intrigued by some of the gameplay mechanics, but they were bothered by the difficulty of simulating such a complicated system of rules and procedures without electronic assistance.

The mechanics related to communications-latency impacted play so severely that players were often confused about the overall game state. The effects of light-speed communications on news broadcasts were mentioned in the previous section of this paper, but I feel the need to elaborate upon some of the things I had to consider when building a coherent simulation of this phenomenon. I submit to the viewer the following example.

A player who is only one light-year away from Earth must wait two turns to buy a security. This process begins with the player sending the message, which would take one year to reach Earth. At this point the price of the security may have changed. If the price change is extreme enough it is possible that the player no longer has enough money to buy the financial products that they ordered the previous turn, but they may not know this yet because they do not themselves have an up to date picture of either their bank balance or current market prices. If everything goes well, the player would receive a confirmation message along with a token representing the shares of stock that they had purchased, along with a message containing the amount of money that they spent on their desired financial product at the time the transaction was parsed. In cases where the player had insufficient funds, it was necessary to send a rejection message instead.

This communications model was obviously unwieldy for a board game, but I could not be sure that it was definitely a bad idea for what was ultimately going to be a computer game. One of the playtesters commented that he enjoyed thinking about a situation where he could trade time for information. The other tester said that the system made her question if she had any agency at all.

Some of the mechanics, such as the marketing staff were completely unbalanced or broken, and had to be removed from the test early on. The television interview mini game received a positive response, as did the buying and selling of rare items. The highlight of this test happened when one of the players had to consider the possibility of flushing a Komodo Dragon out of an airlock to improve their fuel economy. Mercifully, the reptile survived.

VII. First Electronic Prototype

The paper prototype was followed by a single player computer game with 2d bitmap graphics, executed in the Unity engine. This version was an attempt to adapt some of the core mechanics directly from the paper prototype into a contemplative turn-based strategy game. My primary goal was to diagnose the fitness of the communications-latency mechanics that caused so much trouble in the preceding playtest. Simulating these mechanics in software would reveal whether they were fundamentally flawed, or merely too complicated to adjudicate on paper.

The time needed to implement a communications delay in software was substantial even with a simplified ruleset so the first electronic prototype temporarily discarded the mechanics of cultural affinity, staffing, rare item commerce, taxes and reputation. Navigation, market simulation and the buying and selling of index funds were all faithfully reimplemented in digital form.

My interface design goal was to unambiguously communicate the relationships between time, space and money to players, many of whom would not be likely to encounter such systems in their everyday lives. This digital version of the game is controlled through a series of mouse-driven menus, which are accessed in a fixed, sequential order every turn. The first menu is a television where current events are relayed. In the next screen, players may buy and sell securities. Finally, a navigation screen prompts the player to specify their next destination. Turns are punctuated by a short series of cut-scenes that explains where the player has moved, how many years they have aged, what their fuel consumption was for the maneuver performed and how far away from earth they have traveled. End game conditions are also relayed by cutscene.

VIII. Playtest of First Electronic Prototype

I conducted a playtest of the first electronic version of *Banker's Dozen* after several weeks of development. As with the paper prototype, the testers liked the theme of the game but had issues with gameplay. Although each tester chose a different strategy, both believed their plan to be the only reasonable course of action. Both testers ended up ignoring the communication of market prices and events through the television because they knew that their information was often too out of date to make any difference. This response finally convinced me to abandon the use of communications latency in future prototypes. One tester especially liked the visual representation of the television newscaster, who resembled Walter Cronkite. Both players commented that they formulated their strategy early on and spent most of their time implementing this plan, which was not the most pleasant experience. The information cut-scenes between turns were effective, but tedious. They spent most of their time clicking through these repetitive information displays.

IX. Second Digital Prototype

A lackluster playtest forced me to abandon any plans to expand upon the original digital prototype. The mechanics that were present in the paper prototype but absent in the first digital game were promising, however the central navigation and communication mechanics were obviously broken beyond repair. I decided to build another pared-down digital prototype, this time with a real-time flight model.

The navigational play in the second digital prototype feels radically different than either of its predecessors, even though it is still based on Cowen's proposed scenario of paying for time with fuel. The move from turn-based to real-time gameplay was designed to solve the most serious problem experienced during tests of the first digital prototype; players were spending too much time

implementing strategies rather than formulating them, and that implementation was tedious and without challenge. Decisions that could be considered indefinitely in earlier versions must be made immediately in the new real-time navigation game.

This version of *Banker's Dozen* was inspired by several classic science fiction games (*Asteroids*, *Spacewar!*, *Star Control*), however the final real-time simulation incorporates a more comprehensive physics model than these antecedents. Every time the player fires their main engine, takes on cargo or refuels their ship, its mass changes, which in turn affects fuel economy and inertia. Taking on the right amount of fuel at the right time is now a crucial player decision.

The play area has been compressed to the scale of a solar system to encourage more varied play. Planets orbit the sun at noticeable speeds, which means that the sources of gravity that allow the player to turn around without expending fuel will be in different relative positions as time passes. Players can still land on Earth or on one of two tanker ships to trade goods or take on fuel. All fuel prices in this version are linked to inflation, and will rise throughout the course of a game.

The commercial aspects of the game have also been revised. The index funds of the first two prototypes have been replaced by a simple bank account that rewards the player with compounding interest as time passes. Financial returns are enhanced when players are able to maintain high speeds, warping time to their advantage.

The popular rare item trading from the paper prototype was restored. Players can choose to put some of their money into these items, which are controlled by a simple market simulation. When the prices of these volatile rare items change, the news is relayed by the same television anchor from the first digital prototype.

Communications in this version arrive immediately after they are generated, with no latency related effects.

X. Conclusions

At present, the second digital prototype is complete but untested. I have confidence that it is an improvement upon the earlier versions of *Banker's Dozen*. If I am able to confirmed the quality of the latest prototype with another playtest session, future development would likely begin with a restoration of the reputation and culture mechanics from the original version of the game. The gameplay possibilities of general relativity, as discussed in Haug's "Space-Time Finance", should also merit further exploration as simulating the relativistic effects of large gravitational fields such as black holes would be trivial to implement in the current real time engine.

The process of turning an inspiring idea into a satisfying player experience was not an easy or a straightforward process, but in the end *Banker's Dozen* has been an informative experiment in game adaptation.

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