STAR ATLAS

State of the Economy

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Executive Summary

Crypto markets witnessed a significant positive shift in sentiment over the past three months. The total market cap of crypto rose approximately 25%[1] ($204.3 billion), and the market cap of the metaverse gaming index increased by approximately 48% ($3.6 billion). The increase in private Star Atlas wealth over the period was 23% ($19.8 million).[2]

This report incorporates prior work on the ecosystem and economy into business cycle analysis. To achieve this objective, we utilize variables such as Atlas wages and employment (earnings and employment within the game), net investment (business fixed investment, change in capital stock), labor force (at the ship and wallet level, labor force), and ATLAS/USD (real in-game wages), and reframe them as economic indicators that describe the "state of the economy."

Identifying cycle turning points is essential in describing the state of any economy. Once these reference points are established, they can be used for recession shading and provide cut-off points for describing the time-series properties of economic series. Recession dating is one example of the techniques used in this report to help frame metaverse gaming economies as real economic systems.

Key Highlights:[3]

- Aggregate daily ATLAS wages for in-game activity increased by 1.02%.
- The average wage per ship increased by 6.73%.
- The aggregate employment rate per ship decreased by 5.03%.
- The size of the labor force contracted by 0.7%.
- Employed residents and citizens claimed 432.12 million ATLAS through in-game earnings.

Shaping the Zeitgeist

Widespread adoption and belief in the metaverse is still years away. Although advancements in technology and innovation may help, they do not guarantee the acceptance of metaverse economies as real economies. We must present our argument to the professional and academic class to advance our belief in the metaverse as a real economic engine. Academic institutions play a significant role in spreading ideas and transforming them into accepted truths.

[1] Data collected from https://www.tradingview.com/symbols/CRYPTOCAP-TOTAL/

[2] We define private wealth as the sum of privately held R4 inventory, ships, claim stakes and structures, CSS, POLIS, and ATLAS.

[3] Data reported between the period of December 1, 2022 and February 28, 2023.

Economic data shape people's beliefs and can be used to shape how people view the metaverse. We endeavor to make the metaverse economy more accessible to both academics and the general public to draw attention and interest to digital economies, which are made possible by advancements in blockchain technology and uniquely evidenced by the in-game behavior of Star Atlas players.

In this special Economic Quarterly, we leverage one of the greatest facets of digital economies, the blockchain, to create a set of economic indicators that accurately characterize the state of our economy. Importantly, this is a significant advantage that metaverse economies have over traditional economies. The state of the economy is known at each point in time, and there is no uncertainty about the data, only uncertainty about its interpretation.

For this report, we aim to demonstrate that empirical macroeconomics has the potential to contribute significantly to the study of digital economies. We highlight this by employing a set of standard and well-versed tools used in business cycle research to describe the state of the Star Atlas Economy.

In what follows, we use the tools of modern business cycle researchers to illustrate the distinct impact of global and domestic factors in driving the economy. Even though the complete vision of the metaverse has not yet been realized, these tools allow us to start characterizing blockchain programs and participants' interactions with them as real economic activity. Before we dive in, we provide an update on the Star Atlas Census and the performance of the token ecosystem.

The Star Atlas Census and Token Ecosystem Update

On net, 791 wallets have entered the Star Atlas Universe since the last SA Census on November 30th. Nonresident currency holders grew by 828 wallets. Nonresident ship owners declined by 905; nonresident voters increased by 265; residents declined by 310, and there are 913 more citizens. In contrast to the last report, we saw more growth in new faction citizens than in nonresident currency holders.

Table 1: Star Atlas Census (02-28-2023)

Class	Employed	Ship Owner	Voter	Currency	Freq	Frac	Wealth	WShare
Nonresident Currency	0	0	0	1	88635	58.9	28.23	35.93
Nonresident Ship	0	1	0	0	12386	8.2	1.40	1.79
	0	1	0	1	5578	3.7	0.94	1.20
Nonresident Locked POLIS	0	0	1	1	2366	1.6	5.26	6.70
	0	1	1	1	169	0.1	0.34	0.43
Residents	1	1	0	0	4650	3.1	2.37	3.02
	1	1	0	1	30983	20.6	19.32	24.59
Citizens	1	1	1	1	4841	3.2	20.40	25.97

Employed Wallet Token Summary

Residents and citizens with ships staked in S.C.O.R.E. on net spent 76 million ATLAS in the marketplace and 1.16 million in USDC.[4] They locked 251 million ATLAS over the period, and the end-of-period balance grew by 205.8 million ATLAS. They locked 2.1 million POLIS, with their end-of-period balances growing by 1.11 million. Citizens received .98 million in POLIS rewards. Their net token transfers into POLIS totaled .4 million, and out of ATLAS totaled 96.2 million.

Aggregate Token Summary

From December 1st through February 28th, residents and citizens claimed 432.12 million ATLAS (+4.8 million per day) in gross employment earnings. 86.55 million ATLAS (-.96 million per day) flowed back into the DAO from the sale of resources. The DAO also collected 2.3 million ATLAS and 89,446.64 USDC in trading fee revenue for a total DAO revenue of $400,422 (114.4 million ATLAS).[5] As of March 22nd, the DAO has collected $1,669,712 in total revenue.[6] Lastly, ATLAS locked increased by 232 million from December 1st to 769.13 million on February 28th. After accounting for the sinks and the growth in the locker, net ATLAS emissions totaled 111.3 million (or +1.24 million ATLAS per day).

The POLIS locker continues to be a net absorber of privately held POLIS. Private POLIS locker balances grew by 3.14 million since December 1st, but the total amount locked throughout the period was 5.1 million. Rewards totaled 1.9 million, and net token transfers into POLIS by those participating in the facility totaled another .76 million.

Leveraging The Blockchain to Help Shape the Zeitgeist: The Creation of Metaverse Economic Data

Economic indicators play a crucial role in shaping public perception by providing transparency and insights into the state of an economy. A recent study by Gonzalez-Garcia (2022) found that countries subscribing to the International Monetary Fund (IMF) Data Standards Initiative's Special Data Dissemination Standard (SDDS) experienced an average decline of 10-14% in sovereign spreads across models during the year following the subscription.

Since 1944, the IMF has been publishing International Financial Statistics Tables that feature comparable variables on a country-by-country basis. These include exchange rates, international liquidity, interest rates, prices, production, labor, trade of goods, and GDP and components. The Organisation for Economic Co-operation and Development (OECD) also provides a similar dataset with a long history in their Main Economic Indicators release.

Our goal is to create economic indicators that are consistent with global standards and are comparable to existing standards. We aim to use terms and definitions that mirror those used in

[4] This net figure reflects the volume of items purchased less the volume sold in the marketplace.
[5] This is the sum of transfers from the marketplace fees wallet feesQYAaH3wjGUUQYD959mmi5pY8HSz3F5C3SVc1fp3 to the DAO Treasury wallet DRGThVUMGEYcsoTERhmkFSa5q7HVjxBQdKwMNjyvehD1 over the period.
[6] Balance of tokens held in DRGThVUMGEYcsoTERhmkFSa5q7HVjxBQdKwMNjyvehD1 and NPCxfjPxh6pvRJbGbWZjxfkqWfGBvKkqPbtiJar3mom

constructing traditional economic aggregates to promote comparability and familiarity. For us, inflation is a change in the price level of ATLAS to USDC.

The Star Atlas Economic Team strives to create variables that are directly comparable with other nation-states in the long term. However, for this report, we have focused on a few key variables that are critical and reflective of the economy's state. Many labor market variables are well-developed and align well with traditional methods of employment and unemployment. While the economic data is at a daily frequency, making it more volatile than traditional datasets, the data history is not yet long enough to directly compare with other economies.

Star Atlas – Main Economic Indicators

As demonstrated by the examples above, numerous variables are commonly included in panel datasets that summarize the state of economies worldwide. Many of these variables have been studied and employed in empirical research for years. In our previous economic reports, we discussed several of these essential variables. Our main economic indicators are organized into four categories:

- Token Sector: includes variables such as ATLAS/USD, POLIS, Metaverse gaming index, BTC, SOL, and ETH. Token prices influence expectations and are closely related to the size of the player base.
- Net Initial Deposits and Investment: captures changes in the capital stock, which drive economic growth.
- Employment and Earnings: includes measures of employment status and earnings of participants in the Star Atlas economy.
- Ship Prices and Valuations: tracks trends in the value and price of ships in the labor force. The number of wallets compounding fleets directly relates to XXS ships' net USD earnings yield.

In the Star Atlas economy, the wages earned by players are directly tied to the rate of ATLAS-to-USD, which is impacted by various factors such as expectations about crypto, web3 gaming, and ecosystem-specific news and trends. Changes in ATLAS/USD strongly impact player participation, a crucial variable for the real economy. Token prices, particularly SOL, are significant drivers of activity within Star Atlas and impact the amount of ATLAS emissions in the ecosystem.

The net labor force change is a key indicator of the health of SCORE, which ultimately drives the change in ATLAS emissions and determines the size of the capital stock. The top correlations of net labor force change are token prices, the change in the fully employed VWAP, and the diffusion ratio.

Growth in the Star Atlas economy is primarily driven by net additions to the capital stock, which are captured by the net initial deposits. The VWAP volume of new additions relative to existing VWAP is a useful metric for calculating the expected contribution from technological growth on future ATLAS emissions.

The employment of capital is a key determinant of the actual ATLAS emitted in the ecosystem. Each individual wallet can have multiple labor market statuses, and the within-wallet employment rate is

a useful measure of employment. When analyzing ATLAS earnings, it is important to consider trends in the VWAP of ships in the labor force.

Discount rates are an important factor in driving real economic activity. Partial deposit activity is closely related to USD earnings yields on XXS ships and the price-to-book of ships.[7]

The summary of the main economic indicators used in describing the Star Atlas economy is provided in Table 2

Factor Analysis

Measurement is the basis for tracking the state of any economy, and the metaverse proves no exception. Factor analysis has been used by statisticians and econometricians for a long time to deal with data reduction.[8]

Dynamic factor analysis is a statistical technique used in business cycle research to analyze how different economic variables change over time and how they are related. For example, Stock and Watson (1990) developed a dynamic factor model (DFM) that combines a large number of economic indicators into a smaller number of "diffusion indices" which summarize the information contained in the indicators. They used these diffusion indices to predict business cycle turning points and showed that they were able to produce accurate predictions of recessions.[9]

McCracken and Ng (2015) introduce FRED-MD, a comprehensive monthly database of macroeconomic variables for the United States.[10] The authors use a dynamic factor model to extract the common trends among the variables in the database. The authors show that the DFMs can be used to construct a small number of factors that capture most of the variation in the data, allowing for a more parsimonious representation of the macroeconomic environment.

[7] See table 4 in economic quarterly - Q2 2022, p 14 for definitions around accounting for changes in the labor force.

[8] The first economics paper to use factor analysis was "Note on Sampling and Selection of Economic Variables" by Ragnar Frisch. Frisch used factor analysis to identify common underlying factors in a set of economic variables, such as prices, wages, and interest rates. He used principal component analysis to extract these factors and showed how they could be used to simplify the analysis of economic data.

[9] Stock, James H. and Watson, Mark W. "A Procedure for Predicting Recessions with Leading Indicators: Econometric Issues and Recent Experience." Journal of Business and Economic Statistics, vol. 8, no. 2, 1990, pp. 153–162.

[10] We borrow this idea from McCracken, M.W., Ng, S., 2015; FRED-MD: A Monthly Database for Macroeconomic Research, Federal Reserve Bank of St. Louis Working Paper 2015-012. URL https://doi.org/10.20955/wp.2015.012

Table 2: Main Economic Indicators

	Description
Metaverse Gaming Price Index	Market value weighted token price index; Tokens with both the metaverse and gaming tags from coinmarketcap.com; consists of 123 tokens.
ATLAS/USD	ATLAS-to-USD
SOL/USD	SOL-to-USD
Average Wealth (Market Value)	The total market value of core Star Atlas assets divided by total wallets. Includes claim stakes, ships, structures, CSS, Atlas and Polis holdings; Excludes ATMTA and DEX holdings.
Fully Employed (MV)	Market value of fully employed ships, with slight adjustment (+three days of employment) that will slightly overestimate the value.
Number of Wallets Expanding and Contracting Fleets	Total number of wallets expanding and withdrawing fleets in S.C.O.R.E.
Strict Employment Rate (Wallet Based)	Count of wallets with all fleets in full employment divided by total wallets in the labor force; seasonally adjusted.
Ship Sales (USD)	Market value of marketplace ship sales.
Net USD Earnings Yield	Defined for new marketplace ship sales as the net Atlas earnings x Atlas/USD x 365 divided by the total USD volume of ship sales.
Fully Employed (VWAP)	VWAP of fully employed ships, with slight adjustment (+three days of employment) that will slightly overestimate the value.
Partially Employed (VWAP)	VWAP of partially employed ships; ships in the first two days of unemployment.
ATLAS Earnings	ATLAS Emissions from S.C.O.R.E. which come from the emissions wallet - 2ahn5m4zeujE56qKMuEeyX2jktEuJPH5UzoznHKmUMka.
Initial Deposits (VWAP)	VWAP of initial ship deposits as a fraction of labor force VWAP.
Partial Deposits (VWAP)	VWAP of partial ship deposits as a fraction of labor force VWAP.
Withdrawn Ships (VWAP)	VWAP of withdrawn ships as a fraction of labor force VWAP.
Ratio of Wallets Expanding-to-Contracting Fleets	Number of wallets expanding fleets divided by number withdrawing fleets.
Net Wallets Expanding Fleets	Number of wallets expanding fleets less number of wallets withdrawing fleets.
Full Employment Rate (VWAP wtd)	VWAP weighted fully employment rate; includes the adjustment for three additional days of employment past the max fill date.
Activity Ratio (VWAP wtd)	VWAP of daily updated ships divided by the VWAP of fully employed ships.
Strict Employment (Wallet Based)	Count of wallets with all fleets in full employment; no adjustment for employment past max fill date; seasonally adjusted.
Strict Partial Employment (Wallet Based)	Count of wallets with all fleets in partial employment (five days past max fill date); seasonally adjusted.
Average Within-Wallet Partial Employment	Mean of within wallet partial employment rates weighted by VWAP; defined as the period two days past the plus three days adjusted full employment period; seasonally adjusted.
Price-to-Book of Ship Sales	Market value-to-VWAP of ship sales.
Net Investment (VWAP)	VWAP of initial deposits plus partial deposits less withdrawn ships as a fraction of labor force VWAP.
Net Initial Investment (VWAP)	VWAP of Initial deposits less withdrawn ships as a fraction of labor force VWAP.

We employ a dynamic factor model in the style of McCracken and Ng (2015) to create diffusion indexes that characterize the Star Atlas business cycle.

Global Economic Cycles and Domestic Cycles

It is critical to differentiate between long-term structural factors that affect the multi-year trends within the metaverse and the shorter-term cycles that exist within it. The long cycles that have a significant impact on new player growth and player retention are those that follow the multi-year cycles in crypto prices. Bull and bear markets determine realized earnings which drive the size of the player base and even the size of the crypto community. These cycles can be thought of as fundamentally driven by global macroeconomic cycles. The importance of the broader crypto environment has been mentioned several times in previous reports. We can consider these larger forces as the global economic cycle, which heavily weighs on every web3 economy.

The global macrocycles are driven by the commonality of commodity prices and the tight interlinkages found in financial markets. As we have seen globally, rising inflation and interest rates affect every country, and no country is an island. These linkages are particularly important for small domestic economies that share close ties with the rest of the world through exports of commodities, tourism, and access to global capital markets.

For instance, by using a dynamic factor model on the subcomponents of the metaverse-gaming index, we discover a single dominant factor that explains 29% of the variation across 123 metaverse gaming tokens. The median variation explained is 24.3%, with a minimum of 0% and a maximum of 80%. This single factor accounts for 60% of the daily variation in ATLAS and 47% in POLIS. This implies that the broader ecosystem undoubtedly has a role to play. A regression of SOL, ETH, and BTC on this factor indicates that they account for around 80% of the variation in this first factor. The DFM is not used to calculate the global factor we use below because estimating a DFM recursively on 123 tokens is cumbersome. Instead, we use the mean of daily token returns for our global factor, which closely approximates this first factor with a correlation to the first moment of 98%.

A two-step process is employed to analyze the impact of global and domestic factors on the Star Atlas economy. Firstly, the global factor is calculated with the exclusion of ATLAS and POLIS because we want to exclude any influence they may have on the global environment.[11] Secondly, the influence of the global factor on the main economic indicators is removed by regressing the indicators on the factor and keeping the residuals. Our factor analysis was performed on a set of 19 economic indicators. This set of orthogonalized indicators is then used to recursively estimate dynamic factor models, which helps distinguish global and domestic influences on the Star Atlas economy. The exact steps to carry out the DFM are found in the appendix.

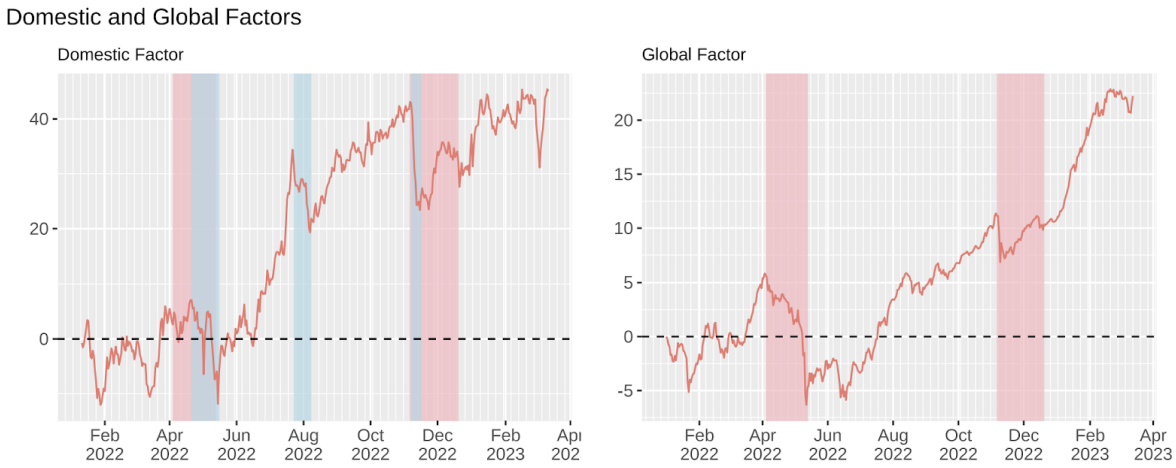
Since the first factor carries most of the variation in the dataset, we will assume that it is characteristic of the domestic business cycle. The figure below plots the first-factor diffusion index and the global factor. The pink shading refers to recessions identified for the global factor, and the blue shading is for those identified for the domestic cycle. Two preliminary observations are worth highlighting.

A. Even though the two indexes are constructed to be uncorrelated, there is a tight overlap in the peaks and troughs. This is particularly true for the recession phases identified in April through May and early November.

B. The global factor contains fewer cycles than the domestic factor, as suggested by the domestic factor containing one more recession period. This is in line with the real-world observation that the phases of the global business cycle are inherently longer.

These two facts suggest that the state of the global economy shapes the domestic economy. Although the figures are intuitive and give us a general idea about the connections between domestic and global factors, a formal statistical treatment will give us greater insight into their interactions and drivers. It is to this more formal treatment that we now turn.

[11] See appendix for exact calculation.



Source: ATMTA, Inc. Economics Department. Notes: The pink shading refers to recessions identified for the global factor and the blue shading is for those identified for the domestic cycle. See appendix for details on index construction.

What does the Dynamic Factor Analysis tell us?

It is instructive to present summary statistics about the results.

By regressing the individual variables on the factors, we get the R^2 , or explained variation of a series by the common factor. These are listed in Table 3 below. The first two columns list the group under which the economic indicator falls and the transformation taken to make the series stationary. As expected, the Global Factor has the highest R^2 on ATLAS/USD and the market value of fully employed ships. The first domestic factor explains much of the common variation in employment indicators, such as strictly employed wallets and the VWAP weighted full employment rate. The third factor has explanatory power for ship reinvestment, as it loads on all three valuation indicators and the diffusion index, which captures the number of wallets expanding their fleets less the number of wallets contracting them.

Table 7 in the appendix presents the variance explained decomposition from a regression of all the factors on the economic indicator. It includes the R^2 and partial R^2 values from the six combined domestic factors, with the remainder assigned to the global factor. Interestingly, this approach suggests that domestic factors dominate when explaining the star atlas economy, with the global factor contribution for ATLAS/USD being 22% and the domestic factors accounting for 46% of the variation. This fact suggests that global influences have an important role in the domestic economy, particularly in influencing the market values of all the deployed capital.

Table 8 in the appendix presents the individual partial R^2 values from the same regression. It shows that the 6th factor captures much of the ATLAS/USD not captured by the global domestic factor. When presented this way, the global factor captures 53.5% of the variation in ATLAS/USD. It also suggests that there may be a role for interaction between player participation (as measured by the number of wallets with all fleets employed) and external token conditions. Once again, we do not live in a vacuum.

Table 9 in the appendix reports the t-statistics from the joint regression of all the orthogonalized variables on each domestic factor. These provide direction as well as a strength since they

incorporate standard errors. ATLAS/USD loads significantly onto all six domestic factors, which suggests

it has a widespread influence over the state of the star atlas economy. 16 of the 19 indicators load significantly on the first domestic factor.

Lastly, in a search using a general-to-specific model with impulse indicator saturation, the first factor was retained for 17 of the indicators.[12] This model assumed six lags of the economic indicator and a retention p-value of .001. The global factor was retained for 11 of the indicators. In particular, the global factor was found to explain 17.2% of the variation in strictly employed wallets and 12.4% of the variation in the net number of wallets explaining vs. contracting their fleets. This points to a significant influence on both the number of active wallets in the player base as well as their willingness to expand their fleets.

In conclusion, domestic and global factors are integral in shaping the Star Atlas economy.

Table 3: Factors Relationship to Domestic Economic Indicators

			R2 of Factor on Indicator						
	Group	Transform	Global	f1	f2	f3	f4	f5	f6
Fully Employed (MV)	Wealth	dlog	**0.17**	**0.15**	0.00	0.05	0.02	0.01	0.00
Price-to-Book of Ship Sales	Valuation	dlog	0.05	**0.12**	**0.13**	**0.07**	**0.09**	**0.07**	0.00
Ship Sales (USD)	Valuation	dlog	0.00	0.02	**0.16**	0.00	0.02	0.00	**0.08**
Net USD Earnings Yield	Valuation	dlog	0.02	**0.07**	**0.07**	**0.29**	**0.12**	**0.10**	**0.09**
ATLAS/USD	Token	dlog	**0.41**	0.01	0.01	**0.13**	0.01	0.01	**0.18**
Number of Wallets Expanding and Contracting Fleets	Labor Force	dlog	0.00	0.03	**0.33**	0.00	0.04	0.06	0.06
Ratio of Wallets Expanding-to-Contracting Fleets	Labor Force	d1	0.03	0.00	**0.30**	0.03	0.00	**0.08**	0.01
Net Wallets Expanding Fleets	Labor Force	d1	**0.06**	0.00	**0.38**	0.03	0.01	0.05	0.00
Net Initial Investment (VWAP)	Labor Force	none	0.05	0.04	0.01	0.03	**0.07**	0.04	0.00
Partial Deposits (VWAP)	Labor Force	none	0.00	0.00	0.06	0.00	**0.09**	0.04	0.01
Strict Employment Rate (Wallet Based)	Employment	dlog	0.02	**0.40**	0.03	0.00	**0.23**	0.03	0.00
Fully Employed (VWAP)	Employment	dlog	0.00	**0.30**	0.03	0.00	0.00	**0.06**	0.01
Partially Employed (VWAP)	Employment	dlog	0.00	**0.26**	0.00	0.04	0.00	0.04	0.04
Full Employment Rate (VWAP wtd)	Employment	d1	0.01	**0.33**	0.01	0.03	0.00	0.04	0.04
Activity Ratio (VWAP wtd)	Employment	d1	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Strict Employment (Wallet Based)	Employment	d1	0.03	**0.44**	0.06	0.01	**0.19**	0.03	0.00
Strict Partial Employment (Wallet Based)	Employment	d1	0.00	**0.23**	0.06	0.01	**0.07**	0.05	0.00
Average Within-Wallet Partial Employment	Employment	d1	0.01	**0.17**	0.01	0.00	0.00	0.00	0.00
ATLAS Earnings	Earnings	log	0.00	0.01	0.01	0.00	0.00	0.00	0.03

In this section, we have aimed to explain how dynamic factor analysis, a tool commonly used in business cycle research, can summarize key metrics related to the Star Atlas economy. Our findings indicate a distinct economic cycle that drives global variables, which differs from the one driving the domestic economy. Despite the technical nature of this discussion, we consider it necessary, as it has allowed us to establish a reference cycle based on important variables related to the overall health of the ecosystem. Armed with this reference cycle, our focus now shifts to identifying the cyclical turning points that define the Star Atlas business cycle.

[12] Results available upon request. Model implemented using the gets package; see Pretis F, Reade JJ, Sucarrat G (2018). "Automated General-to-Specific (GETS) Regression Modeling and Indicator Saturation for Outliers and Structural Breaks." Journal of Statistical Software, 86(3), 1-44. doi: 10.18637/jss.v086.i03 (URL: https://doi.org/10.18637/jss. v086.i03).

Defining The Business Cycle

The first major study in the measurement of business cycles was by Arthur F. Burns and Wesley C. Mitchell (1946). In the book, the authors covered the difficulties in defining the business cycle. Subsequent research ironed out many of those early difficulties, yet new challenges arise when dealing with metaverse game economies. The authors arrived at the following definition for the business cycle,

"Business cycles are a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration, business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own."

— Arthur F. Burns and Wesley C. Mitchell (1946)[13]

As pointed out by Harding and Pagan (2016, pg.21) this definition leads to three choices which have to be made:[14]

- What types of series are to be used to measure aggregate economic activity?
- How many series are to be used?
- How is history to be segmented into periods of expansions and contractions?

To answer the first question, ideally, we would use Real Gross Metaverse Product (RGMP) as our measure of aggregate economic activity. Unfortunately, research is ongoing on how best to construct RGMP. Measures that proxy RGMP include ATLAS and POLIS earned through gameplay and secondary market activity. As mentioned above, employment indicators are crucial for capturing the in-game economy. Furthermore, standard turning points have been identified using monthly and quarterly economic data. This has been the result of data availability. Blockchain data is available instantly, so we rely on daily data to define and measure the business cycle.

The second question suggests that a business cycle impacts many activities across the economy in a common way. We have met this challenge with the creation of dynamic factor indexes. The dynamic factor indexes capture the common variation among 19 economic indicators, covering employment, earnings, valuation, and business fixed investment. Our stance has been to weigh employment indicators heavily in our dynamic factor analysis so that the first factor captures the labor market.

The third question refers to identifying the turning points in the reference cycle. A reference cycle is a complete cycle, including a peak, contraction, trough, and expansion. It is measured from peak to peak or trough to trough. The next challenge is defining the metrics we judge our reference

[13] A. F. Burns and W. C. Mitchell, Measuring Business Cycles (National Bureau, 1946), pg. 3

[14] See Harding, D., & Pagan, A. (2016). The econometric analysis of recurrent events in macroeconomics and finance. Princeton University Press.

indicator. When these are defined, we are tasked with identifying the turning points in the business cycle and dating recessions and expansion phases of the cycle. The phases provide a period by which we can compare a range of economic indicators. There are many different approaches to identifying turning points. The most important reasons for using one method over another are localized to the person identifying them. Approaches used by macro researchers are typically automated and empirical, reflecting their desire to have reproducible results. The most popular automated methods are the Hodrick-Prescott filter[15], Markov-switching models[16], The Bry-Boschan Algorithm (1971)[17], and The Stock-Watson (1991) approach[18].

After careful consideration, we rely on a modified Bry-Boschan algorithm to identify turning points in the domestic factor[19]. Before we begin describing this rule it is necessary to define a few common terms used in describing recurrent cycles.

A **phase** is defined as the time period elapsed after one event up to and including the next event. A recession phase begins in the period after a peak and ends at the next trough. The **duration** of the recession phase is the number of days between the peak and the trough. The **amplitude** of the recession phase is the log difference between the peak and the trough.

Defining Business Cycle Length

The original minimum cycle length assumption of greater than one year was due to the monthly data available to researchers at the time me, as well as the limited technology available to them to seasonally adjust the data and remove the irregular components. Modern authors have largely followed this original framework by using filters and unobserved component models to extract the cyclical components of the data. Before we run our dynamic factor analysis, we perform daily

[15] The Hodrick-Prescott filter is a widely used method for identifying business cycle turning points by separating a time series into its trend and cyclical components. See Christiano, L. J., & Fitzgerald, T. J. (2003). The band pass filter. International Economic Review, 44(2), 435- 465. In this paper, the authors use the Hodrick-Prescott filter to construct a band-pass filter for isolating business cycle fluctuations. They apply this filter to U.S. macroeconomic data to identify business cycle turning points.

[16] Markov-switching models are commonly used to identify business cycle turning points. They allow for changes in the underlying probability distribution of a time series, which can help to identify changes in the state of the economy. The most commonly used Markov-switching model for business cycle analysis is the Hamilton (1989) model. Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. Econometrica: Journal of the Econometric Society, 357-384.

[17] The Bry-Boschan Algorithm (1971) is a popular method for dating business cycles. It uses a set of rules to identify peaks and troughs in economic activity based on changes in a composite index of economic indicators. Bry, G., & Boschan, C. (1971). Cyclical analysis of time series: selected procedures and computer programs (No. NBER Book Series Working Paper 20). National Bureau of Economic Research.

[18] The Stock-Watson (1991) approach is based on the idea that turning points in the business cycle can be identified by changes in the volatility of a broad set of economic indicators. It uses a probit model to identify turning points based on changes in the volatility of the composite index. Stock, J. H., & Watson, M. W. (1991). A probability model of the coincident economic indicators. In Business cycles, indicators, and forecasting (pp. 267-311). University of Chicago Press.

[19] We use the package BCDating Majid Einian (2019). BCDating: Business Cycle Dating and Plotting Tools. R package version 0.9.8. https://CRAN.R-project.org/package=BCDating; See Harding, D. and Pagan A. (2002). Dissecting the Cycle: A Methodological Investigation. Journal of Monetary Economics 49 (2), 365–381.

seasonal adjustments where necessary as well as explicitly adjust the data for Solana and marketplace outage dates. All nonstationary data is then made stationary through differencing.

Several important philosophical caveats must be mentioned with respect to the choice of the minimal phase and cycle length. Many believe that crypto-time is a compression of regular time, akin to dog years. Since crypto's volatility is greater than other assets, the probability of bull markets and crashes increases over shorter windows.[20] This directly ties into the concept of cycle duration; for example, the length of post-WW2 expansions in the United States increased markedly in duration as the volatility of GDP fell. This same concept is relevant here. The probability of any event increases with the volatility of the data.

We address this concern by comparing the volatility of US GDP growth with BTC over the same quarterly horizons.[21] The volatility ratio of BTC to US GDP is roughly 21. If we apply the standard rule that the minimum phase length is to be 2-quarters for GDP (or 180 days), for crypto, this length is around nine days. The limited data tells us that increasing the minimum cycle length from 30 to 90 days does not significantly decrease the number of turning points found within the economy.

Given this evidence and the considerably different circumstances we are performing our analysis, we depart from the original definition of the business cycle by amending the idea that business cycles must last at least one year. We begin our search for turning points by estimating a range of minimum cycle lengths from 29 to 65 days, and minimum phase lengths from 2 to 36 days.[22] Turning points selected at least 25% of the time are retained. The resulting turning points for both the global and domestic diffusion indexes, along with phase durations and amplitudes are shown in the two tables below.

Stylized Facts

Table 4 presents the phase amplitudes for the average within-wallet employment rate, VWAP weighted employment rate, and the ATLAS earnings decomposition. For the domestic cycle, the percentage changes for all three employment rates have the correct signs.

[20] A related concept is that of aggregation. The probability of experiencing a turning point will be much higher when using daily versus monthly data. Measuring data at a daily clip will naturally increase the number of recessions found in the data and by definition, shorten the duration of expansions. The Star Atlas economy is still new, and has mostly lived under the shadow of a declining crypto environment. This suggests that we may have been in a recession over most of the project's life. Still, we can pick up and capture critical localized changes in the economy.

[21] Since 2014.

[22] For the Global diffusion index we selected the following pairs for our turning points (min cycle length, min phase length): (30,9),(32,14),(40,9),(50,9),(62,2),(62,9). For the domestic cycle turning points: (30,9),(36,9),(40,9),(50,9),(62,2),(62,9). The difference in the two pairs was selected to retain the period following the collapse of FTX, and remove an unwanted selection for the global index.

Table 4: Business Cycles and Employment and Earnings

					Amplitude (Log Percentage Change)					
				Duration	Employment Rates		ATLAS Earnings Growth Decomposition			
Cycle	Phase	Start	End	Days	Within Wallet	VWAP Wtd	ATLAS Earnings	Average Wage	Employment Rate	Labor Force
	E	2022-01-29	2022-04-21	82	-0.1	4.9	-3.1	-30.1	3.8	23.2
	R	2022-04-21	2022-05-16	25	-4.4	-2.8	-3.8	-8.8	-3.1	8.1
	E	2022-05-16	2022-07-23	68	3.7	2.1	5.5	-14.3	2.6	17.2
Domestic	R	2022-07-23	2022-08-08	16	-4.0	-2.2	-1.8	0.9	-1.6	-1.2
	E	2022-08-08	2022-11-07	91	4.5	0.6	-3.3	-3.5	2.6	-2.4
	R	2022-11-07	2022-11-16	9	-5.8	-0.7	-0.6	3.1	-3.3	-0.4
	E	2022-11-16	2023-02-17	93	4.6	1.4	-0.6	1.2	2.3	-4.1
	E	2022-01-23	2022-04-04	71	1.0	2.5	-6.1	-25.9	3.6	16.2
	R	2022-04-04	2022-05-13	39	-5.1	-1.0	-3.6	-11.5	-1.2	9.1
Global	E	2022-05-13	2022-11-06	177	3.7	-0.2	0.0	-18.7	2.3	16.4
	R	2022-11-06	2022-12-20	44	-1.5	-1.0	-1.8	3.3	-0.6	-4.5
	E	2022-12-20	2023-02-21	63	0.5	2.2	1.2	1.0	-0.2	0.4

This is an assurance that the algorithm selected the correct dates since the first domestic factor was constructed to load heavily on indicators of employment. The selected turning points for the global cycle also confirm the importance of broader market conditions for employment rates. Average employment rates at the wallet level are most correlated with the global cycle phases. Changes in the labor force and average wages appear less sensitive to both the global and domestic cycles.

Table 5 addresses valuation metrics and ship deposit activity.[23] We find that a complex set of factors are correlated with net ship deposits. This includes marketplace-specific events such as the announcement and implementation of ship discounts, price increases, and removing currency pairs. An additional factor has been the prolonged bear market, which has impacted both the growth of new entrants and existing player retention.

The expansion from May 16th through July 23rd corresponded with the announcement of ship re-pricing and featured mostly favorable ship price-to-book values. As a result, initial deposits and fewer withdrawals averaged $64 thousand per day, and partially deposited ships averaged $104 thousand per day over the 68 days. This recession set the stage for the following cycle from July 23rd through November 7th. This period saw daily VWAP deposits fall to $2.8 thousand.

The week of FTX's collapse saw a sharp decline in token prices, directly impacting the player base. As a result, the VWAP of net investment averaged -$54.6 thousand as withdrawals outpaced the initial and partial deposits of the remaining player base. The ratio of wallets solely making partial deposits to that of all labor force wallets grew by 54.6% as existing players took advantage of the 62.5% decline in the average price-to-book and 19.5% increase in earnings yields from in-game ship deployment. The effect of the shock dissipated during the last expansion phase, and net ship withdrawals fell to an average of $833 thousand per day. Price-to-book values rose 24.8%, and improved token values caused the earnings yield to increase by 13.8%. The ratio of wallets expanding fleets-to-those contracting them rose by 35%, which helped net investment to rebound to a daily average of $58 thousand.

[23] Initial deposits, withdrawals, and partial deposits are multiplied by the ship VWAP value. Then the cumulative sum of each is taken. The reported values are the difference between the phase start and end values, divided by the number of days in the phase.

Table 5: Valuation and Net Ship Investment

	Phase	Start	End	Duration (days)	Valuation (log % ch)		Expansion Activity (log % ch)		ATLAS Rewards Claimed (Avg per day)	Investment into S.C.O.R.E (1,000's VWAP per day)			
					Price-to-Book	Earnings Yield (USD)	Diffusion Ratio	Partial Depositors (Fraction of LF Wallets)		Net Investment	Initial Deposits	Withdrawals	Partial Deposits
Domestic	E	2022-01-29	2022-04-21	82	-40.0	-36.1	16.8	-41.1	5.0	58.6	952.6	1052.5	158.5
	R	2022-04-21	2022-05-16	25	-68.5	-21.8	28.7	11.4	4.7	76.6	361.7	435.6	150.6
	E	2022-05-16	2022-07-23	68	9.8	-18.6	-16.8	-17.8	4.8	167.2	393.5	330.4	104.0
	R	2022-07-23	2022-08-08	16	2.6	-9.4	-31.0	-39.2	5.2	4.5	328.2	372.9	49.2
	E	2022-08-08	2022-11-07	91	-17.0	-50.6	15.1	-29.4	4.9	-1.7	251.6	295.1	41.8
	R	2022-11-07	2022-11-16	9	-62.5	19.5	2.9	54.6	5.1	-54.6	1210.3	1434.2	169.3
	E	2022-11-16	2023-02-17	93	24.8	13.8	35.4	-24.5	4.8	58.3	761.3	833.3	130.4
Global	E	2022-01-23	2022-04-04	71	-29.1	-18.6	0.1	-66.3	5.1	78.9	1159.1	1272.5	192.2
	R	2022-04-04	2022-05-13	39	-70.0	-46.0	36.7	22.6	4.8	37.5	373.5	468.3	132.3
	E	2022-05-13	2022-11-06	177	-12.2	-72.3	-13.2	-87.0	4.9	68.2	317.1	317.2	68.4
	R	2022-11-06	2022-12-20	44	-41.3	11.0	-23.9	2.2	4.9	94.1	1164.0	1288.5	218.7
	E	2022-12-20	2023-02-21	63	-0.2	26.5	58.2	32.1	4.8	15.1	497.3	548.5	66.3

Main Economic Summary

Atlas wages grew by 1% during the period. According to our decomposition, this growth was the result of an increase in average wages per ship (+6.7%), a decrease in employment rates (-5%), and a relatively unchanged labor force size (-0.7%). Approximately half of the growth in Atlas earnings was due to the average wage increase of ships added in December. The labor force experienced its largest increase in January, followed by a decline in February that eliminated the gains. Beneath the surface, the labor force grew the most for higher-class ships, led by commanders (+3.8%), large (3.2%), capital (+1.9%), and medium-class ships (+1.3%). XS ships had the largest decline at 1.5%, while small and XXS ships saw unchanged labor force growth.

Table 6: ATLAS Earnings Growth Decomposition

Date	ATLAS Earned	Average Wage	Employment Rate	Labor Force
2022-12-01	4.73 M	14.80	86.1%	399
2023-02-28	4.78 M	15.83	81.8%	397
log change	1.02%	6.73%	-5.03%	-0.7%

Source: ATMTA, Inc. Economics Department. Notes: Five-day moving average of the employment rate; Net investment by class is by market-value, in thousands of USD.

Concluding Thoughts

In past work, we defined the ecosystem using the flows of funds approach, framed labor markets squarely in the context of job search and matching theory and constructed a democracy index. In this Quarterly, we provide the foundations necessary for analyzing metaverse business cycles. The above applications of modern macroeconomic measurement, techniques, and theory to digital economies shape how people outside the metaverse recognize it as a real economy.

The creation of economic data that has real-world historical precedent is crucial for the advancement and adoption of ideas. Therefore, we defined some of the most critical indicators for data runners and macro researchers. This panel dataset is the Star Atlas equivalent to the country panel data sets frequently maintained by the OECD and IMF. In the future, this economic data will

have to encompass the many inevitable extensions to the metaverse while maintaining its integrity in interpretation.

Next, we applied the methods used by McCracken and Ng (2015) to extract a common domestic and global factor index. The dynamic factor approach is advanced in business cycle research and thus provides a natural starting point for summarizing the Star Atlas economy's trends.

To measure and define the business cycle, we revisited the standard definition laid out by Burns and Mitchell (1946). Here, we updated the requirement that a complete business cycle must last at least one year. We found that a minimum phase length of nine days was congruent with the instantaneous frequency of metaverse economic data. This parameter allowed us to identify turning points using the popular rule-based approach pioneered by Bry and Boschan (1971) and amended by Harding and Pagan (2002). Identifying recessions and expansions further ingrains the idea that the metaverse economies are real economies.

These applications represent a progressive research strategy aiming to establish the core tenants of metaverse economics. The study of empirical and theoretical macro applied to the metaverse shapes the zeitgeist.

Factor Model Details

Data preparation

In our dataset, we rely on the variables listed in Table 2 and must make a series of transformations to ensure that the data is stationary. This involves testing for the order of integration, and then performing the necessary number of differences to make the data I(0), or covariance-stationary.[24] We perform daily seasonality adjustments to prevent seasonals that could load onto factors.[25] Lastly, we account for Solana outages and network performance with event dummies. Network degradation causes fewer transactions to execute, contaminating the data. Also, because network performance affects all blockchain statistics jointly, not accounting for it will increase spurious correlations, which will lower the quality of the factor estimates.

Global Factor Calculation

Steps to calculate the mean global factor:

- Grab token prices and take log differences.
- Take the cumulative sum of each token price change.
- Divide the result in step two by the cumulative number of days of price changes. This gives a recursive mean for price changes.
- Take the column standard deviations of the log differences from step 1.

[24] We rely on the dfms package for the calculations. See Sebastian Krantz and Rytis Bagdziunas (2023). dfms: Dynamic Factor Models. R package version 0.1.4. https://CRAN.R-project.org/package=dfms

[25] We use the dsa package for seasonal adjustments. See Daniel Ollech (2021). dsa: Seasonal Adjustment of Daily Time Series. R package version 1.0.12. https://CRAN.R-project.org/package=dsa

- Subtract from the result of step 1 the iterative means (the result of step 3), and divide by column standard deviations (step 4).
- Take the row means of step 5.
- Lastly, take the cumulative sum of the row means.

This approach results in a diffusion index for token returns that is permitted to trend as the individual token returns are recursively de-meaned. If one wishes to create an index that is independent of ATLAS and POLIS for further analysis, one can exclude them from this process. This is necessary because if we regress the first factor on ATLAS and POLIS and the factor is itself constructed from them, we will violate our regression assumptions, including the assumption of exogeneity.

Domestic Factor Calculation

Here are the steps we take in calculating the domestic factor diffusion index:

- We transform a set of Star Atlas economic indicators to make them mean stationary and remove any seasonality. We also choose signs such that positive values indicate expansion and negative values indicate contraction.
- We impose orthogonality on the domestic indicators with respect to the first differences in the global factor. To do this, we regress the economic indicators on the global factor and keep the residual or unexplained portion of the series returns.
- We perform a recursive dynamic factor analysis on the orthogonalized domestic indicators, setting the number of lags and factors to extract both equal to six. The recursive approach allows for the mean of the underlying series to evolve, which alleviates the problem of a zero endpoint that arises from using the whole sample in the dynamic factor analysis.[26]
- We take the cumulative sum of the factor estimates to produce domestic factors diffusion indexes. This is what is plotted in figure 1.

In the table below we perform a variance decomposition, from jointly regressing the six domestic factors and the global factor on the individual recursively de-meaned economic indicators. Note these are not the orthogonalized time series, as those would have a zero loading on the global factor.

[26] The recursive DFM starts with 90 days, then 91 days, and so on, and extracts the tail value of the factor estimates. For computational speed, we use the two-step factor estimates as in Doz, Giannone and Reichlin (2011), obtained by running the data through the Kalman Filter and Smoother once, with the Filter initialized with results from PCA.

Table 7: Global and Domestic Explained Variation

			Decomposition of Variance		
	Group	Transform	Global	Domestic	R2
Fully Employed (MV)	Wealth	dlog	12.1	29.0	41.1
Price-to-Book of Ship Sales	Valuation	dlog	2.7	42.3	45.0
Ship Sales (USD)	Valuation	dlog	0.1	30.8	30.9
Net USD Earnings Yield	Valuation	dlog	1.0	53.2	54.2
ATLAS/USD	Token	dlog	21.7	46.4	68.1
Number of Wallets Expanding and Contracting Fleets	Labor Force	dlog	0.2	51.8	52.0
Ratio of Wallets Expanding-to-Contracting Fleets	Labor Force	d1	1.9	47.0	48.9
Net Wallets Expanding Fleets	Labor Force	d1	3.0	52.6	55.6
Net Initial Investment (VWAP)	Labor Force	none	4.0	24.1	28.1
Partial Deposits (VWAP)	Labor Force	none	0.2	23.8	24.0
Strict Employment Rate (Wallet Based)	Employment	dlog	0.5	64.1	64.6
Fully Employed (VWAP)	Employment	dlog	0.3	45.0	45.3
Partially Employed (VWAP)	Employment	dlog	0.1	39.8	39.9
Full Employment Rate (VWAP wtd)	Employment	d1	0.5	46.9	47.4
Activity Ratio (VWAP wtd)	Employment	d1	0.5	3.3	3.8
Strict Employment (Wallet Based)	Employment	d1	1.1	68.6	69.7
Strict Partial Employment (Wallet Based)	Employment	d1	0.4	39.5	39.9
Average Within-Wallet Partial Employment	Employment	d1	0.7	19.1	19.8
ATLAS Earnings	Earnings	log	0.1	6.2	6.3

This next table presents the partial R^2 from regressing the six domestic factors and the global factor on each variable.

Table 9: Six Factors Relationship to Domestic Economic Indicators

			t-value of indicator on factor					
Economic Indicator	Group	Transform	f1	f2	f3	f4	f5	f6
Fully Employed (MV)	Wealth	dlog	**10.80**	**-2.03**	**-5.14**	-0.96	1.00	-0.03
Ship Sales (USD)	Valuation	dlog	**2.55**	**9.10**	0.32	1.91	-1.25	**6.27**
Net USD Earnings Yield	Valuation	dlog	**-4.83**	**-3.38**	**5.75**	**5.38**	**2.47**	**5.15**
Price-to-Book of Ship Sales	Valuation	dlog	**8.27**	**5.61**	1.13	-0.90	**-2.57**	**2.77**
ATLAS/USD	Token	dlog	**5.11**	**2.23**	**4.62**	**-2.62**	**3.03**	**10.20**
Number of Wallets Expanding and Contracting Fleets	Labor Force	dlog	**3.35**	**11.66**	-0.89	**2.94**	**4.28**	**4.99**
Partial Deposits (VWAP)	Labor Force	none	**-3.44**	**4.17**	-0.84	**4.61**	**-3.81**	**3.04**
Ratio of Wallets Expanding-to-Contracting Fleets	Labor Force	d1	-1.19	**9.45**	**2.30**	1.25	**5.45**	**-2.90**
Net Wallets Expanding Fleets	Labor Force	d1	-0.91	**8.54**	0.38	0.49	1.18	**-2.90**
Net Initial Investment (VWAP)	Labor Force	none	**5.89**	-1.67	**3.61**	**-4.64**	**3.97**	**3.87**
Strict Employment Rate (Wallet Based)	Employment	dlog	**15.64**	1.25	-0.49	**6.83**	-0.14	**-5.02**
Fully Employed (VWAP)	Employment	dlog	**9.02**	**2.92**	1.61	**-3.29**	**-2.96**	0.21
Partially Employed (VWAP)	Employment	dlog	**9.68**	**-2.13**	**3.39**	**2.53**	-1.95	**-3.21**
Full Employment Rate (VWAP wtd)	Employment	d1	**14.34**	**3.00**	-0.57	-0.85	-1.80	**-3.49**
Activity Ratio (VWAP wtd)	Employment	d1	**2.64**	0.35	-0.56	0.42	-0.39	1.36
Strict Employment (Wallet Based)	Employment	d1	**14.45**	**-7.41**	-0.60	**3.21**	**3.17**	**2.05**
Strict Partial Employment (Wallet Based)	Employment	d1	**7.01**	**-3.46**	-0.71	-0.01	**2.73**	1.13
Average Within-Wallet Partial Employment	Employment	d1	**7.39**	**-3.12**	-1.54	0.07	0.29	**2.43**
ATLAS Earnings	Earnings	log	1.80	**-2.17**	**-3.35**	-1.93	**4.39**	1.39

Table 8: Partial R2 and Global and Domestic Explained Variation

	Partial R2 of Factor on Indicator						
Economic Indicator	Global	f1	f2	f3	f4	f5	f6
Fully Employed (MV)	24.9	18.8	2.0	6.0	6.1	0.1	0.0
Ship Sales (USD)	0.6	2.5	20.3	0.2	4.0	1.3	12.0
Net USD Earnings Yield	3.4	10.3	7.8	20.3	15.0	8.6	5.8
Price-to-Book of Ship Sales	7.5	17.2	14.4	4.0	12.5	5.4	0.9
ATLAS/USD	53.5	7.3	2.9	14.5	0.0	2.4	29.9
Number of Wallets Expanding and Contracting Fleets	0.8	5.0	42.7	0.2	9.9	6.3	8.1
Partial Deposits (VWAP)	1.0	1.5	8.6	0.8	12.7	6.8	3.1
Ratio of Wallets Expanding-to-Contracting Fleets	5.5	0.4	38.2	4.8	1.3	15.4	5.4
Net Wallets Expanding Fleets	10.8	0.5	47.5	4.0	2.9	12.2	1.7
Net Initial Investment (VWAP)	8.0	8.2	1.3	3.2	13.5	6.8	0.1
Strict Employment Rate (Wallet Based)	5.4	48.6	5.7	2.0	30.7	9.5	0.7
Fully Employed (VWAP)	0.0	38.2	4.4	9.6	2.5	8.4	0.4
Partially Employed (VWAP)	0.3	31.9	0.0	12.7	0.4	5.8	4.5
Full Employment Rate (VWAP wtd)	0.1	40.0	2.2	12.2	1.7	5.5	5.5
Activity Ratio (VWAP wtd)	0.5	0.3	2.0	0.3	0.2	0.0	0.5
Strict Employment (Wallet Based)	13.6	56.8	13.5	4.2	23.8	11.7	0.9
Strict Partial Employment (Wallet Based)	2.2	24.7	7.9	2.5	6.6	8.3	0.0
Average Within-Wallet Partial Employment	0.9	17.3	1.8	0.1	0.0	0.1	0.5
ATLAS Earnings	0.1	1.8	1.2	0.0	0.1	0.2	3.0

The following table shows the t-statistics from a joint regression of the orthogonalized variables on the domestic factors.

Table 10: After-tax ATLAS Earnings By Class

Class	Source	Percent Change	December 1, 2022	February 28, 2022
Commander	Net Wages	2.94	0.597	0.615
	Avg Net Wage	0.00	2971.278	2971.365
	Employment Rate	-0.81	96.2	95.4
	Labor Force	3.76	209	217
Capital	Net Wages	1.73	0.814	0.828
	Avg Net Wage	0.14	1002.168	1003.559
	Employment Rate	-0.26	94.6	94.4
	Labor Force	1.85	858	874
Large	Net Wages	2.91	0.684	0.705
	Avg Net Wage	-0.12	309.565	309.208
	Employment Rate	-0.15	92.9	92.8
	Labor Force	3.18	2380	2457
Medium	Net Wages	0.31	0.695	0.697
	Avg Net Wage	0.43	85.71	86.08
	Employment Rate	-1.39	91.1	89.9
	Labor Force	1.26	8895	9008
Small	Net Wages	-0.50	0.832	0.828
	Avg Net Wage	-0.03	29.115	29.107
	Employment Rate	-0.26	91.2	91
	Labor Force	-0.21	31319	31253
XS	Net Wages	1.97	0.153	0.156
	Avg Net Wage	0.55	6.205	6.239
	Employment Rate	2.91	83.6	86.1
	Labor Force	-1.48	29552	29117
XXS	Net Wages	-7.09	0.158	0.147
	Avg Net Wage	0.11	0.566	0.566
	Employment Rate	-6.45	85.6	80.2
	Labor Force	-0.74	326141	323735