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A synthetic world is a computer-generated Earth-like environment that is accessible online to hundreds or thousands of people on a persistent basis. Due to the genuine human interactions that are cultivated in these environments, this technology may stand to offer much as a social science research tool. In this paper we describe a synthetic world, Arden, which has been designed and constructed for use in macroeconomic experiments. We detail the basis of the Arden economy, the resources and production technologies involved, the game structures that will entice players to make use of them, and the monetary and fiscal policy tools available for regulating the virtual market. The paper concludes with a description of example experiments that could be conducted, as well as a review of key principles and practical considerations to keep in mind when employing this new research tool.

Keywords: Virtual Worlds; Economics; Game Design

Synthetic worlds (or "virtual worlds"; we will use the terms interchangeably) are persistent online 3D spaces that replicate many of the features of the real world. One negotiates them through a virtual body or avatar, and, as with a video game character, uses it to interact with a vast physical environment. Oftentimes, these worlds include a number of fantastical elements—monsters, magic, aliens, futuristic technology—as the backdrop for such exchanges between player and environment. Additionally these worlds are "massively multiplayer," in that thousands of individuals are able to simultaneously coexist within a given virtual space. That being the case, in addition to

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engaging the preprogrammed world itself, players are able to interact with huge populations of other users. Thus, while these worlds may be fantastical, they also contain a wide assortment of genuine human interactions.

These interactions reflect the sorts typical of daily life in the real world, resulting in the exercise and exhibition of in-world politics, social norms, and economies. Previous research into such synthetic societies has focused exclusively on what they look like from the *outside*, that is, how we might understand them as *users*. However, to gain real insight into the political organizations, economic systems, and social orders within these spaces, it may be helpful to examine the design underpinnings that permit their emergence—that is, to understand the moderating mechanisms of these social dynamics from the inside.

Here, we report on our experience as *builders*. The authors represent an element of the design team for *Arden: The World of William Shakespeare*, which has been conceived as a massive game world that will serve the dual missions of teaching and research. Arden's teaching function is served by immersing its users in the language, plots, and historical contexts of Shakespeare's plays. The research function is served by conducting controlled experiments on the genuine human social structures that will emerge within the world.

Creating such a research tool is no small endeavor. Comprising a tool that grants breadth of experiment potential and external generalizability requires an educated understanding of game dynamics, human behavior, and technological capacity. A number of considerations must be made in order to construct conditions allowing for the emergence of complex, yet parsimonious systems of measurable sociality. Moreover, this feat necessitates not only intelligent design, but a large-scale, managed production effort. In the process, a primary investigator becomes one-part academic researcher and one-part game producer. Further, building an entire world is not a simple task, and thus completing even the more limited objectives will take time. However, as the practice grows, and the more successful tactics are shared and adopted, a standard can be established for the construction and use of synthetic worlds as tools in research. The initial efforts of Arden represent a small first step in this direction, helping to develop an approach that will allow for the design and study of emergent social structures.

One structure that will certainly emerge is the market. Yet, depending on the world's design, the market can emerge in various ways. If we simply put items into the world and allow people to trade them, there will be economic activity: people will trade things they do not want for things they do want. Trade will happen at a more intense level to the extent that we create specialization, that is, to the extent that we make different people have different endowments of goods and services. For example, we could make a world where people can ride horses, and everyone also is a rancher, saddler, and blacksmith. In that world, everyone would use their own ranch to raise a horse, their own saddling skills to make a saddle, and their own smithing skills to shoe the horse. Alternatively, we could make a world where everyone must choose one of these occupations and "skill up" in it, that is, devote time to improving their character's ability to produce quality items. In this alternative world, there would be

ranchers with many horses but no saddles and no shoes; saddlers with many saddles but no horses and no shoes; and smiths with many shoes but no horses and no saddles. To get all of these people on horses and riding, trade must occur, and there would be far more trade in the latter world than in the former. The relative presence or absence of market trading can be designed into a synthetic world, depending on the objective of the designer. And if one's objective is the study of market dynamics, a designer would then select for proper conditions to allow for a thriving economy to emerge.

This paper lays out our approach to building such a thriving economy. First we will describe how we can create supply and demand in a completely synthetic environment. Second, we give an overview of the kinds of items and production technologies we plan to have in Arden. Third, we talk about the way markets will work in our world: how players will trade and where the money comes from. Fourth, we describe some of our policy tools. And finally, we discuss the kinds of social experiments we expect to be able to do with the economy we have built.

Sources of Demand and Supply

What Drives an MMOG Economy?

Video games in general, and MMOGs (Massively Multiplayer Online Games) in particular, start players with only a fraction of the game play options and abilities that they will have at the end of the game. A newly created player character starts with the most rudimentary abilities and will later gain additional advancements through exploring the world and accomplishing various tasks. One type of character advancement is the acquiring of "innate" abilities—abilities that allow the character to attack in a certain way, heal other characters, or accomplish any number of actions in the world. These innate abilities cannot be transferred from character to character. The second type of advancement is the acquiring of items more "external" to the player character—armor, weapons, and tools that enhance a character's innate abilities. These items can be transferred from character to character, and are what form a MMOG's source of demand.

Within a given virtual game world there is a demand for "finished" items, such as weapons that allow a character to hit harder, armor that allows a character to withstand more blows from a weapon, or potions that give them temporary benefits. Players usually demand these better weapons and equipment because it assists their survival while venturing into new areas of the world; innate abilities are not always enough to ensure save passage. Further, new equipment also usually bestows a new appearance on the wearer and functions as a status symbol. Anyone who sees a character with that equipment knows that they spent the time and energy to go through the necessary steps to obtain it.

Finished items can usually be obtained in two ways. The first way is for a character to venture out in the world and discover an item, either through completing a specific task or defeating an enemy. The second method is similar to the first, but instead of

obtaining finished items, characters obtain item components which then must be taken to a character that is skilled in item creation. This crafting character can turn the components into a finished, useable item. The components have no innate use until a crafter turns them into something useful.

This leads us to the demand for components. Not all items can be directly obtained through killing monsters and completing quests. Often, the best items (those that allow for the greatest character advancements) can only be made by player/crafters. However, crafters cannot create items out of thin air; they require components that are gathered in dangerous areas or obtained through defeating monsters. There is an obvious link of supply and demand between crafters and people who venture out into the world to kill monsters. Monster-killing adventurers need items and crafters need raw materials to create items. Additionally, crafters are also often bound to each other through supply and demand: most finished materials require items made by crafters of various different specialties. For example, a blacksmith might need a leather strap produced by another crafter in order to create the hilt for a sword.

What Makes These Items Scarce and Valuable?

There are three main reasons that items are valuable: some items, such as arrows or food, are constantly being used up and need to be replaced; other items are made valuable by the amount that they increase a character's abilities; and other items are valuable simply because they are hard to obtain and anyone who acquires the item gains social prestige with the other players.

Most MMOGs attempt to enforce value through rarity. Less-powerful finished items and raw materials are allowed into the world on a frequent basis but the truly powerful and valuable finished items and raw materials are much more difficult to collect. For instance, the valuable raw materials might only appear one out of every hundred times a character collects raw materials from the ground. Likewise, the monster that drops the "Sword of Magic" might only drop the sword once every hundred times he is defeated, or the monster may only appear once a day, or the route to the monster might require the cooperation of multiple characters in order to gain passage.

Furthermore, most MMOGs do not institute a system of decay on their items. In those games, once an item is created it never leaves the world unless a player destroys it on purpose. Items are generally made permanent because most games make it hard to get the rare items, and players do not want to feel that their hard work has been wasted. A problem that arises from this system is that rarity is not enforceable over a long period of time. People play MMOGs for months, if not years, and no matter how difficult it is to obtain an item, eventually it will start to appear in the economy with such a frequency as to seem common to the players. In turn, the less powerful items that were originally "common" will begin to look like nothing more than rubbish, and the "rare" items will go from being considered prestigious to being viewed as the new baseline. Players who do not have the "rare" items are then considered to be lower class.

There have been many thoughts on how to enforce scarcity, such as having all items, even the powerful ones, decay over time. That solution can fix the problem of a market getting flooded with "rares" to the point that they are considered common. Another solution to the rarity problem is to create additions to the world that contain different, more powerful rare items, and so the rare items in the new areas become valuable until the cycle repeats itself and the new rare items are then too perceived as common. A MMOG can combine supply and demand with a decay system, requiring that all items need to be replaced on a regular basis. However, care must be taken to ensure that a player does not think that their hard work or time spent in game has been wasted. In many MMOGs a player may spend several hours acquiring an item that gives them a boost of power and is visually impressive, signfying the significant time investment. If that item breaks, the player will may feel the time investment was wasted and leave the game.

A game that requires every single item to decay can still have tasks that are hard or take twenty hours to accomplish, but they must result in permanent, non-item rewards. For instance, any player that slays the ancient red dragon might gain a title to put after their name, so that everyone can see they put in the time and effort. If we wish to give the character an ability reward, we can give them a new intrinsic ability. They fought a dragon, so they now do slightly more damage when fighting this type of dragon. This scenario does not contain any items at all, but we do not want to have a world bereft of items: such a world has no economy. So, we introduce items that enable the use of the dragon-slaying ability that our character has achieved. These items will surely break over time, but the player has not lost their hard work. They merely need to procure a new stock of the enabling item, a task that will surely take time, but not nearly the time that the dragon slaying task required.

Arden will make use of a system similar to the broad ideas outlined above. It will have a constant turnover of items that need to be replaced, but players will retain abilities and mementos that show the rest of the players what they have achieved. The function of rare items will be taken up by abilities and titles, and the common items will be used as enablers that allow a character to use the abilities that they have obtained.

Resources and Production

The most basic type of components for crafting is raw resources. The resources present in Arden will be based on those found in the British Isles during the 14th and 15th centuries. These resources can be harvested by the players from resource nodes, which are three-dimensional graphical representations of a specific resource type (tree, bush, ore, etc). Resource nodes will appear on a predetermined coordinate of the virtual world map, with the location and rarity of the node based on the tier level of the resources contained within (see display below). When harvested, most nodes will yield a "common resource," but occasionally a node will yield a "rare resource." In order for rare resources to remain so, the chance a rare resource will be harvested from a node will be set to one out of every 500 harvests. Additionally, each resource

will also yield a rare byproduct: when 500 units of the rare byproduct of a particular resource are combined, the aggregate will yield an associated rare resource. This system ensures that players who have an unlucky streak can continue to harvest rare resources at a rate of one rare for every 500 resources harvested.

In our design, each resource node hosts 21 harvest nodules, which will spawn over an extended period of time. A node can have up to five simultaneously active nodules available for harvest, and resources can be harvested from a node by accessing one of its nodules. Nodules will individually disappear once harvested by a player and be replaced if any of the 21 remain. Once 21 consecutive nodules have been harvested the node will disappear and subsequently respawn in a new location based on a predetermined algorithm. Our economy design and its purposes call for resources to strike balances between being continuously available or randomly available, as well as predictably located or randomly located. Thus, the numbers and rates used here were chosen to strike a compromise in which (1) a node may be in any one of several predictable locations, and (2) the node could be either fruitful or not fruitful at a given time, especially given the predicted activities of the rest of the player base.

In order to support player advancement, resources will be grouped within a tier-based system. A tier-based system permits players to advance from working with lower tiered rudimentary materials (such as tin for metal crafting) to working with more higher tiered advanced materials (like steel) through an investment of time. Higher tiered resources will appear in more remote locations requiring a larger time investment from the player to achieve and maintain a high crafting level. Higher tier resources represent goods superior to those at lower tiers, and by having incrementally longer production processes for higher tier goods only a marginal cost is added into the production model for superior goods. Extended time investment is preferable to a cost model based solely on entry-barriers (i.e., the cost of achieving high enough level to work with the new materials) in that it still allows for a tier system yet does not implement barriers that may seem overly arduous or arbitrarily restrictive to players.

Production Technologies

The production technologies of Arden will allow us to expand the economic interdependence of the various crafting professions, as well as increase the fun quality by importing a measured dose of realism. To illustrate the interplay of the economic interdependence that permeates crafting, we offer both a general summary of production technologies and a detailed example of how metals are harvested, extracted, refined, and processed into finished goods.

Synthetic worlds often represent progression in a crafting profession by introducing a tiered level system for raw materials. Tiered systems are easy to model with game mechanics and also happen to mirror reality well. Historically humans did work copper metal before producing similar items with more difficult alloys such as bronze, and subsequently iron, and steel. In video games we often see a reflection of this system in which players produce finished goods using a variety of fantasy and

real-world analog materials. This current convention has provided us with the essential foundation, upon which we wish to continue to expand.

In designing Arden, we are using the works of Shakespeare to limit our scope of potential crafting materials; we will rely on real-world analog materials, specifically those resource materials which were plausibly available in the British Isles during the fourteenth and fifteenth centuries. As mentioned above, we have grouped materials into tiers, and their use will mark achievement in a player's chosen trade. Further, and notably, the design of Arden deviates in four different areas from current conventions of most synthetic worlds. First, not all trade skills will represent an equal investment of time from the player. This is positive because not all players visiting synthetic worlds wish to devote an equal amount of time to crafting. By being made aware of this difference, the player can choose a craft which suits their anticipated time investment. This does require a balancing of investment with return, and this balance must take into account the individual demands of the craft, the balancing of the rewards of one craft versus another, and the rewards of crafting compared to other achievement methods. For example, historically metal workers were highly valued crafts persons due to the difficultly of the profession; similarly, metalworking in Arden will be a crafting profession which requires a higher investment of time.

Second, those synthetic worlds which typically implement tier-based systems encourage linear consumption of game resources. Tier one resources are located in areas with tier one player mobs, tier two resources are located with tier two player mobs, and so on up through the tier structure at a rate predicable to the developer and the player. This system produces a negative effect of segregating players into groups based on tiers, diminishing their social interactions and shrinking the visible player base for a given player. In Arden the system will be slightly different, as metalworkers, for example, will progress through tier one and two relatively quickly and spend a much longer time using the tier three resources, with some high achievers occasionally requiring tier four materials. This also mirrors reality well, for by the fifteenth century apprentices and journeymen were widely taught in tin, copper, and bronze-smithing, while the current mode of the craft was ironwork, and only the most accomplished craftsmen had the advanced knowledge and ability to work with steel. Other crafting groups will have similarly structured, but different progression paces. Such a design will limit the tier-based social segregation of players through an overlapping of different crafters at different points in tier progression.

Third, resource materials from lower tiers will still remain valuable to players once they have moved beyond that resource tier. This deviation from convention is required by the previous deviation; however it is also useful in its own right as it further reduces the tier based segregation. There will be incentive for a craftsperson to use materials which are below his tier level because, as different crafts will advance at various rates, other crafting professions will still require goods based on these lower level materials. This system thus also makes possible the fourth and most important improvement on convention: that players engaging in a crafting profession must have a system of interdependency with other crafting professions.

In order to measure inflation or any other economic indicator within a synthetic world there must be high levels of trade. By having a large number of goods that players want, with only a small number which they can create themselves, high levels of trade can be induced in a crafting system. In this system a player will create a large quantity of one particular item, and then trade those particular items for items which are desired but cannot be made by that player. By deconstructing the barriers between resource and production tiers, we have created interdependency between crafting professions and increased the proportion of the player base that any given crafter can count on as their customers or suppliers. In aggregate, these four refinements enable us to more accurately measure the marketplace economy of Arden. Additionally, the system will promote interaction between players, limit the frustration of depending on a set fraction of players for advancement, and reduce the tedium of repetitive crafting.

Markets and Money

Richard III ruled England for a two-year period beginning in 1483. The money of Shakespeare's day was mostly introduced shortly after Richard's reign, particularly the sovereign. To mirror the currency of the England of Richard's era as much as possible, Arden will use the most common currency available in England in the late 1400s. The basic units of value at the time were the pound, the shilling (s), and pence (d). Unlike the British currency today, pounds, shillings, and pence did not follow a decimal progression. Each pound was worth 20 shillings and 240 pence, with each shilling therefore worth 12 pence. Coins like the Rose Noble (worth 15 shillings) and Florin (worth 6/8) were not commonly used and so are not included in Arden's system of currency.

The currency of Arden is presented in Table 1.

In Richard's day, the highest value coin was worth less than half a pound, so most commerce was conducted using only shillings and pence. Prices were thus given as combinations of shillings and pence. For example, two shillings and six pence would be written as "2s 6d" or "2/6" and pronounced "two and six." Two shillings alone would be written "2/-." To convert between denominations, players will have to visit the King's Market, where the King's Merchants will trade denominations freely.

Table 1 Currency of Arden

Unit of currency	Value	Value (pence)
Noble	6/8	80d
Half Noble	3/4	40d
Quarter Noble	1/8	20d
Groat	4d	4d
Half Groat	2d	2d
Penny	1d	1d
Halfpenny	0.5d	0.5d
Farthing	0.25d	0.25d

However, the Marketplace will convert between currencies automatically, so most users will have to exchange currency infrequently. Players may find foreign coins during play (for example, by completing a quest for a foreigner), but these coins will act like normal inventory items and cannot be directly converted to British currency.

Arden has two separate market interfaces. The Marketplace proper can be accessed anywhere in the world and facilitates buying and selling between players. The King's Market is a physical location in the central town with satellite locations in the nearby villages. At the King's Market, players can convert currency and possibly buy or sell with the Crown. In other respects, the two markets are very similar. For players, the primary purposes of the King's Market are to convert currency and to pick up items and money from buying and selling through the Marketplace. In addition, the King's Market functions as a tool with which researchers and the design team may regulate the money supply of Arden.

If at a given point there is not enough money in the economy for researchers to implement a particular economic study, the Crown will purchase basic crafting materials from players for more than the market rate. Similarly, if there is too much money in the economy, the Crown will sell crafting materials for less than the market rate in order to regulate the world's money supply. To buy or sell items through the King's Market (that is, when the King's Market is buying or selling goods), players must travel to one of the Warehouses scattered across the kingdom. In these Warehouses, talking to the King's Merchants will bring up a simple interface that indicates the current items available and the prices per unit.

Unlike most games, Arden does not have computer-governed merchants to sell basic equipment. To gain improved items, players must complete quests, craft items, or (primarily) buy them in the Marketplace. Similarly, players cannot sell most items to computer-controlled characters. The only way to gain money is to sell items on the Marketplace. For this reason, the Marketplace is thus central to the player experience. At any time and any place in the world, players may open the Marketplace interface to buy or sell items. To buy items, players may search through current listings for items. Items are listed with a quantity, price, and seller and in ascending order by price per unit. Players can buy portions of an entire lot at the given price per unit. Once a purchase has been made, the appropriate coins will be removed from the player's inventory and the items bought (and change, if necessary) will then be available for pick up from any King's Merchant. To sell an item or items, players can open the Marketplace and place the items from their inventory into the Marketplace. They must also set a price per unit in pounds, shillings, and pence. Once confirmed, these items will be placed on the marketplace immediately. When an item is sold, the player will receive their money in the largest denominations possible from any King's Merchant.

Economic Policy Tools

Policy administration is a vital aspect to the sustainability of the Ardenian economy. Unlike many synthetic worlds of its class, Arden is a closed economy where all money

within the system is accounted for by the system administrators. The system will always conserve the amount of money in the system (e.g., money will never just "sink" out of the system). The administrators will, then, need tools to circulate this money amongst the denizens of Arden. By controlling the money supply, administrators should also be able to affect aggregate demand in the system as well as inflation just like any other fully functioning closed economy.

The two approaches administrators will have to alter economic policies will be through monetary and fiscal policies. From the approach of this synthetic world, the monetary policy should be of greater value. Each of these policies, though, offers strategies for affecting the dynamics of the economy: monetary policy for actual currency issues and fiscal policy for taxation and government aid. There will be separate interfaces for administering each of these policies.

Monetary Policy

The general approach taken for the development of these tools is one of monetarism. Monetarism revolves around the principle of the quantity theory of money. Patinkin (1969) contrasts two approaches to monetarism. The first called the Chicago oral tradition from Milton Friedman described the quantity theory as a theory about the demand of money. This demand for money depends on "(a) the total wealth to be held in various forms, (b) the price of and return on this form of wealth and alternative forms, and (c) the tastes and preference of wealth-owning units" (p. 48). This view is put in contrast with the other Chicago tradition. This tradition states that the quantity theory is not about the demand for money but rather the money supply's relation to aggregate demand, price, and output. The changes necessary in the money supply can develop as a result of open market operations or fiscal policy deficits.

The system employed in Arden will blend the two traditions together. We will focus on the quantity theory of money ($Mv = PQ$) in terms of its relation to aggregate demand and the affects it has on aggregated prices and produced goods. Like Friedman (1982), however, the monetary policy tools will focus on supply of money to affect this balance in the economy. With this approach, however, there are two different assumptions that must be addressed. The first is that the velocity of money, which according to Friedman is the rate at which money circulates from person to person, is a constant factor in the equation. Serrano (2003), in his discussion of economies basing themselves off of a standard, discusses the "Triffen dilemma" that, among other things, states that the velocity of money can be kept constant if the currency can be tied to some standard such as gold or, in the case of Arden, a resource that most players will find valuable, such as iron. Serrano takes issue with this dilemma on the grounds of the expansion of credit. The economy of Arden has no credit, and so making our first assumption would seem justified. The second assumption is that by setting target money supplies for consumers, one will not also be setting interest rates. From the standpoint of credit, interest rates are not a part of the system because credit is not a part of the system. From a practical standpoint,

however, the mechanism by which money enters into circulation for consumer's use functions very similarly to setting interest rates.

The actual mechanism for manipulating monetary policy, mentioned in the previous section, happens through the King's Market. At the start of every "season" of Arden, new players enter the world. At this point, there is no currency in circulation, but only resources scattered throughout the world that could be gathered. Non-player characters (NPCs), characters that appear in that are controlled by the game program, denoted as King's Merchants will then buy certain types of these resources at a price determined by administrators. This price will be higher than that of the market value for that item. While this transaction will in turn affect the market value of that item, it is by this method that money enters into circulation from the King's Treasury. Each NPC who works as a King's Merchant will be tied to a pool of money that can be used by them to purchase these goods. When the pool dries up, then the NPCs will have no more money to buy these items. At this point, the supply of money is fixed. The same mechanism can be used when administrators feel the need to remove money from the system. NPCs will sell items of the same class that they buy for a price below market value in order to bring money back out of circulation. This money then is deposited into a different pool, which cannot be used to buy new items by the NPCs. The actual items sold by the NPCs will not be conserved, which means that these will not be the same items that they bought from players since their preservation is not crucial for the system to function.

The interface for influencing this interaction between players and NPCs, and hence influencing the supply of money that enters into circulation, will be in the management of each pool accessible by NPCs as well as the prices of buying and selling back items. These values represent relative prices that are more or less than the market values of the items that are being bought or sold. The "buying" pool, which is used for buying items from consumers, will contain amounts of each of the different types of currency. Administrators can add to this pool (either from the "selling" pool or through the process of "minting" new money) or remove money from the pool. The "selling" pool, which is used for storing money from sold items, can only have money removed from it. Removed money will either be put into the "buying" pool and recirculated or removed from the world entirely. The interface will also include several values that the administrators can alter that will change the buying and selling values of each of the items that are going to be sold by the King's Merchants. In between each of these pairs of values for each item, there will be the calculated market price for that item. There will also be an automatic way to set these values by choosing a relative proportion above and below market value, which will adjust each of the items' values being bought and sold by the King's Merchants.

Knowledge of inflation and deflation are critical for the administration of monetary policy. The quantity theory of money, however, is not the best suited for dealing with inflation (Alvarez, Lucas, & Webber 2001). Nonetheless, the supply of money does affect the amount of inflation in the economy. It has been observed that there is a strong correlation between the variability of prices and the variance of inflation (Caplin and Spulber 1987). By circulating more or less of the money supply,

administrators can target varying inflation rates. Another interface, therefore, will be needed to implement monetary policy such that it displays real-time database-driven values for the money currently circulating into the system, as well as the aggregate amount of finished goods times their market value (price) for all items that are in the economy. This interface can track the average price over many time steps to provide a fairly reliable real-time heuristic of the inflationary or deflationary activity of the economy. From these data, administrators can respond by adjusting the amount of money that is being circulated in the system.

Fiscal Policy

From a monetarist perspective, such as the one employed within the Arden economy design, fiscal policy is not as important towards affecting aggregate demand and inflation. This distinction comes out most succinctly in the difference between the Monetarist tradition and the New Keynesian tradition. Whereas monetarists argue that price is determined by the supply of money and hence a strong monetary policy is more important, New Keynesians argue that prices do not change in the short run, but only in the long run, and New Keynesians believe much more enthusiastically in using fiscal policy to affect long-term prices (De Long 2000).

While the monetarist tradition does not see fiscal policy as contributing greatly to aggregate demand or inflation, they do not view it as harmful to the activities of monetary policy. Given this, fiscal policy provides a convenient mechanism to encourage or discourage certain types of behaviors in Arden. Due to the imbalance of time that various people will inevitably spend exploring and interacting with the world, fiscal policy could be used to ensure that all players, regardless of how active or casual they are, have a fun experience playing the game (and not becoming hopelessly destitute).

The way most normal governments administer fiscal policy is through generating funds and expenditures. Generating funds can be accomplished through taxation, minting money, or borrowing from the public (e.g., using T-bills). Administrators can apply these funds to various spending programs through their expenditure. The important difference between a real world government and the King's Government of Arden is that with respect to the actual economy of Arden, operating costs for maintaining this government are nil. Administrators of Arden have taxation at their disposal as a fiscal policy mechanism. Minting money, another fiscal tool, can be a part of the monetary policy, but it is not necessary for maintaining the fiscal policy. Finally, a procedure for borrowing from the public, which can increase funds, will not be implemented in Arden. Thus, taxation will likely be the primary manner in which funds are generated for fiscal policy.

Taxation in Arden will be used to promote the sorts of behaviors and activities that we feel players should follow. One possible tax is a hoarding tax, which could be construed as a modified wealth tax. If hoarding is getting out of control in the space, this tax could be levied to take a percentage of the total monetary wealth that a player has. This would encourage players to spend their money and continue circulating it

in the system. The interface window for this tax will allow designers to decide the tax value for different levels of hording, including the option of progressively charging higher rates to people who are hoarding the most. Further, in addition to being taxed for hoarding monetary wealth, player characters will also be taxed for hoarding property in "Houses." A similar interface can be used to manage this tax as well. Likewise, if players are engaging in behaviors that pollute or otherwise damage the environment for other players in the space, taxes could be collected on the amount of damage or pollution caused. This tax would be levied at the completion of any production process that, as a by-product, produces waste or pollution. The player will be notified that they are being taxed for this activity. The interface for this tax will be a rate per unit pollution.

That which comes into government must also be spent. Expenditures going to welfare can be used to help players who play more infrequently and are having a difficult time getting into the economy. This could occur through automatic messages being sent to players who have low amounts of wealth and items. If the player requests aid, a portion of the funds raised could be used to help these players. Alternatively, the remainder could be recirculated into the economy through the "buying" pool. This will require an interface that allows administrators to transfer money to player's accounts by selecting them from a list and specifying an amount. There will also be a portion of this interface to specify the amount going back into the "buying" pool.

Possible Experiments and Conclusions

The economy of Arden has been designed to be rich, deep, persistent, complex, nuanced, and rigorous. It is not an exact analog of a contemporary economy; indeed, it is not an exact analog of the economies on which it is based, those of medieval England. Our claim is that we can learn something about how societies of humans act by examining the behavior of human societies in synthetic worlds. Any experimental environment can be relevant to questions about the real world, if the questions are posed at the proper level of abstraction. The questions we would like to pose to the economy of Arden involve very general issues of market dynamics, at the macroeconomic level.

One general question, for example, involves the relationship of the money supply to the price level. It is believed that increases in money, unless accompanied by increases in trade, will lead to increases in the price level, that is, inflation. Questions posed at that level of abstraction can indeed be studied within Arden, because Arden contains genuine, real instances of all of the items being queried: it has money, it has trade, it has a price level, and it has inflation.

Thus one can imagine the following sort of experiment. Set up two versions of Arden, exactly alike. Allocate players to the two versions randomly. In one, we set the money supply at an arbitrary level, say £1,000. In the other, we set the money supply at £2,000. We would predict that the price level for items ought to be higher in the latter world. If not, we would have to examine the environment and see whether

the result is replicable. If it is, such a finding would serve as an empirical challenge to some fairly fundamental notions in macroeconomics.

Conclusion

This discussion of experimental potential highlights two key ideas that functioned as the conceptual base for the design and construction of Arden. The first is the notion that the virtual world is more real than most people may think. As mentioned earlier, the human behaviors found within these environments are genuine—they are the interactions of real people in a virtual setting. It does not matter if the virtual environment is filled with vile monsters or intergalactic space ships; what *does* matter is that people lead, teach, explore, trade, compete, cooperate, and otherwise engage one another and the virtual environment in much the same manner we do the real world. Thus, again, though the virtual world is fantastical, the gameplay and interactions within are invariably human. As such, these interactions, particularly when examined in aggregates, may prove to be revealing of the nature of real world macrolevel behavior. Behavioral patterns in virtual settings may provide insight into the rise of social norms, the formation of political institutions, and the patterns of market dynamics. Thus, with the proper experimental design and data collecting tools, virtual worlds may then be employed as social science Petri dishes.

Second, in designing Arden, we aim to make fun gameplay our top priority. This is because no matter how parsimonious or valid an experimental design, players will not engage a game that is not fun to play—much like any other playground, if not fun, it will be left unused. Indeed, virtual worlds, despite the fertility of their graphics or the depth of their mechanics, are soulless machines given verve and life only through the presence and dealings of their human inhabitants. And since it is that very humanity which social science seeks to study, providing a fun experience is imperative for any virtual world research.

However, while these theoretical principles are easy enough to maintain during the design process, the practical demands of constructing a world may infringe upon our ability to actualize our design. In order to create an all-purpose research tool that could be used again and again for multiple experiments, we have sought to create a fun, commercial-grade game experience. Thus, unlike other laboratory environments, when constructing such a virtual space we must consider the wide range of art, audio, and writing assets required for implementing our design. These sorts of considerations require both labor and finances, and a lack of either type of resource may require that certain fun and engaging design elements be sacrificed. While such a scenario would not bring our efforts to a halt, reducing the simulation's complexity may limit the types of research questions our new tool could reasonably tackle. While this would in no way decrease the generalizabilty of our findings, it may reduce the ecological validity of the environment, placing it somewhere between the validity of a perfect simulation of the real world and the abstraction of a rat maze. While our tool would still be many times more ecologically valid than the latter, the questions that could be potentially investigated with such a tool would reflect this shift in

abstraction. An easy solution to this issue, however, would be to adopt a more case-specific approach to world construction—rather than building a single, all-purpose research tool requiring all manner of resources, researchers could instead build smaller-scale environments that specifically fit the requisites for answering a given question.

Traditionally, if one has had a question about society, the available methods for obtaining an answer included relying on pure theory alone, drawing inference from historical data, collecting subjective reports, or deriving conclusions through small experiments. Each of these approaches has its own strengths and weaknesses, pertaining to issues of causation, generality, relevance, and objectivity. Our contention is that the methodology of constructing virtual environments may not only address such shortcomings, but also permit researchers to experimentally test hypotheses about aggregate human behavior otherwise impossible to test in the real world. Our objective in designing the economics of Arden has been to create a world that can examine and control for the dynamics of emergent markets. These efforts represent but one example of how virtual worlds offer a unique new tool for social science research.

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