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Front Pages

Athens Journal of Business & Economics

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The current issue is the second of the ninth volume of the *Athens Journal of Business & Economics (AJBE), published by the Business & Law Division and the Economics Unit of ATINER.*

Gregory T. Papanikos
President
ATINER

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- Abstract Submission: **28 March 2023**
- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **29 May 2023**

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- Abstract Submission: **21 March 2023**
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Compounded Markups in Complex Market Structures

By Constantin Colonescu[*]

Using a publicly available input-output database that covers 44 countries and 56 industries, I show that most prices are, on average, two to three times higher than the natural costs of production, costs that include a normal rate of return to capital. The novelty in this research is the argument that the true markups are compounded—they incorporate the markups already existing in the intermediate goods and services (inputs) that a company purchases in a vertical chain of production. A complex market structure, one in which companies sell and purchase intermediate products from each other in both horizontal and vertical directions, is the perfect environment for inflating a price well above its natural level. This research may help understanding the true extent of market power. Market power has a substantial impact in such matters as income inequality, standard of living, and economic development.

Keywords: *complex market structure, compounded markup, monopoly pricing, world input-output tables*

Introduction

Monopoly pricing is more pervasive than many people think. Virtually every item that is available for purchase incorporates monopoly pricing to some degree through the prices of its intermediate inputs. While consumers do occasionally point to isolated items as being too pricey or being produced by conspicuous monopolies, most of the time consumers just take prices as given (literally) by the goddess of competition and free markets. Consumers' faith in the ability of markets to converge towards the lowest and fairest prices comes from popular theories saying that markets are in general under nobody's interference, efficient, transparent, and highly competitive. The data show otherwise.

In 1776, the founder of modern economics, Adam Smith, explains in memorable words what a natural, fair price would be in a well-functioning economy (Smith 2007, p. 73). He starts by setting the stage: in any society or "neighborhood," there must be "naturally regulated" rates of rent, profit, and wage. Then, Adam Smith continues, "natural" prices of commodities are those prices that just pay for the rent, profits, and labor used to manufacture and bring the products to the market. I call Adam Smith's "natural" price of an intermediate good or service, one that is to be used in the production of other intermediate of final goods, a *pure* cost of production. Unlike the natural price, the market price, Adams Smith explains, normally gravitates towards the one determined by supply and demand, though "exclusive privileges of corporations" may keep the prices above the natural rate for a long time ("for ages together," in Adam Smith's language).

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Adam Smith's insight into the works of the free market appears, though, to have been lost when Alfred Marshall inflicted scientific rigor upon it, stripping it of much of its real-life flavor (Marshall 1893). Perfect competition (demand and supply) models originating in Marshall's work are very elegant and easy to grasp, but of little relevance in reality because most markets are not even remotely as assumed by such models. The success of these models is most likely owed to their formal perfection and apparent simplicity. Using world input-output data, I show that *compounded*, or true price markups are substantially higher than the conventional ones in all industries, being magnified by the flow of intermediate products down the vertical chain of production, each new transaction in intermediate goods adding an extra layer of markup.

The paper is organized as follows: the next section demonstrates compounded markups in two stylized, very simple examples. The Methodology section gives the theoretical framework for determining conventional markups when sector-level data are available and establishes a formula for compounded markups in input-output data. Data section describes the world input-output datasets used in this paper. Results section shows the calculations and discusses the results. Last section concludes and suggests possible generalizations of complex market structure models. Appendix A gives a simple theoretical framework to show that compounded markups must be greater than the conventional ones. Appendix B extends the idea of markup compounding to a purely vertical market structure.

Two Simple, Hypothetical Examples of Markup Compounding

A Two-Sector, Vertical Market Example

The simplest example of a *complex market structure* would only involve one final sector and one input (an intermediate product). Suppose the natural, economic cost of producing the input is \$5 but it sells for \$6, such that its markup is $6/5 = 1.2$. Suppose the final product uses the \$6 input, plus some \$4 value added, so that its *conventional* cost of production is $6 + 4 = \$10$, and it sells for \$11, so its conventional markup is 1.1. The *compounded* markup of the final good, though, is equal to the final price divided by the sum of all the natural, or pure costs incurred in all stages of the vertical production chain: $\mu_f' = 11/(5 + 4) = 1.2$, which is greater than its conventional counterpart, $\mu_f = 1.1$. The same result can be obtained when pure costs are not known, but the conventional markups are known; all we need to do to retrieve the pure costs is to divide the selling prices by the conventional markups of the intermediate and the final products, as shown in the next hypothetical example. Appendix A gives a more general proof that the compounded markup of the final product must be greater than the conventional one, $\mu_f' > \mu_f$.

The Simplest Input-Output Economy (A Hypothetical Example)

A second, more involved, example simulates an input-output table and explains the calculations of the compounded markup. As I have mentioned, a *complex market structure* involves an intricate network of transactions in intermediate goods and services leading to the production of a final product (see also Colonescu 2021). To better understand the method of markup compounding, let us consider the hypothetical input-output matrix presented in Table 1. I denote the two industrial sectors by *S1* and *S2*; *VA* is value added, *mu* is the conventional markup of each sector, and *MU* is the calculated compounded markup.

A value in Table 1, say the 0.4 in the first row, indicates that sector *S1* sells intermediate inputs to sector *S2* that will make for a share of 0.4 in the total cost of sector *S2*'s output. Thus, the entries in the table (except the *mu* and *MU* columns) are shares of intermediate inputs moving from the row-heading sectors into the column-heading sectors. Companies may purchase inputs from their own sector, inputs that will be subject to the same-sector markup.

Table 1. *An Example of an Input-Output Table with Value Added and Markups*

Sector	**S1**	**S2**	**mu**	**MU**
S1	0.3	0.4	1.9	2.5
S2	0.5	0.1	1.2	1.5
VA	0.2	0.5	1.0	1.0

The sum of the shares, including the value added, must equal 1 in each column. This observation helps us determine the value added, when it is not known, as the difference between 1 and the sum of the intermediate input shares. I assume the markup (price over marginal cost) for value added is equal to 1—no markup. (The value added comes, for instance, from the contributions of labor and capital, priced at their natural rates.)

Each input in the table consists of two unobservable parts: a *pure*, or *natural* price, and a (conventional) markup. Once the markup is determined in separate calculations, the natural part can be determined as the share shown in the table over the respective sector's markup. For instance, sector 1's *compounded* markup is calculated as the market value of the output, which is equal to $\mu_{S1} \times 1$, over the sum of all the *natural* prices of the inputs. Equation (1) gives the calculation for sector 1. The resulting value of 2.45 for the compounded markup exceeds sector 1's conventional markup of 1.9.

$$\mu_1' = \frac{1.9 \times 1}{(.3/1.9 + .5/1.2 + .2/1.0)} = 2.45 \#(1)$$

The purpose of this paper is to show that $\mu' > \mu$ is a general result. The observation that the compounded markup is greater than the conventional one may seem trivial, but, to my knowledge, it was never subjected to empirical investigation, nor quantified; moreover, with the rare exception of the double

marginalization theory in industrial economics, this market feature is never mentioned.

Method

The first part of the method is not new, but it is necessary for my purpose, so I briefly explain it here. The method serves at calculating industry-level, or *conventional* markups, where the marginal cost consists of the sum of the prices a company pays to purchase the intermediate products it needs, plus the rent it pays to use the machinery, plus wages. The key part at this point is that the intermediate products already contain a markup charged by upstream sectors; the upstream markups are "laundered" in the downstream sectors and incorporated in legitimate costs; in other words, the costs in the current sector already contain markups originating in upstream sectors. Conventional markup calculations disregard these hidden markups.

The second part of my method adds up all the conventional markups incorporated in a final-use commodity. Adding up, however, is a misnomer, because vertical supply chains do not add up, but multiply, or compound, successive markups (see also Appendix B).

A Theory of Conventional Markups

The Cost-Minimization Problem

Following an established literature, such as Hall et al. (1986) and De Loecker and Warzynski (2012), I measure the degree of monopoly pricing by markup, defined as the ratio of price over marginal cost and use the *production approach* developed by the same authors. This method assumes that firms minimize costs in the short run by choosing the amounts of some variable inputs, in particular intermediate products they purchase from upstream sectors. Under this approach, capital is considered fixed, and the production function is homogeneous of degree one (constant returns to scale).

Let us denote the intermediate product used by sector i by I_i, capital by K_i, and the target amount of output by $\bar{F}_i$; the price of the intermediate product purchased by sector i is P_i^I. The price of the intermediate product is a price index, and the quantity of the intermediate input is measured by its dollar value. This way, we can aggregate all inputs from all sectors in one variable in firm i's cost function. The rental rate of capital in sector i is P_i^K. Given the production function $F_i(I_i, K_i)$, the total cost to be minimized is (2) and the Lagrangean function corresponding to the conditional cost minimization problem is (3).

$$TC_i(I_i, K_i) = P_i^I I_i + P_i^K K_i \#(2)$$

$$\mathcal{L}(I_i, K_i, \lambda_i) = P_i^I I_i + P_i^K K_i - \lambda_i[F_i(I_i, K_i) - \bar{F}_i] \#(3)$$

With capital being maintained fixed, the only first-order condition of the minimization problem is (4).

$$P_i^I = \lambda_i \frac{\partial F_i(I_i, K_i)}{\partial I_i} \#(4)$$

In the cost-minimization problem, the Lagrangean multiplier, λ_i, can be interpreted as the change in the total cost at its optimum level when the target output increases by an extra unit (the envelope theorem). In other words, λ_i is the marginal cost of production. The next few equations try to find a simpler form for the markup, μ_i, by manipulating the first order condition (4). With P_i^O denoting the price of output of sector i, equation (4) is equivalent to the following sequence:

$$\frac{P_i^I}{\lambda_i} = \frac{\partial F_i(I_i, K_i)}{\partial I_i} \frac{I_i}{\bar{F}_i} \frac{\bar{F}_i}{I_i} \frac{P_i^O}{P_i^O} \#(5)$$

$$\frac{P_i^O}{\lambda_i} = \frac{P_i^O \bar{F}_i}{P_i^I I_i} \times \frac{\partial F(I_i, K_i)}{\partial I_i} \frac{I_i}{\bar{F}_i} \#(6)$$

Let us now introduce the following notations: Call *markup* the ratio of the price of output over marginal cost, $\mu_i = P_i^O / \lambda_i$; denote the share of input expenditure in the value of output by α_i, given by the formula $\alpha_i = P_i^I I_i / (P_i^O \bar{F}_i)$; finally, denote the elasticity of output with respect to input by θ_i, calculated as in the last part of equation (6). With these notations, we can finally write the markup equation for sector i, as in Hall (1988) and followers, as shown in (7). Relationship (7) gives a compact formula to calculate what I call the *conventional* markup.

$$\mu_i = \frac{\theta_i}{\alpha_i} \#(7)$$

Estimating Output Elasticity

The challenge with the markup described in (7) is to determine θ_i, the elasticity of output with respect to input, which can be done by estimating a constant-elasticity production function. The task is, though, complicated by the endogeneity of the input term in the production function: as Rovigatti (2017a) mentions, a productivity shock affects the dependent variable (output), which, in turn, affects the independent variable (input). Successive efforts by Olley and Pakes (1996), Levinsohn and Petrin (2003), Ackerberg et al. (2006), Ackerberg et al. (2015), and Wooldridge (2009) have refined our knowledge in estimating production functions. The underlying idea, put foreword among the first by Olley and Pakes (1996) and subsequently refined by others, is to use a *control* function.

I use here the Olley and Pakes (1996) approach, as described in Rovigatti (2017a). The production function to be estimated has the form in (8), keeping the notations introduced in (2); Q stands for output and A stands for total factor

productivity, $A_j = \exp(\alpha_j + \omega_{ktj})$; j denotes sector, k denotes country, and t denotes year. Each sector works according to the production function (8). The production function in logarithmic form is (9), where u_{ktj} is an identically and independently distributed error term.

$$Q_{ktj} = A_j I_{ktj}^{\theta_j} K_{ktj}^{\gamma_j} \#(8)$$
$$q_{ktj} = \alpha_j + \theta_j i_{ktj} + \gamma_j k_{ktj} + \omega_{ktj} + u_{ktj} \#(9)$$

To estimate (9), Olley and Pakes (1996) propose modeling the state variables in the problem, such as capital and the idiosyncratic error term ω, as a polynomial function, $\Phi(k_{ktj}, g_{ktj}))$, where ω has been replaced by a proxy, a known variable, g_{ktj}. With this, the production function to be estimated becomes (10).

$$q_{ktj} = \alpha_j + \theta_j i_{ktj} + \Phi(k_{ktj}, g_{ktj}) + u_{ktj} \#(10)$$

The two stages in estimating (10) involve estimating first the control function, Φ, then the parameter of interest, θ_j.

Calculating Compounded (Grand) Markups

Following Miller and Blair (2009), let us use the following notations: Z is the input-output matrix, where the element z_{ij} is the dollar value of industry (sector) i's output used in production by industry j. X is the vector of total output, one element for each industry, measured in dollars. If we divide all elements z_{ij} by their corresponding total output, we obtain the technical coefficients, $a_{ij} = z_{ij}/x_j$. The technical coefficient a_{ij} represents the value of input coming from industry i into industry j necessary to produce $\$1$ worth of output j. (This $\$1$ worth represents the cost-value, not the market value of the final product; it is equal to the sum of all costs of production.)

The value of all inputs used in $\$1$ worth of sector j's output is the sum of all input shares a_{ij} coming from all sectors i into sector j, as in equation (11), where C_j represents the total cost of the intermediate products used in production by sector j, and N is the number of all sectors. Each input a_{ij} includes a markup charged by industry i.

$$C_j = \Sigma_{i=1}^{N} a_{ij} \#(11)$$

Consumers would like to know how much of this cost is total markup charged by all the sectors providing inputs to sector j. Let μ_i stand for the markup charged by sector i for delivering an intermediate product to sector j; I call this the

conventional markup because it corresponds to the usual definition of markup. Let us denote by c_i some measure of pure marginal cost in sector i's output, which is the marginal cost striped of any markups charged by upstream industries. Equation (12) gives the relationship among the technical coefficients, pure marginal cost, and the markup ratio.

$$a_{ij} = c_{ij}\mu_i; \quad c_{ij} = \frac{a_{ij}}{\mu_i} \#(12)$$

The total cost of production of the final good j must include both the cost of inputs (11) and the value added by sector j, and must be equal to 1.

The pure marginal cost of the output of sector j is equal to the sum of all pure marginal costs of all inputs; the grand markup is denoted by μ'_j. Equation (13) is the key relationship that allows calculating μ'_j, the *grand* markup of sector j. Each side in (13) represents the market value of sector j's output.

$$\mu'_j \times (\text{pure cost})_j = \mu_j \times (\text{conventional cost})_j \#(13)$$

The conventional cost in (13) is equal to 1, such that the formula for the grand markup is (14).

$$\mu'_j = \frac{\mu_j}{(\text{pure cost})_j} \#(14)$$

If the value added in the final sector is included in its total cost as just another input, then the compounded markup can be calculated using the remarkably simple equation (15), which is a generalization of equation (1).

$$\mu'_j = \frac{\mu_j}{\sum_{i=1}^{N} \frac{a_{ij}}{\mu_i}} \#(15)$$

The goal of this research is to calculate the grand markups, μ'_j, for all country-sector entries in the world input-output database (WIOD 2018). While the technical coefficients, a_{ij}, are easily available through simple operations on the input-output tables, calculating the conventional markup ratios, μ_j, given by (16), requires estimating the regression equation (10). Equation (16) is the same as (7) but written for sector j.

$$\mu_j = \frac{\theta_j}{\alpha_j} \#(16)$$

Data

I use the socio-economic accounts part of the world input-output database (WIOD-SEA 2016) for calculating the *conventional* markups, μ_j, and the 2009 full input-output table (WIOD 2018) for calculating the compounded markups, μ'_j. The database covers 44 countries and 56 industries (sectors). Thus, the input-output table is a square matrix, Z, of dimensions $2\,464 \times 2\,464$, a matrix with over six million data entries. Each row in the matrix is a country-sector item and has a corresponding column. The z_{ij} entry in the input-output table is the value of an intermediate product sold by the country-sector i and purchased by the country-sector j to be used in the final product of the country-sector j. The notations in this part follow Miller and Blair (2009) and the authors of the R package *ioanalysis*, Wade and Sarmiento-Barbieri (2020).

As I have mentioned, each entry in the input-output table represents the dollar value of the respective input. If this value is divided by the value of the final product, the result is the share of the input in output, which is denoted by a_{ij}; matrix A is the matrix of all elements a_{ij}, also called *technical coefficients* in the input-output jargon.

Table 2 provides descriptive statistics for a very small part of matrix *A*, the matrix of technical coefficients. All the elements of this matrix must be less than 1, with many being zero or close to zero, because an industry in a country will only purchase inputs from a relatively small number of the other country-industry entities. The column names in Table 2 stand for *Austria*, followed by a number indicating the industry, according to the *RNr* column in Table 3.

Table 2. *Descriptive Statistics for the Technical Coefficients (Sample)*

	AUS 1	**AUS 2**	**AUS 3**	**AUS 4**	**AUS 5**
Number of values	2 464.0	2 464.0	2 464.0	2 464.0	2 464.0
Number of zeros	221.00	272.00	234.000	230.00	235.00
Max	0.183 9	0.089 0	0.072 0	0.043 7	0.301 1
Range	0.183 9	0.089 0	0.072 0	0.043 7	0.301 1
Sum	0.555 4	0.357 8	0.379 4	0.421 1	0.699 2
Mean	0.000 2	0.000 1	0.000 2	0.000 2	0.000 3
Std. deviation	0.004 0	0.002 8	0.002 0	0.001 8	0.006 7

Table 3. *Industry Descriptions and Codes*

ISIC industry code	**Industry description**	**RNr**
AtB	Agriculture, hunting, forestry, and fishing	1
C	Mining and quarrying	2
15t16	Food, beverages, and tobacco	3
17t18	Textiles and textile products	4
19	Leather and footwear	5

Results

To calculate the conventional markups, I use, first, the function *prodestOP* in the *R* software package *prodest* (Rovigatti 2017b), which estimates the regression equation (10) following the two-stage method by Olley and Pakes (1996). Equation (17) shows the practical version of the theoretical equation (10). The symbols in (17) are chosen to correspond to those in the database; they represent the following variables: *GO_QI* represents output, *II_QI* represents intermediate inputs (the adjustable input variable), K_GFCF represents capital (the state variable), and the ratio *GF_CF/GFCF_P* represents investment (the control variable in the two-stage method). Equation (17) is estimated in logarithms. Table 4 shows some descriptive statistics of the variables used in (17), as they appear in the database. The values of each variable in the socio-economic part of the database and represented in Table 4 (17) are given for each country-sector observation.

$$GO\_QI_{ktj} = \alpha_j + \theta_j\, II\_QI_{ktj} + \Phi(K\_GFCF_{ktj}\,, GF\_CF_{ktj}/GFCF\_P_{ktj}) + u_{ktj} \qquad (17)$$

Table 4. *WIOD-SEA: Descriptive Statistics of Selected Variables*

Variable	Description	Nr. val.	Median	Mean
GO_QI	Gross output, volume indices	21 360	119	145
II_QI	Intermediate inputs, volume indices	21 015	122	158
K_GFCF	Real fixed capital stock, mil.	20 045	15 912	6 125 139
GFCF	Gross fixed capital formation, mil.	20 415	1 802	538 521
GFCF_P	Price level of *GFCF*	20 008	110	313

Now that we have the estimated values of θ for each sector, we use (16) to calculate the conventional markups at country-sector level, and, with these, the *compounded* markups (15). For one country-sector observation, the sum in the denominator of (15) extends over all inputs coming from all other countries and sectors; value added is included in this sum as just another input. Table 5 shows a sample of the compounded markups by sectors, averaged over all countries.

Table 5. *Average Compounded and Conventional Markups by Sector (Sample)*

Sector description	Compounded markup	Conventional markup
Real estate activities	3.16	2.31
Financial intermediation	3.19	2.15
Education	4.22	2.08
Renting of m&eq and other business activities	1.28	1.94
Inland transport	2.13	1.63
Mining and quarrying	4.38	1.51
Health and social work	2.08	1.43
Air transport	5.42	1.41
Rubber and plastics	3.58	1.37
Water transport	4.60	1.36

The values of the compounded markups in Table 5 are high but plausible, considering they accumulate all markups in all intermediate inputs. In rare instances, the calculations yield conventional markups greater than the compounded ones, as one of the entries in Table 5 appears. This anomaly may be generated by measurement errors and missing data; some of the missing data have been imputed, which also introduces measurement errors. A small number of observations giving obviously erroneous results, such as negative markups or extremely high values have been eliminated. I estimate that such cases make for less than ten percent of all observations.

Even understanding the nature of the compounded markups, many of us will be, probably, surprised by their magnitudes. A large compounded markup may not, however, reflect a high conventional markup in the concerned final-good sector, but it may indicate high-markup inputs in the vertical supply chain leading to the respective final-good sector. Table 6 shows a sample of grand (compounded) markups, averaged by country over all sectors. These are somehow smaller than the sector averages because averages blur large, inter-sector differences.

Table 6. *Average Compounded and Conventional Markups by Country (Sample)*

Country code	Country name	Compounded markup	Conventional markup
IND	India	3.05	2.01
MEX	Mexico	3.63	1.71
GRC	Greece	3.63	1.71
TWN	Taiwan, Province of China	2.27	1.56
BRA	Brazil	2.13	1.49
LTU	Lithuania	3.40	1.47
EST	Estonia	3.21	1.21
BGR	Bulgaria	2.92	1.20
IRL	Ireland	2.86	1.20
KOR	Korea, Republic of	1.74	1.19
HUN	Hungary	2.75	1.19
CZE	Czechia	2.30	1.15

Table 7 shows a comparison between the distributions of the conventional and compounded markups. This table is the key finding of this paper; it shows that the compounded markups are higher than the conventional ones at all quartiles of the distribution. While this result is hardly surprising, the interest is also in the magnitudes of the difference. At the higher end, 25% of the observations show conventional markups greater than 1.52, but compounded markups greater than 3.87; the average conventional markup is 1.44, and the average compounded markup is 3.04.

Table 7. *Comparing the Distributions of Conventional and Compounded Markups*

Markup type	Min	Q25%	Median	Mean	Q75%	Max
Conventional	1	1.13	1.27	1.44	1.52	6.6
Compounded	1	1.60	2.34	3.04	3.87	9.8

Table 8 shows the result of testing the difference in means between the conventional and the compounded markups. The method is a paired t-test, and the hypothesis is $H_0: \bar{\mu} \geq \bar{\mu'}$, $H_A: \bar{\mu} < \bar{\mu'}$, where $\bar{\mu}$ is the sample mean of the conventional markup and $\bar{\mu'}$ is the sample mean of the compounded markup. The test supports the alternative hypothesis that the conventional markup is less than the compounded markup.

Table 8. *Test of Difference in Means between the Conventional and the Compounded Markups*

Estimated difference	Statistic	*p*-Value	Method	Alternative
-1.3	-24.1	0.0	paired *t*-test	less

Conclusion

A *grand*, or *compounded* markup, defined as the ratio between price and an unobserved, *pure*, marginal cost, is found to be significantly higher than the conventional markup. While the theory suggests that compounded markups are always greater than the conventional ones, real data may occasionally show exceptions from this rule due to errors or measurement, missing data, and errors of data imputation.

The compounded markups calculated in this study are substantially higher than the conventional ones; and yet they must be underestimated, because only one layer of the vertical production chain is included. In reality, there is a multiplying (compounding) effect in markup when intermediate products travel down the vertical production chain. Thus, the analysis in this research is still incomplete. A realistic theory of a complex market structure should paint a complete picture of the full network of intermediate transactions—a challenging task for future research. Appendix B explores a model of a purely vertical production chain. It shows that, in this case as well, the compounded markup of the final-good sector exceeds the conventional markup.

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Appendix A

Suppose there are N sectors producing intermediate goods, all selling their products to one of them, which is the producer of a final good. In general, companies in the final-good sector may buy from each other the final product to be used as just another input; to keep things simple, though, I will assume in what follows that this is not the case. Let us denote the pure cost in sector i by c_i, the price by p_i, the conventional markup by μ_i, and the compounded markup by μ_i'. Markup is defined in general by the ratio of price over pure cost, such that $p_i = c_i\mu_i$. Without loss of generality, all the calculations can be thought of concerning one unit of the final product.

The main claim of this paper is that the compounded markup in a final product is greater than the conventional markup, where the compounded and conventional markups are defined as follows:

$$\text{Conventional markup: } \mu_f = \frac{p_f}{c_f + \Sigma_{i=1}^{N-1} p_i} = \frac{p_f}{c_f + \Sigma_{i=1}^{N-1} c_i\mu_i}$$

$$\text{Compounded markup: } \mu_f' = \frac{p_f}{c_f + \Sigma_{i=1}^{N-1} c_i}$$

It is clear that the compounded markup is greater than the conventional one, since the (conventional) markups of the intermediate products, μ_i, are all greater than 1.

Appendix B

As a further step towards a full model of complex market structures, consider the simple case of a purely vertical production chain, where sector i has a pure (natural) cost c_i and markup μ_i, and sells an intermediate good to sector 2, which sells its product to sector 3, the producer of the final good. As opposed to pure costs, the conventional costs of production in each of the three sectors, C_i, are the following:

$$C_1 = c_1$$
$$C_2 = c_2 + C_1\mu_1 = c_2 + c_1\mu_1$$
$$C_3 = c_3 + C_2\mu_2 = c_3 + c_2\mu_2 + c_1\mu_1\mu_2$$

With p_3 being the market price of the (final) product of sector 3, the conventional markup in the final sector is

$$\mu_3 = \frac{p_3}{C_3} = \frac{p_3}{c_3 + c_2\mu_2 + c_1\mu_1\mu_2}$$

On the other hand, the compounded markup in the final sector is

$$\mu_3' = \frac{p_3}{c_1 + c_2 + c_3}$$

Since the conventional markups μ_1, μ_2, and μ_3 are all greater than 1, it is clear that the compounded markup of sector 3, μ_3', is greater than the conventional one, μ_3, the former having a smaller denominator.

In general, the conventional cost of production in the final sector is

$$C_f = c_f + c_1\mu_1\mu_2 \dots \mu_{N-1} + c_2\mu_2 \dots \mu_{N-1} + \cdots + c_{N-1}\mu_{N-1}$$
$$= c_f + \Sigma_{i=1}^{N-1} c_i \Pi_{j=i}^{N-1} \mu_j$$

With this, the conventional markup, with $N-1$ intermediate sectors in a purely vertical production chain, is

$$\mu_f = \frac{p_f}{c_f + \Sigma_{i=1}^{N-1} c_i \Pi_{j=i}^{N-1} \mu_j}$$

By comparison, the compounded markup, which is the ratio between the final price and the sum of the pure costs of all upstream stages, is

$$\mu_f' = \frac{p_f}{c_f + \Sigma_{i=1}^{N-1} c_i}$$

Comparing μ_f to μ_f' in the last two equations, it can be observed that μ_f', the compounded markup, is greater than μ_f, the conventional one. The longer the vertical chain of intermediate-good producers, the greater the difference between the true (compounded) markup of the final product and the conventional markup.

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Testing Distributions in Banking Sector Loans with Different Computer Programs: An Experimental Analysis for Turkey

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Within the fields of risk management and banking, the normality condition is one of the basic assumptions to apply value at risk, capital asset pricing or linear regression models on credit risk assessment. However, banking sector data related to loans may not be normally distributed. Hence, it needs to be put through scientific tests. For this purpose, firstly, Anderson-Darling, Jarque-Bera, Kolmogorov-Smirnov, Shapiro-Wilk, and Shapiro-Francia tests are applied to ninety-two banking sector loan variables and it is demonstrated that most of the variables are not normally distributed. Additionally, the parameters of Normal, Birnbaum-Saunders, Exponential, Extreme Value, Gamma, Generalized Extreme Value, Inverse Gaussian, Log-Logistic, Logistic, Lognormal, Nakagami, Negative Binomial, Non-Parametric, Poisson, Rayleigh, Rician, t-Location-Scale, and Weibull distributions are estimated for loan variables. Thirdly, when the data are not normally distributed, it is necessary to examine the other test results. Therefore, Kolmogorov-Smirnov, Anderson Darling, and Chi-square test results are employed for sixty-one distributions related to the variables and best fitted distribution per variable is aimed at. The results indicate that different computer codes and programs may give different outcomes in connection with the normality and best fitting distribution. Therefore, the use of different strategies may also be adopted in risk management courses along with the traditional ones since the normality assumption is an essential first step for the application of such techniques. Finally, pedagogically speaking, it should be noted that teaching the essence of mathematical background and computer codes could be strategically useful for students in internalizing these distribution concepts.

Keywords: *distribution, banking sector loans, risk management*

JEL Codes: *C46, G21, G32*

Introduction

Researchers working on economics, banking and finance need the data to be stationary and normally distributed. The assumption is evident in both theoretical and empirical studies. For instance, the capital asset pricing model of Sharpe (1964) assumes that data are normally distributed. However, in conditions when they are not, problems arise in measuring and interpreting the data. Apart from theoretical assumptions, normality is also prerequisite for application of different

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methods in statistics and econometrics. For example, the stationarity assumption for linear regression method is a required condition for normality where studies like Suhar and Zaki's (2021) apply normality tests for both independent and dependent variables before estimating the linear regression model as a pre-condition.

It is expected that normally distributed data would be symmetric around the mean and would have constant variance. While the sample mean would be distributed symmetrically, it should not be too fat-tailed or skewed to the right or left. However, as stated by the *principle of Heisenberg uncertainty*, one may not know the exact location and speed of an electrode simultaneously (Kaku 2019, p. 62). This principle may also be valid for economic time series. Since mean is similar to location and variance, it may be interpreted as speed where the mean and the variance of a variable cannot also be known at the same time. There may currently be a mean that does not change for the time being yet variance may indicate a heteroscedasticity problem. Therefore, non-normality is a natural context consistent with the above-mentioned physics principle. In addition, as the *catapult effect* indicates, another object may be benefitted to accelerate its speed (see Kaku 2019, p. 191). Similarly, for credit data you may need government support to decrease nonperforming loans. However, this may disturb the data and create a non-normal structure. To visualize whether there is non-normality, the normality test can be conducted either with graphs or statistical techniques. The simplest two-dimensional graph would be a histogram or a quantile-quantile (QQ) plot to detect the shape. One may also apply basic tests such as Jarque-Bera, skewness and kurtosis. There is a variety of distributions, and selecting an appropriate one may become a difficult task and require technology.

There are several normality tests applied in economics, money, banking and finance studies. Aparicio and Enstrada (1997) test the normality of the Scandinavian stock market and reject the normality by Kolmogorov-Smirnov (KS), Goodness of Fit (GF), and Jarque-Bera (JB) statistics. They conclude that the data fit to the scaled-t distribution by GF tests. One may also refer to Jantschi and Bolboaca (2018) for further evaluation of some GFs. Aparicio and Estrada (2001) also reject the normality for European stock markets' daily data. Goncu et al. (2012) benefit from Istanbul Stock Exchange data and apply Anderson-Darling test (AD) claiming that generalized extreme value distribution is superior to normal distribution. Therefore, they support the extreme value theorem for the Turkish data. On the other hand, Coronel-Brizio and Hernandez-Montoya (2010) apply AD for power-law distribution for Dow Jones Index of the US economy. Borowski (2018) also tests the normality of sixty-five equity market indices using normality tests Cramer-von Mises (CM) and AD and rejects the normality for all of them. Azat (2014) applies the Shapiro-Francia test (SF) to several countries' financial and banking sector data including nonperforming loans and finds them to be normally distributed. This study aims at comparing the results of different tests and computer programs and demonstrating that they may be problematic in the field of education when teaching the normality concept in risk management courses.

The following section describes the data and the methodology applied in this paper. The third section provides the results and discusses them briefly. The last section offers a brief summary and provides recommendations regarding teaching strategies.

Materials and Methods

Obtaining healthy and well-constructed data is crucial to conducting a study on testing normality. For this study, monthly data are gathered from the Turkish Banking Association Risk Center[1]. Appendix presents a detailed explanation of the data spanning between the years of 2009 and 2021. This paper also employs several normality tests[2]. One may refer to Berlinger et al. (2021, Table 1) for cumulative distribution functions of several distribution types which benefit from AD in terms of comparison. Anderson and Darling (1954) suggest that the criterion W_n^2 is the average of the squared discrepancy $\left[F_n(x)-F(x)\right]^2$ weighted by $\psi\left(F(x)\right)$, and the increase in $F(x)$ and *n,* which is for normalization purpose, indicates the number of sample data points (see Equation 1).

$$W_n^2 = n\int_{-\infty}^{+\infty}\left[F_n(x)-F(x)\right]^2\psi\left(F(x)\right)dF(x)\right) \qquad (1)$$

Within the equation, $F\left(x\right)$ is the continuous distribution function, and $F_n(x)$ is the empirical distribution function. Anderson and Darling (1954) benefit from $\psi\left(F(x)\right)=\frac{1}{F(x)(1-F(x))}$ which assigns heavy weight to tails. Therefore, their assumption is different than that of the CM (Von Mises 1931) which acknowledges the weighting function as equal to 1. Therefore, the difference between AD and CM relies on the weighting function. According to Anderson and Darling (1952), this test is superior to KS due to giving more weight on the tails of the distribution. It should be noted that the AD statistic is the modification of KS via changing the weight attached to the tails of distribution. The AD gives more weight on the observation within the tails of distribution (Wikipedia 2021). Moreover, critical values of the AD change depending on the distribution. However, this is not true for KS which is distribution-free (ITL 2021). Therefore, for each distribution, there is a different critical value table in the AD. If this statistic is higher than the critical values of theoretical distribution, one may reject the null of normality. Hence, the AD can be summarized by the following equation where the weighting function is different than 1 (Equation 2)[3].

[1]Available at: https://www.riskmerkezi.org/en/home. [Accessed 20 June 20 2021]
[2]See Akdeniz (2018) for basic distributions in statistics.
[3]One can also refer to Giles (2001) for this topic.

$$AD^2 = n\int_{x=-\infty}^{x=+\infty} \frac{\left[F_n(x) - F(x)\right]^2}{F(x)[1-F(x)]} dF(x) \qquad (2)$$

Authors as Marmor and Bashkansky (2018) used the AD test to detect change in the distribution. They make the difference between a theoretical distribution and a stable process and interpret AD^2 as the observed fluctuation divided by the expected fluctuation. Therefore, the high change in the deviation from the stable points would carry one to a higher AD statistic. Marmor and Bashkansky (2018) claim that the AD statistics has the capacity to capture the structural change in the distribution of the data. The change in the AD statistics by data points may be beneficial to detect the change in the distribution and observe abnormal events. The sectoral homogeneity in terms of normality would decrease the credit risk of banking and allow one to observe problematic sectors. One may benefit from *p*-values of AD to produce a knowledge of credit risk in a banking sector.

Results and Discussion

In 1827 Robert Brown observed the movements of pollens in water, and several scientists including Einstein and Wiener tried to explain these irregular interactions and collisions by functions (Capar 2013, p. 259). As these movements are random, predetermination of pollen behavior is impossible. Apart from this non-stationarity, the concept of normal is also the inverse of non-normal in social sciences. Therefore, if a person thinks and acts like an average person, he is accepted as normal in a society. Then people having marginal thoughts and behaviors would be on the tails of distribution. Similarly, in banking sector, some sectors and loans are also considered as marginal. If the number of people not paying their loans is not distributed normally, it means the banking sector is at risk. If there is a case of normality, its expected value will be equal to its mean. In such a case, it would be easier to decrease the credit risk and take precautions. Methods such as value at risk (VaR) might be applied, and the parameter estimates could be tested by *t*- statistics. Thus, banking sector authorities would be able to observe whether it is resilient or not *a la* Brunnermeier (2021).

The credit risk of a bank would diminish by the level and quality of collaterals. Banks may take payrolls and be on the safe side working with employees but with companies, since credit amount is usually high, the type and volume of the collateral are essential for protecting the bank's profitability position during a high probability of credit default case. Since companies have tangible and intangible assets, some sectors would have more tangible assets than others. Realistically speaking, almost all sectors need credit to increase their production and services. Banks ask for a collateral from these companies. The cash is the best collateral, but not all companies would have sufficient amount of it. Some sectors produce intangible goods such as software. These companies would have less collateral and have a lower chance of getting a loan from a bank. At this stage, a competition problem may arise since high tangible asset-intensive companies

would have a bigger opportunity to get a loan. As stated by The Economist (2021, p. 14), there will be a distinction between data and collateral. It will also be possible to get a loan by the past data of a customer rather than his/her current assets. Here, the indicator may be the data for a bank while lending.

Interpreting *p*- values for AD, Jarque-Bera, KS, Shapiro-Wilk (SW), and Shapiro Francia (SF) normality test results that are given in Table 1 is not a simple task. The null hypothesis for all these five tests is normality. 18 out of 92 variables are normally distributed according to these AD- test results. In addition, Table 2 provides Normal, Birnbaum-Saunders, Exponential, Extreme Value, Gamma, Generalized Extreme Value, Inverse Gaussian, Log-Logistic, Logistic Lognormal, Nakagomi, Negative Binomial, Nonparametric, Poisson, Rayleigh, Rician, t Location Scale and Weibull tests' results for parameters as well as their log-likelihood ratios. These parameters are obtained using Matlab. To see whether the "Distribution Fitter" tool of Matlab selects normality as the other tests; variables B1, K5 and K8 are normally distributed according to the AD-test in Table 1. However, Matlab Distribution Fitter Tool selects B1 (t Location-Scale), K5 (Birnbaum-Saunders) and K8 (Birnbaum-Saunders) by the lowest log-likelihood ratio tests. As a final experiment, Easy Fit 5.5 computer program results are provided in Tables 3-5 for the first thirteen variables. As seen in tables, KS, AD, and Chi-Square tests select different distributions. For instance, KS selects B1 (Dogum (4P)), K5 (Logistic), and K8 (Inv. Gaussian) (Table 3). AD selects B1 (Dogum (4P)), K5 (Gamma), and K8 (Weibull (3P)) (Table 4). And finally, Chi-Square test selects B1 (Cauchy), K5 (Inverse Gaussian), and K8 (Erlang (3P)) (Table 5)[4].

[4]Tables 1-5 provide only the significant test results. Complete test results are given in Appendices A-D which can be found on author's website: https://sites.google.com/view/afsinsahin/home.

Table 1. *Tests for Normality*

Var.	AD-Test (*p*- value)		Jarque-Bera Test (*p*- value)		Kolmogorov-Smirnov Test Statistic (*p*- value)		Shapiro-Wilk Test (*p*- value)		Shapiro-Francia Test (*p*- value)	
B1	0.7044		0.7193		0.0510		0.1994		0.1772	
K5	0.1157		0.0754	*	0.1120	**	0.0001	***	0.0004	***
K8	0.2058		0.1006		0.1110	**	0.0011	***	0.0040	***
K11	0.1233		0.0170	**	0.1160	**	0.0007	***	0.0015	***
K12	0.1170		0.0540	*	0.1210	**	0.0003	***	0.0014	***
K15	0.1606		0.0512	**	0.1220	**	0.0004	***	0.0019	***
K17	0.2733		0.1043		0.0930	**	0.0009	***	0.0032	***
K19	0.5541		0.1853		0.0930	**	0.0171	**	0.0343	**
K25	0.1723		0.0778	*	0.0940	**	0.0003	***	0.0017	***
K33	0.1374		0.0471	**	0.1230	**	0.0002	***	0.0011	***
K35	0.1938		0.0789	*	0.0940	**	0.0013	***	0.0053	***
K37	0.8489		0.6838		0.0930	**	0.2788		0.4036	
K42	0.4531		0.2719		0.0930	**	0.0119	**	0.0316	**
K43	0.1128		0.0575	**	0.1060	**	0.0001	***	0.0004	***
K44	0.1232		0.0446	**	0.1290	**	0.0002	***	0.0008	***
K52	0.5292		0.8801		0.0930	**	0.0376	**	0.0583	*
K53	0.2145		0.0742	*	0.0970	**	0.0029	***	0.0092	***
K62	0.1464		0.0484	**	0.1150	**	0.0005	***	0.0023	***

Note: The table provides the p- values of the test statistics. The statistics that fail to reject the normality are shown in bold font. Anderson-Darling Test (AD), Kolmogorov-Smirnov Test Statistic, and Jarque-Bera Test are calculated by WinRATS 8.1. The WinRATS 8.0 codes are written by Doan (2019). Eviews 10.0 add-ins were used to test the normality with Shapiro-Wilk and Shapiro-Francia tests.

Table 2. *Matlab Distribution Tests Results*

Distribution	Parameters	B1	K5	K8
Birnbaum-Saunders	Beta (Scale)	50,763.70	171,866,000,000.00	3,517,580,000.00
	Std. Err.	3,041.99	4,922,420,000.00	90,862,300.00
	Gamma	0.78	0.28	0.25
	Std. Err.	0.05	0.02	0.02
	Log likelihood	-1,788.72	-2,444.76	-2,069.47
t Location-Scale	Mu (Location)	67,827.90	178,624,000,000.00	3,629,680,000.00
	Std. Err.	1,916.11	5,126,520,000.00	93,928,300.00
	Sigma (Scale)	21,994.90	49,770,100,000.00	910,244,000.00
	Std. Err.	2,327.34	3,630,300,000.00	67,599,200.00
	Nu (Degrees of Freedom)	17.13	2,770,140.00	6,166,880.00
	Std. Err.	25.58	456,441.00	746,056.00
	Log likelihood	-1,687.08	-2,448.67	-2,072.52

Note: The parameters are estimated by using the Matlab computer program.

Table 3. *EasyFit 5.5 Kolmogorov-Smirnov Test Results*

Distribution	B1	B2	B3	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
Cauchy		0.05											
Dagum (4P)	0.04		0.07										
Frechet							0.09						
Gen. Extreme Value									0.09	0.10			
Gen. Pareto													0.05
Inv. Gaussian											0.07		
Logistic								0.09					
Lognormal						0.07							
Pearson 6				0.08									
Johnson SB					0.09							0.06	

Table 4. *EasyFit 5.5 Anderson Darling Test Results*

Distribution	B1	B2	B3	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
Cauchy		0.63											
Dagum (4P)	0.32		1.11										
Frechet (3P)							1.10						
Gamma								1.31					
Gen. Extreme Value									0.84	1.70			
Gen. Gamma				0.75									0.53
Gen. Pareto					1.44							0.68	
Log-Pearson 3						0.90							
Weibull (3P)											0.66		

Table 5. *EasyFit 5.5. Chi-square Test Results*

Distribution	B1	B2	B3	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
Cauchy	2.65	5.48	11.18										
Erlang (3P)											3.58		
Exponential (2P)													2.18
Frechet										3.69			
Gamma				1.14									
Gen. Extreme Value									9.65				
Gen. Pareto												1.85	
Inv. Gaussian								4.58					
Log-Logistic (3P)						1.40	13.93						

Conclusion

In this study, distribution tests are applied to banking sector data. The banking sector loan data should be normally distributed. If the data of customers not paying their loans on time are normally distributed, the credit risk would be easily measured by risk measurement techniques such as VaR and classical regression methods, and forecast techniques would be applied. However, as demonstrated here they may not be normally distributed, and it is also necessary to determine their shape and parameters. Computer codes and programs that are available for this purpose, provide different results as also shown here. At this point it should be remembered that conventional strategies of education orient us to use the simplest tools such as Excel which does not inherit necessary commands. Therefore, the

most scientific and appropriate way of teaching the distribution of economic variables is teaching their mathematical background. Using available computer programs and codes may be misleading and have inverse effects in teaching these topics. In addition, mapping techniques would help one to distinguish between normality and alternative distributions while making use of test statistics. Pedagogically, mapping techniques would increase the visualization in teaching risk management in banking. Finally, in order to explain them in a simpler way, advanced distributions may be taught and applied in risk management courses through benefiting from digitalization and graph techniques.

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Appendix

Explanation of the Variables			
Var.	**Explanation**	**Date**	**Result**
B1	The Number of Real People Defaulted in Paying Individual Loans	2009:M1-2021:M03	Normal
B2	The Number of Real People Defaulted in Paying Individual Credit Cards	2009:M1-2021:M03	Not Normal
B3	The Number of Real People Defaulted in Paying Individual Loans or Credit Cards	2009:M1-2021:M03	Not Normal
K1	Cash Loans, Wood and Wood Products, Amount, (One TL)	2013:M07-2021:M04	Not Normal
K2	Cash Loans, Fishery, Amount (One TL)	2013:M07-2021:M04	Not Normal
K3	Cash Loans, Manufacturing Industry not Classified in Another Places, Amount (One TL)	2013:M07-2021:M04	Not Normal
K4	Cash Loans, Personal Loans (Others), Amount (One TL)	2013:M07-2021:M04	Not Normal
K5	Cash Loans, Personal Loans (Housing), Amount (One TL)	2013:M07-2021:M04	Normal
K6	Cash Loans, Personal Loans (Automobile), Amount (One TL)	2013:M07-2021:M04	Not Normal
K7	Cash Loans, Personal Loans, Loan Card, Amount (One TL)	2013:M07-2021:M04	Not Normal
K8	Cash Loans, Textile and Textile Products Industry, Amount (One TL)	2013:M07-2021:M04	Normal
K9	Cash Loans, Mines Excluding Metal Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K10	Cash Loans, Other Essential Social Services, Amount (One TL)	2013:M07-2021:M04	Not Normal
K11	Cash Loans, Other Essential Social and Individual Services, Culture Services Amount (One TL)	2013:M07-2021:M04	Normal
K12	Cash Loans, Education, Amount (One TL)	2013:M07-2021:M04	Normal
K13	Cash Loans, Electric, Gas and Water Resources, Amount (One TL)	2013:M07-2021:M04	Not Normal
K14	Cash Loans, Electrical and Optical Instruments, Amount (One TL)	2013:M07-2021:M04	Not Normal
K15	Cash Loans, Real Estate Commission, Renting and Management Activities, Amount (One TL)	2013:M07-2021:M04	Normal
K16	Cash Loans, Energy and Mining, Amount (One TL)	2013:M07-2021:M04	Not Normal
K17	Cash Loans, Non-Energy Mining, Amount, (One TL)	2013:M07-2021:M04	Normal
K18	Cash Loans, Financial Intermediaries, Intermediary Institutions and Others, Amount, (One TL)	2013:M07-2021:M04	Not Normal

K19	Cash Loans, Financial Intermediaries, Leasing, Factoring Firms and Others, Amount (One TL)	2013:M07-2021:M04	Normal
K20	Cash Loans, Food, Beverage and Tobacco Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K21	Cash Loans, Cash Loans, Construction, Amount (One TL)	2013:M07-2021:M04	Not Normal
K22	Cash Loans, Private Persons Employing Worker, Amount (One TL)	2013:M07-2021:M04	Not Normal
K23	Cash Loans, Pulp and Paper Industry, Printing Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K24	Cash Loans, Pulp and Paper Industry, Printing Industry, Pulp and Paper Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K25	Cash Loans, Rubber and Plastic Products, Amount, (One TL)	2013:M07-2021:M04	Normal
K26	Cash Loans, Chemistry and Chemical Products Industry, Amount (One TL)	2013:M07-2021:M04	Normal
K27	Cash Loans, Machinery and Equipment Industry, Electrical and Electroless Home Appliance, Amount (One TL)	2013:M07-2021:M04	Not Normal
K28	Cash Loans, Machinery and Equipment Industry, Machinery and Equipment, Amount (One TL)	2013:M07-2021:M04	Not Normal
K29	Cash Loans, Main Metal Industry and Worked Metal, Processed Goods Production, Processed Metal Goods Industry (Excluding Equipment), Amount (One TL)	2013:M07-2021:M04	Not Normal
K30	Cash Loans, Main Metal Industry and Worked Metal, Processed Goods Production, Main Metal Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K31	Cash Loans, Nuclear Fuel, Coal Production, Amount (One TL)	2013:M07-2021:M04	Not Normal
K32	Cash Loans, Hotel and Restaurant (Tourism), Amount (One TL)	2013:M07-2021:M04	Not Normal
K33	Cash Loans, Health and Social Services, Amount (One TL)	2013:M07-2021:M04	Normal
K34	Cash Loans, Defense and Public Management, Required Social Security Institutions, Amount (One TL)	2013:M07-2021:M04	Not Normal
K35	Cash Loans, Agriculture, Hunting, Forestry, Amount (One TL)	2013:M07-2021:M04	Normal
K36	Cash Loans, Transportation, Storage and Communications, Other Transportation Activities and Storage, Amount (One TL)	2013:M07-2021:M04	Not Normal
K37	Cash Loans, Transportation, Storage and Communications, Communication, Amount (One TL)	2013:M07-2021:M04	Normal
K38	Cash Loans, Transportation, Storage and Communications, Transportation, Amount (One TL)	2013:M07-2021:M04	Not Normal

K39	Cash Loans, Textile and Textile Products Industry, Leather Clothing and Fur Processing Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K40	Cash Loans, Textile and Textile Products Industry, Clothing Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K41	Cash Loans, Textile and Textile Products Industry, Textile Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K42	Cash Loans, Wholesale, Retail Sale, Motor Vehicle, Motor Vehicle Spare Parts and Accessories, Sale and Repair, Amount (One TL)	2013:M07-2021:M04	Normal
K43	Cash Loans, Wholesale, Retail Sale, Motor Vehicle, Motor Vehicle Services, Retail and Personal Goods, Amount (One TL)	2013:M07-2021:M04	Normal
K44	Cash Loans, Wholesale, Retail Sale, Motor Vehicle, Motor Vehicle Services, Wholesale Trade and Brokerage, Amount (One TL)	2013:M07-2021:M04	Normal
K45	Cash Loans, Transportation Vehicles Industry, Ship Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K46	Cash Loans, Transportation Vehicles Industry, Motor Vehicles, Amount (One TL)	2013:M07-2021:M04	Not Normal
K47	Nonperforming Loans, Wood and Wood Products Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K48	Nonperforming Loans, Fishery, Amount (One TL)	2013:M07-2021:M04	Not Normal
K49	Nonperforming Loans, Manufacturing Industry Not Classified in Another Places Amount (One TL)	2013:M07-2021:M04	Not Normal
K50	Nonperforming Loans, Individual Loans, Other, Amount (One TL)	2013:M07-2021:M04	Not Normal
K51	Nonperforming Loans, Individual Loans, Housing, Amount (One TL)	2013:M07-2021:M04	Not Normal
K52	Nonperforming Loans, Auto, Amount (One TL)	2013:M07-2021:M04	Normal
K53	Nonperforming Loans, Credit Card, Amount (One TL)	2013:M07-2021:M04	Normal
K54	Nonperforming Loans, Leather and Leather Products Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K55	Nonperforming Loans, Other Non-Metal Mines Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K56	Nonperforming Loans, Other Social and Individual Services, Other Social Services, Amount (One TL)	2013:M07-2021:M04	Not Normal
K57	Nonperforming Loans, Other Social and Individual Services, Amount (One TL)	2013:M07-2021:M04	Not Normal
K58	Nonperforming Loans, Education, Amount (One TL)	2013:M07-2021:M04	Not Normal
K59	Nonperforming Loans, Electricity, Gas	2013:M07-2021:M04	Not

	and Water Resources, Amount (One TL)		Normal
K60	Nonperforming Loans, Electricity and Optical Instruments, Amount (One TL)	2013:M07-2021:M04	Not Normal
K61	Nonperforming Loans, Real Estate Brokering, Renting and Management, Amount (One TL)	2013:M07-2021:M04	Not Normal
K62	Nonperforming Loans, Extraction of Energy Producing Mines, Amount (One TL)	2013:M07-2021:M04	Normal
K63	Nonperforming Loans, Extraction of Non-Energy Producing Mines, Amount (One TL)	2013:M07-2021:M04	Not Normal
K64	Nonperforming Loans, Financial Intermediation, Intermediary Institution, Amount (One TL)	2013:M07-2021:M04	Not Normal
K65	Nonperforming Loans, Financial Intermediary, Leasing Factoring, Amount (One TL)	2013:M07-2021:M04	Not Normal
K66	Nonperforming Loans, Food, Beverage and Tobacco Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K67	Nonperforming Loans, Construction, Amount (One TL)	2013:M07-2021:M04	Not Normal
K68	Nonperforming Loans, Private Persons Employing Worker, Amount (One TL)	2013:M07-2021:M04	Not Normal
K69	Nonperforming Loans, Pulp and Paper Industry, Printing Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K70	Nonperforming Loans, Pulp and Paper Industry, Pulp and Paper Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K71	Nonperforming Loans, Rubber and Plastic Products Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K72	Nonperforming Loans, Chemistry and Chemical Products, Amount (One TL)	2013:M07-2021:M04	Not Normal
K73	Nonperforming Loans, Machinery and Equipment Industry, Electricity and Electroless Household Appliances, Amount (One TL)	2013:M07-2021:M04	Not Normal
K74	Nonperforming Loans, Machinery and Equipment Industry, Machinery and Equipment, Amount (One TL)	2013:M07-2021:M04	Not Normal
K75	Nonperforming Loans, Base Metal Industry and Processed Mine Production, Amount (One TL)	2013:M07-2021:M04	Not Normal
K76	Nonperforming Loans, Base Metal Industry and Processed Mine Production, Amount (One TL)	2013:M07-2021:M04	Not Normal
K77	Nonperforming Loans, Nuclear Fuel, Oil and Coal, Production, Amount (One TL)	2013:M07-2021:M04	Not Normal
K78	Nonperforming Loans, Hotel and Restaurants, Amount (One TL)	2013:M07-2021:M04	Not Normal
K79	Nonperforming Loans, Health and Social Services, Amount (One TL)	2013:M07-2021:M04	Not Normal
K80	Nonperforming Loans, Defense and	2013:M07-2021:M04	Not

	Public Management, Obligatory Social Security Institutions, Amount (One TL)		Normal
K81	Nonperforming Loans, Agriculture, Hunting and Forestry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K82	Nonperforming Loans, Transportation, Storage and Communications, Other Transportation Activities and Storage, Amount (One TL)	2013:M07-2021:M04	Not Normal
K83	Nonperforming Loans, Transportation, Storage and Communications, Amount (One TL)	2013:M07-2021:M04	Not Normal
K84	Nonperforming Loans, Transportation, Storage and Communications, Transportation, Amount (One TL)	2013:M07-2021:M04	Not Normal
K85	Nonperforming Loans, Textile and Textile Products Industry, Leather Clothing and Fur Processing Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K86	Nonperforming Loans, Textile and Textile Products Industry, Clothing Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K87	Nonperforming Loans, Textile and Textile Products Industry, Textile Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K88	Nonperforming Loans, Wholesale, Retail, Motor Vehicle Services, Motor Vehicle Sale, Amount (One TL)	2013:M07-2021:M04	Not Normal
K89	Nonperforming Loans, Wholesale and Retail Motor Vehicle Services, Retail Trade and Individual Wares, Amount (One TL)	2013:M07-2021:M04	Not Normal
K90	Nonperforming Loans, Wholesale and Retail Motor Vehicle Services, Wholesale Trade and Brokering, Amount (One TL)	2013:M07-2021:M04	Not Normal
K91	Nonperforming Loans, Means of Transport, Construction of Ship Industry, Amount (One TL)	2013:M07-2021:M04	Not Normal
K92	Nonperforming Loans, Means of Transport, Motor Vehicles and their Accessories, Amount (One TL)	2013:M07-2021:M04	Not Normal

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Customers' Opinions on Voluntary-Insurance in Bank-led Digital-banking: Statistical Analysis for Policymakers' Attentions

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In 21st century business-mentality era, bank-services have been modernized where customers compete for comparative time-saving-options. However, many factors in services are unpredictable. Perceived-risk has been undermining the prospects of cashless-society country-wise such as Bangladesh. But banks should work eliminating issues particularly perceived risk by adopting Voluntary Insurance (VI) provision as proposed by Rahman (2018) in literature. Now using statistical techniques, this study examined customers' opinions on VI as provision in e-banking services. Findings of this study show that customers' "age group" and "education level" have preferences for enacting VI as Provision. Data statistics were collected from 200 respondents of city & rural areas of Bangladesh, which was used to test the mediated model using the Hierarchical Regression. The results have supported that the perceived-risk has acted as a partial mediator in the relationship between independent variables particularly psychological risk, trust, financial, performance, dispute, pin-fraud, social/ privacy-risk to dependent variable, that is, customers' preferences for VI provision in e-banking services. Absolute risk-free services can attract more users of bank-led e-banking. Accordingly, policymakers can play vital role ensuring modern-society when it come e-banking services. Since digital transactions are not insured under Bank Laws in Bangladesh, like in other countries, this effort is for bringing the findings to the attentions of policymakers country-wise.

Keywords: *bank-led digital, perceived risk, voluntary insurance as banking-provision, risk-free digital-banking services*

Introduction

Meeting the demands of modern-banking-services in technology-driven human-society, bank-services have been restructured in world-economy country-wise. In this race, Bangladesh is no exception. Besides traditional bank-services operating side-by-side, digital-banking, particularly, mobile-led, and bank-led digitals are playing significant roles. In this progression in Bangladesh-economy, Agent-banking, bKash, Western-Union etc. serve new-way financial-services. However, this new era things are driven with business-mentality-theme where many factors are unpredictable. It is well recognized that strict laws and its application can marginalize the magnitudes of "Perceived risk" problem. In these efforts, developed countries are ahead of developing countries in today's world.

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In this journey, Bangladesh has made huge progress in digital-banking over the last decade where approximately over six percent of the population makes payments using mobile-led banking (The Daily Star 2021). Being a country with population of 160 million, there are lot of opportunities and prospects when it come e-banking services. However, for prompt and effective outcome in Bangladesh-economy, three factors are needed to come together and work in cohesions. These factors are a) payment instruments from end-user's sides b) acceptance instruments from retailers & businesses and c) the trust factor. No doubt, the government has been playing important roles enabling environment with the help of FinTech - Confirmation & Tech Communication. But, the FinTech services have been facing difficulties addressing the trust issues since the beginning of its journey in financial services (The Daily Star 2021, Khan 2016). It does not guarantee absolute risk-free digital transaction where developing countries are more vulnerable than that of developed countries. It might have led to a slower-growth of digital-banking in countries like Bangladesh. Transferring cash takes a lot of trust in the system. Many people in the country do not seem to truly trust the digital money transfers (The Daily Star 2021). They feel it to be risky in multi-faucets i.e., they face "perceived-risk". It is a concept that attempts making future foreseeable for current state by predicting unfavorable circumstances and its negative impacts on the risk, individual may face. Thus, trust and "feeling risky" are pivotal, which has been undermining the progression of digital-banking trends in world-economy country-wise.

Dealing with determinant "perceived-risk" (PR), the current author proposed in literature Voluntary Insurance (VI) a probable banking-provision in digital-banking services (Rahman 2018). In a comparison study between bKash and bank-led digital, underpinning Factor Analysis and Hypothesis Testing on customers' opinions in Bangladesh, Rahman (Rahman 2020) concluded in two-folds. They are a) attribute "Phone call confirmation" has influenced customers' preferences using bKash and b) attribute "No transaction fee" has influenced using bank-led digital. It clearly tells that having mobile-led banking such as bKash, Agent-banking, bKash, and Western-Union in place has eased overcoming technology type factor.

However, there is at least one critical-factor category, which is overlooked or has received inadequate attention in policy-design, is the PR. Accordingly, Rahman (Rahman 2020) re-emphasized the policy proposal of the VI as an e-banking provision in world-economy country-wise (Rahman 2018, Rahman 2020). The recent studies in countries such as the United States of America reveal that 70% of digital bank customers and 44% of traditional bank customers want embedded insurance offers based on transaction data (Global News Wire 2021, Indiana Department of Financial Institution 2022).

Now it involves building policy mandate for effectively addressing the trust issues that have been undermining the expected progression of digital banking country-wise such as Bangladesh. Like in many countries, there are lots of problems, which do not attract the attentions of policymakers' country-wise such as Bangladesh. Because they lack efforts or supports from relevant leaderships of entities such as bank-services-industry, consumer groups or relevant executive-

branches such as Bangladesh Bank – the Central Bank of Bangladesh. However, it is often contingent to public opinions, which in turn is influenced by treatment of the issue in the media. World-wide observations suggest that when key interest groups and policy experts agree on the importance and scope of the problem, it gets on the agenda of public policymakers. In practice, there are many approaches for building a mandate, which varies country-wise. In Bangladesh, sometime, some agencies use panels or committees of experts in a particular field. These groups make recommendations that are used by agencies to build a mandate.

Since such efforts, if any, are unknown at least in Bangladesh-economy at the present and since the research-findings in literature are very often used by panels or committees of experts, it is assumed that the corresponding agency(s) are familiar with the proposal of VI e-banking-provision. It deserves to be empirically scrutinized using customers-opinions in world-economy country-wise such as Bangladesh on how the customers would take it in their decisions using bank-led digital-banking services.

This study takes on the challenges statistically testing customers opinions on how they feel about adopting Voluntary Insurance as a provision in bank-led digital-banking services in Bangladesh-economy. The findings can serve as a "paradigm findings" of studying world-economy country-wise in general. Thus, it can be instrumental to today's policymakers for effective-policy design ensuring risk-free bank-led digital-banking services in world-economy country-wise. Accordingly, it can be a win-win to parties involved in the progression of digital-banking in Bangladesh-economy.

Literature Review

Bauer (1960) first introduced "perceived risk" in literature and called it an influence, which led the overall perceived value of purchasing behavior of a customer. As an abstract concept, it means an undesirable outcome that a customer may anticipate that it can follow the customer's current action. Later, Mitchell (1999) divided it into two components: uncertainty about the consequences of a wrong choice and uncertainty about the outcome. Perceived risk can be seen as the deterministic feeling if the result is adversely unfavorable (Cunningham 1967, Malika 1997).

With this progression in literature, Technology Acceptance Model (TAM) of Davis (1989) revealed three components namely a) perceived-usefulness b) perceived ease of use and c) system usages. Hong et al. (2001) added two categories of external variables. They are "individual differences" and "system characteristics". Chau (1996) simplified it by using four perceived factors a) perceived ease of use b) perceived long-term usefulness c) perceived short-term usefulness and d) behavioral intention to use. Venkatesh et al. (2003) compared and tested the variables in eight different models about users' technology acceptance including the TAM and subsequently, they proposed a Unified Theory of Acceptance and Use of Technology (UTAUT). It is consisted of four core determinants of acceptance and four moderating factors. Im *et al.* (2008) investigated four potential

variables in users' technology-adoption. These variables were a) perceived risk b) technology type c) user experience and d) gender. Their findings showed that perceived risk, technology type and gender were found to be significant variables.

Since we live in a world of business-mentality where many factors are often unpredictable, it is palatable saying that strict-laws and its fullest application can marginalize the magnitudes of this "perceived risk". On this matter, in today's world, developed countries are doing better and ahead of developing countries. But it does not guarantee an absolute risk-free e-banking service even in developed countries. On risk issue, developing countries are vulnerable, which might have led a slower growth of bank-led digital-banking in countries such as Bangladesh where mobile-led payment (bKash), has been dominating the trend (Rahman 2018).

In aim to deal with the determinants of "perceived risk" and "trust issue", current author proposed in literature VI in banking services (Rahman 2018). Under the proposal, if VI e-banking provision is in place, bank will introduce the VI as a new product in e-banking services where customers of e-banking will decide buying it or not buying it. In literature, the proposal has not yet been challenged. Instead, many companies or organizations such as the Global News Wire in the United States of America have completed surveys (Global News Wire 2021). But the proposal deserves to be scrutinized on how the customers feel about it. In other words, it deserves having customers' opinions and then carryout statistical analysis for policymakers' attentions. This study takes on the tasks of statistical analysis using customers' opinions. The expected findings can be guidance to policymakers for addressing the issue of "perceived risk" and "trust" by crafting or enacting e-banking provision in practice in world-economy country-wise. This study advances with the goal where Bangladesh is chosen as a case study, which can fill-up the gap in literature.

Objectives of the Study

To study customers' perceptions on "perceived risk" that can serve as Lessons-learnt to the progression of e-banking services in Bangladesh.

To examine the relationship between customers' preferences and policy proposal of VI as guidance for policy design addressing perceived risks in e-banking services.

To assess e-banking-customers' perceptions whether the proposed VI banking provision should be enacted addressing perceived risks in e-banking services.

Theoretical Background: Hypotheses Development

Perceived Risks in Bank-led Digital-banking Services

The concept "risk" is shaped around the idea that any customer behavior involves risks in the sense that customer's actions may create consequences, which the customer cannot anticipate with certainty (Bauer 1960). Thus, "Perceived risk" is powerful explaining customer's behaviors. This is because customers are more motivational to avoid mistakes than maximizing utility of using bank-led e-

banking (Mitchell 1999, Florea 2014, Rahman 2018, Ahmadksath 2022). Risk is often present in choice-situation as customers cannot always be certain that a planned-use of bank-led e-banking will achieve full-satisfaction. Accordingly, the Online shoppers perceive greater risk when paying online-bills even though goods are non-standardized and often sold without warranties (Zeithaml 1981, Yousafzai 2009). With this reality in today's competitive markets, perceived risk is regarded as being a composite of several categories of risks. In literature, several types of perceived risks have been identified in e-banking services (Featherman 2001, Pavlou 2003, Lee and Chung 2009, Florea 2014, Rahman 2020). For better understanding, first, the definition of perceived risk, its distinct types and some other factors that influence today's individual's behavior are outlined as follows

Perceived Risk

It is an abstract concept that suggests future foreseeable for current state by predicting unfavorable circumstances and its negative impacts individual may face. On this aspect, in initial stages of digital-banking progression, six major factors of perceived risk were identified (Littler and Melanthiou 2006). They are i) financial ii) performance iii) time iv) social v) psychological and vi) security.

Psychological Risk

It is a threat when something goes wrong with Internet banking transaction and customer feels frustrated. Also, sometime customer feels shamed to be.

Trust Factor

Despites huge investment in the progression of bank-led digital, "lack of trust" remains a barrier in the widespread adoption of Internet banking both in the context of the bank and the overall online environment (Yousafzai 2009). The magnitudes of trust issue are more in rural and urban areas than that in city areas. These are common country-wise.

PIN Fraud Risk

As alternative delivery channels, customers use Credit card or ATM card or Dual currency card etc., which requires password, or PIN. However, it can be stolen or misused.

Security/Privacy Risk

It is a kind of threat where a fraud or hacker may get unauthorized access to online-bank-users' accounts and acquire sensitive information such as username, password, credit card/debit card information and then misuse it. Overall, system reliability is a critical issue.

Financial Risk

It is a kind of threat where monetary loss could take place due to transaction-error.

Performance Risk

It is a kind of annoying issue where unexpected breakdown or disconnection from the Internet can take place.

Customer Dispute

It refers to the possibility of getting into dispute with digital-service-providers or Online seller or with individual or group that has caused the problem. It may warrant legal cases.

Social Risk

It refers to the possibility that using Internet banking may result in the disapproval of one's family, friends, or work group (Lee 2009). It happens when family member or friend or workgroup signed on as the guarantor.

Time Risk

When using "Internet & completing transaction" it may take unexpected longer times, or server can be down. With this cause and delay, customers may become frustrated losing time. On scheduled payment issues, sometime customers may be penalized for late transaction completion.

Other factors that individual/bank-led customer cares about no matter what society s/he belongs to

Familiarity with Internet

Using bank-led digital services require familiarity with internet.

Bonus for Digital

Offering bonus by banks for using digital service can inspire customers to use it more.

Self-image

In digital era, digital-banking users feel better and to be modern, which may carry self-image.

Comparison Effects

In business-mentality era, people focus on comparison effects of his/her each decision.

Lessons-learnt: Can Mobile-led Banking Shed Lights for Bank-led Digital Progression?

In literature, on customers' preferences, a comparison-study between mobile-led and bank-led options was carried out by the current author (Rahman 2020). It is here assumed to be served as lessons-learnt for better understanding of factors that has resulted a higher trend of bKash (mobile-led) usage over bank-led usage digital in Bangladesh.

There are more than thirty million customers who use bKash for digital-transactions and accordingly there are over 0.2 million agents located around Bangladesh (The Daily Star 2021). Here trend of bKash-users has been growing geometrically. However, trend of bank-led-users has been growing mathematically – very slowly in city areas & it would not be overstated claiming it does not exist in rural areas, even though bank-sector promotes it desperately curtailing the magnitudes of its operating cost (Rahman 2020). For clarity on whether perceived risk factor has overall played significantly undermining the growth of the trend of bank-led digital-banking, the author used a comparison as follows.

Table 1. *Position in Consumer's Preferences Mobile-led (bKash) vs. Bank-led "Digital-banking"*

Determinant	b-Kash	Bank-led
	Position	Position
Confirmation by making phone call(s)	1st (+)	1st (-)
Perceived risk factors		
Psychological risk	4th (+)	4th (-)
Privacy risk	2nd (-)	2nd (+)
Financial risk	3rd (-)	3rd (-)
Performance risk	6th (+)	6th (-)
Social risk	5th (+)	5th (-)
Access / Familiarity with Internet	2nd (+)	2nd (-)
Convenience for transaction	1st (-)	1st (+)
Bonus for digital banking	1st (-)	1s (+)
Confirmation *via* SMS	1st (+)	1st (+)
Focus option (phone call confirmation)	1st (+)	1st (-)
Focus of comparison effects	1st (+)	(+)
Know-how-skill	1st (+)	1st (-)
Self-image	1st (-)	1st (+)

Source: Rahman 2020.

In Table 1, the serial number or position of the factor in contribution reflects customer preferences in choosing bKash or bank-led digital banking. Here positive (+) sign means "positively influences" and negative (-) sign means "negatively influences" the choice of bKash or bank-led digital banking when a customer is decided for On-the-Go banking. It further shows mobile-banking is more appealing than that of bank-led digital because of perceived risk (PR) issue, which raises question: what is VI and how can it be instrumental?

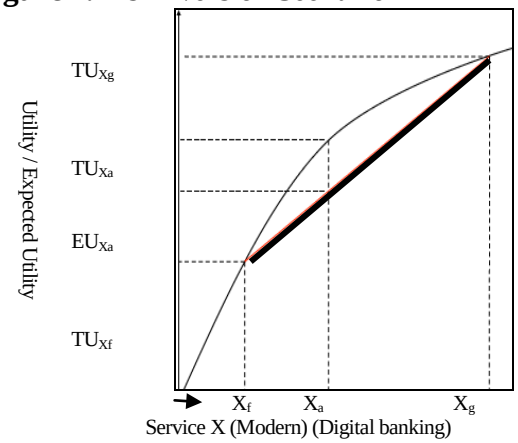
VI in Digital-banking (Rahman 2018): What is it?

It would not be overstated that PR plays an influential role in setting the stage for the VI option in e-banking services (Rahman 2018, Global News Wire 2021, Ahmadksath 2022). It is palatable assuming that customers of e-banking services are risk-averse. They prefer certainty to uncertainty.

In these uncertainty-world-activities, a customer receives actual utility from digital services, which will never fall on the TU (X) but on the chord (the bold

line) as shown in Figure 1. The X_g as shown in Figure 1, represents digital-banking service-outcome. Figure 1 illustrates risk preferences of a risk-averse banking-customer.

Figure 1. *Risk Aversion Scenario*



Source: Rahman 2018.

Here customer may use a certain level of service X. Since the X_f represents negative outcome, thus, customer may use less of service X. Since the existence of the level of uncertainty is undeniable, a customer may not use X_g units of service X. Thus, the utility that this customer receives will lie somewhere on the chord (the bold line). Here the chord represents the expected utility (EU) of using service X that lies in the concavity of the curve. This is because, it is the average probability that the customer will use service X or will not use it. As a result, an individual will never receive TU (X_a), but s/he will receive EU (X_a). Thus, it can be preferable to customers of e-banking in Bangladesh-economy.

Current Research Question

The above as a background, the current research questions are: a) What derive a customer's preference choosing the VI in bank-led e-banking services? b) How do customers prefer the VI as e-banking provision in e-banking services in Bangladesh?

Research Hypotheses for this Study

Underpinning the facts, the following hypotheses are developed and tested statistically.

H1: Psychological risk is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H2: Trust-factor is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H3: Pin fraud risk is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.

H4: Security or privacy risk is positively related to preferences of e-banking-customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H5: Financial risk is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H6: Performance risk is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H7: Customer dispute risk is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H8: Social risk is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H9: Time risk is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.
H10: Perceived risk is positively related to customers' preferences for the proposed VI Provision in bank-led digital-banking services.

The regression equation can be written as follows

$$Y = f(x_i) \quad (1)$$

$$\hat{Y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_i x_i \quad (2)$$

where
Y = VI-provision is a dependent variable and x_i are independent variables.
$\hat{Y}$ = Preference for having VI as a provision in bank-led e-banking services β_i = Coefficients and $x_1 \ldots x_i$ are independent variables where

x_1 = Gender x_2 = Age x_3 = Edu level x_4= Psychological risk x_5 = Trust factor x_6 = Pin-fraud risk x_7 = Privacy risk x_8 = Financial risk x_9 = Performance risk x_{10} = Dispute risk x_{11} = Social risk x_{12} = Time risk x_{13} = Perceived risk x_{14} = Familiarity with Internet x_{15} = transaction conveniency x_{16} = Bonus for bank-led digital x_{17} = know-how-skill x_{18} = Self-image x_{19} = Confirmation via SMS and x_{20} = Focus option (phone call confirmation).

Methods and Data Collection

Sample, Survey Instrument and Measures

Sample Represents Customers of Bank-led Digital-banking in Bangladesh

Data were collected from two hundred respondents using Google Survey Form. Among the respondents, 25 respondents were in rural areas and 175 were in city areas of Bangladesh. Today over half of the population of Bangladesh live in rural areas where electricity is mostly accessible to and most markets in rural areas are facilitated with network services if individual wants to use it. With this facilitation, most rural people are more familiar with mobile-led digital-banking than that of bank-led digital-banking. Also, in rural areas, in most cases, people can receive services from professionals, in case they need digital-banking including bank-led digital services. Thus, preferences of using bank-led digital-banking depend on individual's preferences. Location, that means, residing in rural areas or city areas in Bangladesh, does not matter or influence the preferences of using

bank-led digital-banking. It is the scenarios of world-economy country-wise no matter where customer resides.

Demographic profile of the respondents reveals that 60 percent of them were married, 70 percent were male, and the 36 percent were below the age of 35 years. Furthermore, from the sample, 85 percent respondents had savings bank account where 35 percent of them were using bank-led digital banking for over 2 years and 25 percent were pampered using bank-led e-banking. On educational aspect, 85 percent respondents were holding at least undergraduate degree.

Survey Instrument Used in this Study

In this study, a structural questionnaire-form was designed to collect the data statistics. Here respondents were asked to answer the questions on a 5-point Likert Scale ranging from "5 = strongly agree" to "1 = strongly disagree".

Measures Used in this Study

These measures were adapted author's earlier studies (Rahman 2018, Rahman 2020).

Psychological risk: reliability coefficient of Cronbach's alpha for this measure is 0.631.
Trust factor overall: reliability coefficient of Cronbach's alpha for this measure is 0.713.
Pin fraud risk: reliability coefficient of Cronbach's alpha for this measure is 0.758.
Security/privacy risk: reliability coefficient of Cronbach's alpha for this measure is 0.744.
Financial risk: reliability coefficient of Cronbach's alpha for this measure is 0.669.
Performance: reliability coefficient of Cronbach's alpha for this measure is 0.880.
Customers' dispute: reliability coefficient of Cronbach's alpha for this measure is 0.964.
Social risk: reliability coefficient of Cronbach's alpha for this measure is 0.734.
Time-risk: reliability coefficient of Cronbach's alpha for this measure is 0.661.

Results

Descriptive Statistics

The means, standard deviations and zero-order correlations are reported in Table 2. The initial analysis of correlations suggests that the highest correlations were between psychological risk and customer preference for the VI provision in bank-led digital-banking (r=0.527) and pin-fraud and performance risk (r=0.509). In viewpoint of multicollinearity, since correlations of 0.80 or higher may be problematic as noted in literature (Kennedy 1979), a statistical check for multicollinearity using variance inflation factor (VIF) for each of the independent variables has been carried out and the VIF was appeared to be two (VIF≤2). Thus, the results here support that the multicollinearity is not a problem.

Table 2. *Descriptive Statistics: Means, Std Deviation and Correlations*

	Var	Mean	Std	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	Gender	1.42	0.494	1																				
2	Age	2.20	1.079	0.029	1																			
3	Edu Level	2.62	0.877	0.060	0.026	1																		
4	Psychological	4.22	0.621	-0.045	0.105*	0.051	1																	
5	Trust	4.0	0.627	-0.024	-0.005	0.140**	0.074	1																
6	Pin-fraud	3.87	0.680	-0.096*	0.099*	0.070	0.053	0.475**	1															
7	Security	3.96	0.801	-0.012	-0.022	0.032	0.023	0.090*	0.276**	1														
8	Financial	3.80	0.615	-0.147**	0.016	0.001	-0.111*	0.373**	0.318**	0.347**	1													
9	Performance	4.07	0.765	-0.111*	0.169*	0.070	0.071	0.245**	0.495**	0.305**	0.106*	1												
10	Dispute	3.95	0.668	-0.049	0.021	0.002	0.129**	0.478**	0.349**	0.293**	0.355**	0.107*	1											
11	Social	4.15	0.731	-0.042	0.062	-0.045	-0.055	0.377**	0.100**	0.241**	0.498**	-0.034	0.322*	1										
12	Time	4.11	0.634	-0.146**	0.059	-0.026	0.001	0.434**	0.212**	0.296**	0.509**	0.195**	0.416**	0.416**	1									
13	Perceived risk	4.22	0.060	-0.177**	0.049	0.011	0.220	0.332**	0.211**	0.123**	0.342**	0.100**	0.441**	0.312**	0.221	1								
14	Familiarity	3.99	0.026	-0.134*	0.023	0.100	0.232	0.122	0.100	0.211	0.010	0.111	0.144	0.122	0.231	0.101	1							
15	Conveniency	1.22	0.012	-0.122	0.011	0.121	0.121	0.223	0.002	0.000	0.120	0.122	0.000	0.000	0.100	0.001	0.120	1						
16	Bonus	3.77	0.212	-0.223*	0.232	0.232	0.221	0.234*	0.212*	0.111	0.122	0.211*	0.111	0.021	0.211	0.222	0.100	0.112	1					
17	Know how	2.99	0.572	-0.123	0.234*	0.321*	0.211*	0.311*	0.211	0.221	0.221	0.231*	0.200	0.213*	0.111	0.212*	0.200	0.211	0.121	1				
18	Self-image	2.67	0.234	-0.233	0.111	0.120	0.100	0.220	0.101	0.100	0.133	0.110	0.100	0.111	0.011	0.110	0. 010	0.001	0.110	0.100	1			
19	Via SMS	4.03	0.546	-0.245*	0.432*	0.212*	0.233*	0.232*	0.202	0.233*	0.211*	0.200	0.221	0.232*	0.211*	0.111	0.211	0.231*	0.121	0.112	0.102	1		
20	Focus option	2.87	0.123	-0.231	0.110	0.111	0.111	0.100	0.100	0.001	0.11	0.11	0.001	0.001	0.121	0.101	0.100	0.101	0.001	0.111	0.10	0.0	1	
21	For VI	4.10	0.626	-0.025	0.102*	0.056	0.039	0.29**	0.435**	0.411**	0.143**	0.252**	0.143**	0.148**	0.527**	0.232**	0.321**	0.231*	0.341*	0.222*	0.231*	0.22	0.22	1

Source: Author.
Note: Cells contain zero-order (Pearson) correlations
**Correlation is significant at 0.01 level and *Correlation is significant at 0.05

Hypotheses Testing

Here the Hierarchical Regression has been used to test each hypothesis. The reason of this choice is that the Hierarchical Linear Regression, a special form of a Multiple Linear Regression Analysis, facilitates adding more variables to the model in separate steps called "blocks". In study, it has facilitated statistically controlling some variables to see whether adding variables significantly improves model's ability to investigate a moderating effect of a variable. The column 1 and column 2 show the results of effect of independent variables to preferences for the proposal of the VI provision enactment. After entering control variable in step 1, the results are presented in Table 2.

In column 1 of Table 3, where all the control variables - gender, age, education-level are shown, gender was a significant predictor for the proposed VI provision (β=−0.148, p<0.001).

The corresponding model was significant (R^2=0.26; Adj R^2=0.18; F=3.240, p<0.001). Then main independent variables are entered in step 2. The results show that the beta coefficient of psychological-risk (x_1) was significant (β=0.170, p<0.001), thus supporting Hypothesis-1, that is, psychological-risk is significant and positively related to preference for proposed VI provision in e-banking services. The beta coefficient of trust-factor (x_9) (β=−0.142, p<0.05) was significant and supports Hypothesis 2. Beta coefficient of time-risk (β=0.051, p=0.241) was not significant. Hence, Hypothesis 9 is not supported.

The beta coefficient of customer-dispute (x_5) (β=0.301, p<0.001) was significant, thus supporting Hypothesis 7. The regression coefficient of performance risk (x_3) (β=0.154, p<0.001) was significant and hence supporting Hypothesis 6. The beta coefficient of financial risk (β=0.133, p<0.001) was significant and hence renders support to Hypothesis 5. The beta coefficients of social risk (x_6) (β=0.040, p=0.350) was not significant, hence not supporting Hypotheses 8.

Finally, the beta coefficient of "perceived risk" (β=0.119, p<0.05) was significant, hence it was supporting Hypothesis 10. Here main effects of the model are significant (R^2=0.393; Adj R^2=0.377; F=24.210, p<0.001; Δ R^2=0.367; ΔF=32.688, p<0.001) and it explains 36.7 percent of variance in support of the preferences for the proposed VI provision in the bank-led e-banking services. Here main independent variable "perceived risk" represents all independent variables.

The regression result in support of proposed VI provision is presented in column 3 and column 4 of Table 2. Among control variables, age and education-level are the significant predictors (β=0.105, p<0.001) and (β=0.133, p<0.001) of customer preferences for bank-led e-banking. The control variable gender is not significant. The control variables model was not significant (R^2=0.014; Adj R^2=0.006; F=1.806, ns.). In step 2 (column 4), the main variable, perceived risk, was entered the regression equation. The beta coefficient of perceived risk (β=0.181, p<0.001) was significant, thus supporting Hypothesis 10 that perceived risk-factors are significant and positively related to preferences of customers for the proposed VI provision in bank-led e-banking.

Table 3. *Results of Multiple Regression*

	Colum 1	**Colum 2**	**Colum 3**	**Colum 4**
	Step 1	**Step 2**	**Step 1**	**Step 2**
Variables	**Perceived Risk**	**Perceived Risk**	**For VI Provision**	**For VI Provision**
Gender	0.148** (-3.298; 0.001)	-0.065 (-1.772; 0.077)	-0.030 (-0.674; 0.501)	-0.004 (-0.081; 0.936)
Age	0.062 (-3.298; 0.001)	0.023 (0.605; 0546)	0.105** (2.221; 0.027)	0.094** (2.010; 0.045)
Education level	-0.014 (1.302; 0.763)	-0.047 (-1.226; 0.221)	0.059 (1.228; 0.220)	0.061 (1.303; 0.193)
Psychological		(0.170)** (-2.947; 0.003)		
Trust		0.051 (1.173; 0.241)		
Pin-fraud		0.301** (6.430; 0.000)		
Security		0.154** (4.005; 0.000)		
Financial		0.133** (3.014; 0.003)		
Performance		0.040 (0.935; 0.350)		
C. dispute		0.081 (1.722; 0.086)		
Social risk		0.001 (1.002; 0.211)		
Time risk		0.110** (1.030; 0.230)		
Perceived risk		0.211** (0.981; 0.110)		
Familiarity		(0.001) (0.761; 0.153)		
Conveniency		(0.011) (1.223; 0.312)		
Bonus		(0.123)** (1.111; 0.123)		
Know how		(0.124)** (0.321; 0.121)		
Self-image		(0.121) (1.221; 0.212)		
SMS		(0.111)** (0.671; 0.100)		
Focus option		(0.012)		
VI Provision				0.181*** (4.068; 0.000)
R^2	0.26	0.393	0.014	0.046
Adj R^2	0.18	0.377	0.006	0.037
ΔR^2		0.367		0.032
F	3.240**	24.210***	1.806	4.800***
ΔF		32.668***		16.550
Df	4,495	13,486	4,495	5,494

Source: Author.
Note: *** $p<0.001$; ** $p<0.05$

Since Hypothesis 10 was concerned with perceived risk as a mediator in the relationship between nine independent variables and dependent variable, it requires to fulfill mediation conditions.

As Aiken and West (Aiken et al. 1991) indicated in literature, three conditions are necessary to demonstrate mediation. The first condition is to ensure independent variables, in this case: security, financial, performance, psychological, customer dispute, pin-fraud, and trust factor, are significantly related to the mediator, that is, perceived risk.

The second condition is to ensure that these independent variables are significantly related to preferences of customers for VI provision. The third condition is to ensure that when perceived risk is included in the full equation, the relationship between the nine independent variables is either no longer significant or less significant.

If the relationship is not significant, then full mediation is present; if the relationship is significant, then psychological risk becomes partial mediator. The regression results of test of mediation hypothesis are presented in Table 4.

Table 4. *Regression Results of Full Mediation Analysis Multiple Regression*

	Colum 1	**Colum 2**	**Colum 3**
	Step 1	**Step 2**	**Step 1**
Variables	**Preference for VI**	**Preference for VI**	**Preference for VI**
Gender	-0.03 (-0.674; 0.501)	0.118 (0.223; 0.823)	-007 (0.190; 0.885)
Age	0.105** (2.221; 0.027)	-0.001 (-0.041; 0.967)	-0.001 (-0.030; 0.976)
Education level	0.059 (1.228; 0.220)	-0.005 (-0.124; 0.901)	-0.005 (-0.147; 0.088)
Psychological		0.054 (1.380; 0.168)	0.011 (0.241; 0.810)
Trust		0.008 (0.176; 0.860)	0.173*** (3.780; 0000)
Pin-fraud		0.176*** (3.871; 0.000)	0.195*** (4.749; 0000)
Security		-0.194*** (4.738; 0.000)	-0.130** (-2.841; 0.005)
Financial		- 0.135** (-3.081; 0.002)	0.067 (1.815; 0.070)
Performance		0.064	-0147 (-3.501; 0000)
C. dispute		0.149***	0.387*** (-3.501; 0.001)
Social risk		0.387***	0.311** (7.341; 0000)
Time risk		0.087**	0.017 (0.190; 0.885)
Perceived risk		0.121**	-0.017 (-0.478; 0.684)
Familiarity		0.054	0.001 (0.0123; 0.211)
Conveniency		0.111	0.211 (2.331; 0.002)
Bonus		0.001	0.221 (0.897; 0.001)
Know how		0.234**	0.211** (0.786; 0.001)
Self-image		0.001	0.012 (2.002; 0.005)
Focus option		0.001	0.112 (0.987; 0.002)
R^2	0.014	0.463	0.463
Adj R^2	0.006	0.448	0.447
ΔR^2		0.447	0000
F	1.806	32.183***	29.845***
ΔF		45.0421***	0.166
Df	4,495	13,486	14,485

Source: Author.

Note: *** $p<0.001$; ** $p<0.05$

All control variables are entered first in the regression equation (column 1). As seen earlier, none of the control variables represents significant predictor of customer satisfaction.

In step 2 (column 2), all independent variables are entered. The results are particularly interesting because there is no direct relationship of (a) time risk and perceived risk (b) social risk and perceived risk. Therefore, the first condition of mediation is not satisfied for these two variables.

Out of nine variables, time risk and social risk are not significantly related to customer preference for VI provision. Therefore, the second condition of mediation is not satisfied for these variables. Only variables that satisfied the condition to check mediation are psychological risk, privacy risk, financial risk, performance risk, customer dispute, pin fraud and trust factor. Results show that (a) the beta coefficients for perceived risk were significant before and after entering the mediator into the equation (β=0.176, p<0.001; β=0.173, p<0.001), (b) the beta coefficients for trust factor (β=−0.135, p<0.05; β=−0.130, p<0.05) were significant, (c) the beta coefficients for security/privacy (β=−0.149, p<0.001; β=−0.147, p<0.001) were significant and (d) the beta coefficients for customer dispute (β=−0.309, p<0.001; β=0.311, p<0.001) were significant. After entering the mediated variable, the beta coefficient of perceived risk became non-significant (β=−0.017). These results support partial mediation of perceived risk in the relationship between psychological, security, financial, performance, customer dispute, pin fraud and trust factor and dependent variable, that is, bank-led digital-banking users' preferences for the proposed VI provision.

The mediated model was significant and explained 46.3 percent of variance in customer preference for VI provision (R^2=0.463; Adj R^2=0.447; F=29.845, p<0.001). Post-hoc analysis of the study also showed some interesting results. Other than psychological risk and trust factor, all other independent variables are related to customer preference for VI provision.

The beta coefficients (before and after entering the mediated variable for psychological risk (β=0.196, p<0.001; β=0.176, p<0.001), financial (β=0.194, p<0.001; β=0.195, p<0.001), performance risk (β=−0.135, p<0.05; β=−0.130, p<0.05), customer dispute (β=−0.149, p<0.001; β=−0.147, p<0.001), trust factor (β=0.387, p<0.001; β=0.387, p<0.001) and pin fraud (β=0.087, p<0.05) were significant. No hypothesis was formulated for these as this is a post-hoc analysis. Summary of Hypotheses Tests is presented in Table 5.

Table 5. *Summary of Hypotheses*

Hypotheses	**Results**
H1: Psychological risk (x_4) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Supported
H2: Trust-factor (x_5) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Supported
H3: Pin fraud risk (x_6) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Partially supported
H4: Security or privacy risk (x_7) is positively related to preferences of e-banking-customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Supported
H5: Financial risk (x_8) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Supported
H6: Performance risk (x_9) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services.	Not supported
H7: Customer dispute risk (x_{10}) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Supported
H8: Social risk (x_{11}) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Partially supported
H9: Time risk (x_{12}) is positively related to e-banking customers' preferences for the proposed VI-Provision in bank-led digital-banking services	Not supported
H10: Perceived risk (x_{13}) is positively related to customers' preferences for the proposed VI Provision in bank-led digital-banking services	Supported

Source: Author.

Discussion

As foundation of earlier studies in literature by the author on the VI policy-proposal in e-banking services (Rahman 2018, 2020, Rahman and Islam 2021), the present study is aimed examining customers' preferences in bank-led e-banking in Bangladesh-economy. It can serve as an example of world-economy country-wise.

Like in many developing countries, the infrastructure for bank-led e-banking is still in its embryonic stage in Bangladesh. This is because, people are not here habituated to do so particularly in rural areas where little over 50% of the population resides. In today's Bangladesh, most areas are facilitated with electricity and Internet services where customers preferences for using it are important. Despite this reality, rural people do not use bank-led digital unless individual is required to submit application along with fees. However, majority of them have access to and prefer to use facilitations of commercial mobile-led banking services that are available in rural market areas too. However, on bank-led digital approaches, rural populations still face limitations with several reasons including education-level and lack of smartphone devices and frequent access to Internet service. But based on literature review, very recently few studies on the possibility of having Voluntary Insurance (Rahman 2018) as a provision in practice were conducted in several countries including in the United States of America (Global News Wire 2021) as noted in the Introduction Section.

The present study examines the factors – perceived risk-factors that can derive a customer's preference of choosing VI in e-banking in Bangladesh-economy,

which can serve as an example in world-economy country-wise. This study revealed interesting results. First, the psychological risk significantly undermines a customer's preference choosing the bank-led e-banking services. Secondly, contrary to what is expected, "social risk" and "time risk" variables are not related to the perceived risk factors of online banking. Thus, these two do not influence a customer's preference of choosing the VI in e-banking services. Third, other risk-factors particularly security/privacy, financial, performance, customer dispute, pin-fraud and trust contribute to undermine the preferences of using bank-led digital-banking. The "perceived risk" as mediator in the relationship between independent variables and customer's preference for VI policy are partially supported. The post-hoc analysis revealed that most of the independent variables are also related to customer's preference for VI enactment, even though not hypothesized, as these are expected results.

The present study is not without limitations. First, the common method bias, which is common in survey research, is one potential problem that needs to be acknowledged. It was tried to reduce the common method bias by Harmon one factor analysis. Secondly, social desirability bias is addressed by confirming to confidentiality in the survey. Even though the psychometric properties of the survey instrument are tested which provide internal validity, there is some problem of generalizability because the sample is from rural areas and city-areas. However, the selection was such way that the results from this study are expected to be generalizable across all areas of Bangladesh. This is because the survey study was conducted Online, which ratifies everyone had opportunity to participate. It further suggests that access to electricity and Internet facilitations were not problems, but it was reachable to people if they had preference or chose to use it. On this aspect, income level probably had dominated the decision of the preferences.

Current Effort in Support of Policy-design: How can it be Instrumental?

This effort is to bring the findings of the Survey-Opinions to the attentions of policymakers so that the proposed provision can be introduced in digital-banking services in Bangladesh-economy. Thus, it can be an example in world-economy. This raises questions: how can the proposed provision be instrumental to bank-sector and to the human society in this modern world?

Answer to the questions posed, it is no overstated that transferring risk away from customers will benefit banking sector. It will facilitate customers and the nation in its economic growth. It will attract new customers who were feeling it to be risky to use. Under the proposed provision, offering bonus on number of e-banking transaction will facilitate customers with incentives for more usages while maintaining optimal utility of it. Furthermore, the proposed provision will facilitate a new product, obviously legal one, which can serve as lifeblood to business-companies and to human societies. It can ease in multi-faucets 1) ensured new value for customers 2) improved society and 3) continued existence of the company in competitive market.

Thus, policymakers of world-economy country-wise such as Bangladesh can play effective roles in modern-society for its better-ness when it come e-banking

services. Bank Laws in Bangladesh, like in many countries, contains multi-faucets provisions. The adoption by the Bangladesh Bank of a deposit insurance system (DIS) was a significant development, which now covers bank-deposits, bank-account, however, digital transactions are not insured.

The proposed VI provision in place can ensure risk-free e-banking, which can guarantee elevated self-service-banking activities in Bangladesh-economy, which can be an example to world-economy country-wise. This can be beneficial to customers because it can ensure savings in the form of cost and time. Also, it can facilitate a sense of relief of a user from psychological stress of perceived risk-factors in digital-banking. Accordingly, customers will flock to it when they use banking services. By extra advancement of ICT usages, banking sector can be further competent cutting-off its operating costs, meeting customers' needs and keeping up with global changes. Also, it can ensure the e-banking to be a secured product underpinning VI provision, if it is, in bank-service sector in Bangladesh-economy, which can be example in world-economy country-wise.

With this win-win setting for service-provider and customer (user) of the product secured under the VI provision, if it goes as law in digital-banking, financial sector. To sail through tough competition and to sustain revenues, financial sector in many countries such as Bangladesh are engaging more than that of other kind banks on adoption of ICT in its operation (Khan 2016). Thus, it warrants for policy-practitioners' prompt effective-efforts on attracting more customers meeting the challenges in case Bangladesh is moving for being "cashless society" sooner than delaying.

Conclusion

It can be concluded that VI digital-banking as provisions in place can be helpful for further growth of digital-banking usages. This is because assurance of risk-free services can attract more users by improving customer's satisfaction, customer base, banks benefits and many more. It is now undisputed that customers are deriving several benefits from e-banking over their traditional way of banking. However, several negative and positive factors are significantly affecting the prospects of e-banking to its fullest. Accordingly, banks should work to eliminate the negative issue particularly perceived risk-factors by adopting the proposed VI e-banking provision, which can ensure a cashless society sooner than delaying.

The results of this study clearly show that age-group and education-level of customers have different preferences for enacting the proposed VI provision. Data were collected from two hundred respondents of rural and city areas in Bangladesh. It was used testing the mediated model using the hierarchical regression. The results supported the perceived-risk-factors and acted as a partial mediator in the relationship between various independent variables particularly psychological risk, trust, financial, performance, dispute, pin-fraud social/privacy-risk to dependent variable, customers' preference for VI provision in e-banking services. These findings can attract more users by significantly reducing "perceived risk" in e-banking services. Accordingly, policymakers of Bangladesh can play vital role

society for its better-ness when it come e-banking services. Since digital transactions are not insured under Bank Laws in Bangladesh, like in many other countries, the current effort is for bringing the findings to policymakers' attentions.

Since it is well accepted among today's policy-practitioners and official country-wise that e-banking serves so many benefits not just to bank itself but to humankind no matter where they reside, this study-findings can be inspirational for actions. This is because, the e-banking has been making finance economically possible in multi-faucets. They are: (i) Lowering operational costs of banks (ii) Automated process (iii) Accelerated credit decisions (iv) Lowered minimum loan size to be profitable and (v) Making the entire economy country-wise moving faster. These scenarios are no different in Bangladesh-economy even though over half of its population lives in rural areas where most of its populations are now covered with electricity and Internet facilitations. So, the proposed provision in e-banking services might be introduced eventually in Bangladesh-economy for the benefits of its society, which can be an example in world-economy country-wise.

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Hesiod on Scarcity

By Gregory T. Papanikos[*]

This study deals with Hesiod's most important economic contribution. He introduced and explicitly defined the concept of economic scarcity, relating it to the productivity of labor. The latter can be enhanced by an unbounded Prometheus (technology), which permits the exploitation of new materials such as iron. In this paper, a distinction is made between a static and a dynamic definition of scarcity. Related to scarcity is the debate on the etymology of the word "economics". In Works and Days, the word itself is absent, but, nevertheless, the word "oikos" is mentioned many times to clearly mean family business, which needs economic management within the institutionally-determined peace and justice. Without these two pre-conditions, the economies cannot flourish (grow).

Keywords: *Scarcity, Hesiod, Ancient Economy, economic growth, justice, peace, productivity of labor*

Introduction

Scarcity is defined as the lack of means of life. The opposite is abundance, i.e., more goods exist than needed. Hesiod understood the importance of scarcity in determining human behavior, clearly defined it and provided an excellent and unsurpassed metaphysical explanation of its existence, which, nevertheless, included a pragmatic way of mitigating its intensity. All of these are examined in this paper. Hesiod's discussion of the scarcity issue may be considered as his most important economic contribution. Papanikos (2022a) examines Hesiod's overall place in the economics literature. Scarcity is one of his important contributions that puts him at the beginning of the history of economic thought and economic analysis. Hesiod's clear definition of scarcity and its relationship to economic activities makes him the first known economist in the world.

Scarcity is, by definition, the economic problem of humanity. Hesiod not only provides, what I call, a static definition of scarcity, which most contemporary economists would feel comfortable with, but he also gives a dynamic definition of scarcity, which encompasses a continuum of the intensity of scarcity, which is demonstrated by three distinct categories: deprivation (famine, starvation), saturation (bliss point), and abundance. This dynamic approach entails comparisons across time of the same household, and most importantly comparisons between households across space and time.

All three of these possible categorical human conditions are analyzed in *Works and Days*, which includes both normative and ontological effects that these conditions have on the allocation of time in work activities, leisure time and

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idleness (laziness). Papanikos (2022b) presents, in detail, Hesiod's book, *Works and Days*, arguing that it is the first known economics textbook. At the individual level, Hesiod states that the scarcity problem can be solved by four means. Firstly, by stealing other people's products, i.e., those who sleep during the day so they can "work" during the night. Secondly, extort other people's property and goods by bribing the kings-judges or by lying and borrowing money/goods, which are never returned back. Thirdly, by begging. Fourthly, by working honestly and hard to produce what is needed. According to Hesiod, the last is the best solution in the long-run to the scarcity problem.

Thus, the scarcity problem can be solved when individuals become saturated (the exact word used by Hesiod is *κορεσσάμενος*[1]), and even better when their accumulated wealth is abundant, i.e., their warehouse is full of material goods. Further accumulation of wealth, beyond saturation, might be the result of either the subjective utility of wealth and/or as a result of the demonstration effect when an individual compares himself with others, such as neighbors, relatives and people of the same profession. Hesiod also has a theory of unhappiness because of the diminishing marginal utility of income (consumption), which can turn negative after the bliss point is reached.

In addition to his pragmatic analysis of the scarcity problem at the level of the individual, Hesiod's metaphysical explanation (Prometheus' fable and Pandora's jar) of the existence of scarcity also suggests that, at the level of humanity, the intensity of scarcity can be mitigated by applying technology (fire) to produce more goods and services and to discover new materials (iron[2]). Technology and new discoveries give hope. It is what is left inside Pandora's jar for the humanity to use in order to alleviate the intensity of the scarcity problem.

Hesiod has so far been vindicated. The history of the human race is the struggle against scarcity—ethical and unethical or legally and illegally. One can paraphrase Karl Marx and state that the history of all hitherto existing societies is the history of struggles against the intensity of scarcity. The class struggle is only one manifestation of these struggles and relates more to the distribution of the intensity of the scarcity rather than its overall mitigation. At the world level, the struggle against scarcity continues, especially as this is manifested by absolute poverty, malnutrition and the dire condition of the everyday living of billions of people. This is despite Prometheus being unbounded now. Unfortunately for billions of people, Prometheus has been unable to solve the deprivation manifestation of the intensity of the scarcity problem. Hunger, famine, starvation, child malnourishment and diseases still exist, or as Hesiod put it:[3]

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[1]The same word is used in modern Greek economic terminology to indicate "saturation", i.e., *κορεσμός*.

[2]Hesiod, in his economic history (Papanikos, 2022c), uses metals to identify the various historical phases of human development such as gold, silver, copper and iron. Hesiod lives in the iron race (age, epoch, period). However, even in this purely economic explanation of human development he adds something mythical-metaphysical, which is the race of heroes, i.e., those who fought in the battles of Troy and Thebes. My interpretation is that this insertion made his book more attractive to his listeners.

[3]Unless specified otherwise, I provide the English translation of the original text. By doing so I chose from the many meanings that a word has, the one which makes sense to modern day

but myriad other catastrophes for the people untold	ἄλλα δὲ μυρία λυγρὰ κατ' ἀνθρώπους ἀλάληται [100]

The moral of the story is that the war of the human race against Gods (searching for the truth and creating new knowledge) continues! After all, Prometheus was the first to challenge the Gods' power to hide the truth and look at them straight in the eyes (and minds) as equals. Since then, the human race is able to theorize and find out, through the acquisition of new knowledge, solutions to the myriad of human problems. Literally speaking, the word "theory" means, "I see God" and therefore I know what is known by God. Building theories, then, is like building ladders to reach Gods, i.e., to acquire new and useful knowledge.

Singer (1958) was the first to notice Hesiod's important and unique economic contribution to the scarcity issue. Gordon (1963) further developed Hesiod's exceptional scarcity idea by comparing Hesiod and Aristotle. As is the case with Homer, Aristotle has received much greater attention by contemporary economists even though, unlike Hesiod, he was not an economist. Gordon (1963) correctly pointed out that Hesiod was the first to define and analyze the scarcity issue as an economic problem. Aristotle did not. Unfortunately, Singer's and Gordon's papers have not motivated economists to change their views on the origins of the scarcity issue. Almost all economists consider Robbins (1932) as having invented the idea of scarcity. In this paper, Hesiod is considered as the genuine Prometheus while Robbins a pseudo-Prometheus. This predatory practice has happened many times in the history of scientific innovations.

In this paper, I argue that Hesiod's concept of scarcity is not only his most important contribution to economic analysis, but it is much better than Robbins's contribution, i.e., he explains more than Robbin's definition of scarcity. At least this is my reading. Hesiod clearly recognizes, as many economists do today, that people must "economize" because the means of life are scarce. Unlike contemporary economists who ignore the question, "why does scarcity exist?",[4] Hesiod gives his own metaphysical explanation; not only of its existence, but also of its intensity. The myth of Prometheus is a heuristic way of saying that the scarcity problem may be mitigated by technology and new discoveries.

Scarcity is not the same for all people living in different times and places. Hesiod's metaphysical story can be used to interpret his concept of scarcity as a dynamic one which relates the long historical trend of the scarce means of life to productivity of labor (technology) and to the satisfaction of an ever-growing number of human needs, taking into consideration the declining marginal utility of consumption. Therefore, there exists a point of saturation (*κορεσσάμενος*), or as economists call it, a "bliss point". Hesiod had developed an explicit theory of

economists. Unfortunately for the economic interpretation of Hesiod's work, classicists and philologists translate the text having in mind other criteria.

[4]Robbins (1932, p. 15) does make a note that, "We have been turned out of Paradise. We have neither eternal life nor unlimited means of gratification". This of course cannot compare with the Hesiod's Prometheus fable and Pandora's jar and the non-metaphysical hope this entails for future human races to mitigate the intensiveness of the scarcity problem as explained below in this paper.

diminishing marginal utility of income and wealth and applied it to the economic problem of scarcity.

Undoubtedly, the study of economics is the study of scarcity. Even the distributional aspects of economic analysis, which mainstream economists ignore, depend upon scarcity. On the other hand, the so-called radical economists failed to recognize that the greatest achievement of the contemporary economic system (or human race, to use Hesiod's term) has been its continuous ability to substantially mitigate the intensity of the scarcity problem. Hesiod wishes for such a world when he stated that he wanted to live in the future because better things can happen (along with bad of course). It seems that from the scarcity point of view, if Hesiod lived today, he would conclude that many good things have happened along with many bad; as is always the case, I may add.

Robbins (1932, p. 15), in an excellent paragraph, describes the role of scarcity in defining the subject matter of economics. I give here the full passage because it has many similarities to Hesiod's concept of scarcity:

> Here, then, is the unity of subject of Economic Science, the forms assumed by human behaviour in disposing of scarce means. The examples we have discussed already harmonise perfectly with this conception. Both the services of cooks and the services of opera dancers are limited in relation to demand and can be put to alternative uses. The Theory of Wages in its entirety is covered by our present definition. So, too, is the Political Economy of War. The waging of war necessarily involves the withdrawal of scarce goods and services from other uses if it is to be satisfactorily achieved. It has therefore an economic aspect. The economist studies the disposal of scarce means. He is interested in the way different degrees of scarcity of different goods give rise to different ratios of valuation between them, and he is interested in the way in which changes in conditions of scarcity, whether coming from changes in ends or changes in means—from the demand side or the supply side—affect these ratios. Economics is the science which studies human behavior as a relationship between ends and scarce means which have alternative uses.

Economic textbooks cite the last sentence as the definition of economics. Economics is not what economists do, **but the analysis of what people are forced to do when they are compelled by the scarce means of living.** I have chosen the word "force" because in many cases people, out of desperation and caused by the scarcity of the means of life, do things which go beyond what a civilized society would consider ethically and legally acceptable. At the individual level, this takes the form of theft and crime and other unethical behaviors, but at the polity (social) level it takes the form of wars (plundering) and injustice. Hesiod analyzes them extensively, but rejects all these alternative ways of solving the scarcity problem. He bases his arguments on ethical and realistic (historical) grounds as I shall show below in this paper.

Robbins is wrong in the above quotation when he stated that the war reduces the scarce resources from other uses. This is a static and short-run analysis. It does not take into consideration the distributional effects of a war. A dynamic historical analysis will show that staging a successful war increases the scarce resources available to be used for non-war purposes by the winner. The present value of a successful war far exceeds the present value of costs, including the initial costs of preparing for a war. A war (the use or the threat of violence) is one of many methods to acquire scarce means of life and has nothing to do with its many other

excuses in staging a war, such as the clash of civilizations or for the beauty of Helen in Homer's story of the Trojan War. If Troy was not where it is and the whole area was not providing the scarce means of living to the Greek city-states, I doubt very much if Greeks would have cared if Helen fell in love with someone from Troy and left her husband in mainland Greece.[5] In a nutshell, and contrary to Robbins' allegations in the above quote, after the successful war in Troy, the Greeks had much more means of life than before the war. Their war expedition had risks as all "investments" do. It is true that the Trojans lost not only their means of living but their lives as well. This is a distributional problem of scarce resources and economists like Robbins and many others like him ignore this fundamental economic solution to the scarcity problem. On the other hand, Hesiod did not ignore it.

My conclusion from reading history[6] is that the entire ancient history of wars (almost two millenniums) for which we have written information from the Trojan War up to the collapse of the Roman Empire, a long-lasting war is always a continuous struggle to acquire scarce means of life; they are wars against scarcity. Classical Athens of the fifth century BCE is the best-known case along with many other examples.[7] At the cost of overstating it, one may argue that the history of scarcity is the history of wars to "steal" scarce resources, primarily food and natural resources from other countries and people. The scarce resources (money) that poured into Athens after the successful battles against the Persian Empire in the early fifth century BCE were unprecedented. It created an Athenian empire, which by the continuous use of wars, attempted: (a) to mitigate the intensity of the starvation problem of the very poor Athenians by securing the importation of cheap food (grains) from all over the known world at the time; (b) to satisfy the cravenness for wealth of many individual Athenian citizens; and (c) to show off their wealth by building such masterpieces as the monuments on the Acropolis Hill.[8] This is exactly what Hesiod had predicted a few centuries before in his *Works and Days* and so eloquently have been told by the two great historians of the world: Thucydides and Xenophon. Robbins lived in a period when people knew and studied the ancient Greek sources (classical studies). It seems that he did not read it, or if he had read it, he did not appreciate the important implications of Hesiod's economic contributions. It seems that many contemporary scientists have started to look again at ancient (economic) history for inspiration, and most

[5]Gorgias (5th-4th Century BCE), in his masterpiece of *Encomium of Helen*, gives four reasons (God's will, use of force, love, and logos-soothing) why Helen was the innocent part of the Trojan War. Of course, Herodotus (5th Century BCE) also gives an excellent catalogue of the women who were allegedly the causes of wars (including Helen), but right away dismisses such an approach. Herodotus was writing history and not novels.

[6]In other works, I examined what history is as well as its other aspects, including how history can be used to assist in the implementation of economic policy; see Papanikos (2020a, 2006, 2005) and Papanikos and Pappas (2006).

[7]The most famous one is of course the *Peloponnesian War*, which has so masterfully been narrated by Thucydides in his 5th Century BCE book, including an excellent presentation of the pandemic which hit Athenians in the first year of the war; see Papanikos (2020b).

[8]This includes the temple of Parthenon with an unmatched economic cost. The cost was close to 500 silver talents which was equivalent to half of the annual revenue of the Athenian state. In today's Greece, the cost would have been at least 20 billion euro.

importantly to avoid not only the "Thucydides Trap", but also to take into consideration the Ancient Greek proverb: a wise man does not make the same mistake twice (*το δις εξαμαρτείν ουκ ανδρός σοφού ἐστί*), which allegedly was said by Meandrous.

The notion of scarcity is tautological to the concept of the economy. Without scarcity, the study of economics is useless. Without scarcity there is no need to economize; *φειδώ* is one of the verbs Hesiod uses which can be translated as being frugal, or as the fourth century BCE Greek scholars would call it, "do economy" or economize. This term has survived to the Modern Greek language, and if someone is good at being frugal, it is called, *οικονόμος*. This relates to the history of the adoption of the word "economics" by later writers. However, as Hesiod points out, the scarcity problem cannot be solved by frugality alone. The human race is "condemned" to work hard because of the threat of scarcity.

The above is an overview of Hesiod's contribution to scarcity and therefore to economic analysis. All the above issues are examined in this paper. The paper is organized into six sections, including this relatively long introduction. Section two discusses the static definition of scarcity, which appears in the contemporary economics textbook. Section three presents Hesiod's unparallel explanation of scarcity, which I call a dynamic definition of scarcity. Section four gives Hesiod's metaphysical explanation of why scarcity exists and how using technology can mitigate the intensity of scarcity. Section five discusses the issue of the concept of "economy", "economics" and "economize" in Hesiod's *Works and Days*. The final section concludes.

The Static Definition of Scarcity

Economics is the study of human behavior when they are faced with the harsh reality of material scarcity. Robbins is credited with giving the best definition of economics. It is based on his meaning of scarcity as was shown in the introduction above. The received view of his analysis of the meaning of scarcity in his well-known book, *An Essay on the Nature & Significance of Economic Science*, Robbins (1932, p. 15) stated that, "Scarcity of means to satisfy given ends is an almost ubiquitous condition of human behavior."

Just to note that the use of the word "almost" leaves room for exceptions because there are some human ends which cannot be satisfied by any allocation of scarce means alone. For example, one cannot buy God's love with scarce means (money), even though some religions have promised God's love if the worshipers donate (pay money) or even sacrifice their lives. Equivalently, you cannot buy someone's true love, including the love of your family members, using scarce resources alone or even by sacrificing your life. You may be able to "buy" their pity, but not their love. Also, you may buy people's pretense of loving you, and for many "consumers of love", this might be sufficient. Finally, and most important of all, one cannot always buy good health, and sooner or later the fate of any individual, rich or poor, has been predetermined by their own birth. Humans are mortals and this is independent of their wealth. In 2017, the last human being born

in the nineteenth-century died. Now it is the turn of the twentieth-century human race to start departing from earth! Hesiod emphasizes this throughout his work. This fatality of the human race underlies all his theory of economic history discussed in Papanikos (2022c). One may distinguish then, between material and non-material scarcity. It is only the material aspect of scarcity, which is the subject of economic analysis.

I call the above description of scarcity the static definition. The problem of scarcity becomes a mechanical dilemma which can be easily solved by linear programming. Every household can make its daily, monthly, annual and lifetime planning by allocating its past, current and future accumulation of scarce resources (income) to meet the infinite ends (consumption). Hesiod gives a full daily, monthly and annual calendar of all the activities necessary to create the means of life to satisfy human needs. This is the necessary, but a mechanical and a relatively easy solution to the scarcity problem. Nonetheless, I consider this static definition as a necessary starting point, but not sufficient to define the meaning of scarcity and therefore the totality of the subject matter of economics.

The static definition unnecessarily and unjustifiably restricts the rich field of economics because some economists have been infected by what I call a "monomaniac ideological framework". This disease has penetrated their "heart and soul" as Hesiod would have put it. There are many economists who suffer from "a phobia of distribution". They do not want to consider any economic analysis which touches upon the distribution of income and wealth, or what is similar, the interpersonal comparisons of utilities at the level of individuals, social classes and countries. Robbins went to great lengths in explaining why his definition of scarcity and the obvious fact of the diminishing marginal utility of income (wealth) should not be related to its distribution. Even though he relates scarcity to the law of declining marginal utility, Robbins, nevertheless, unsuccessfully attempted to refute the distributional implication of the law.

Hick's contribution in the 1930s called the ordinals "revolution", "liberated" economists from the need to analyze demand along the lines of declining marginal utility. My feeling is that he did not liberate them from their phobia of distribution. Robbins' publication of 1932 missed this "revolution". However, Hicks did not give a parsimonious answer to the same question, but restricted the domain of the question to be answered.[9] The difference is on the distribution of scarce means to satisfy the infinite ends. The Hicksean analysis of indifference curves cannot answer the following question: should economics examine whether society's welfare can increase if there is a way that income and wealth can be redistributed from rich to poor households without, however, reducing the total quantity of goods and services produced either today or in the future?[10] Is this an entirely

[9]Cooter and Rappoport (1984) provided an excellent overview of the difference between ordinalists and cardinalists.

[10]Hicks is credited as having invented the compensation principle, i.e., those who lose have the potential to be compensated by those who gain and are still left better off. This is a perfect (happy) society where the scarcity problem is solved with perfect harmony. It is like the perfect competition or the perfect (ideal) society of Plato. Their common characteristic of all these perfections is that they do not exist. Nevertheless, they have a tremendous value as yardsticks to be used to evaluate real world situations.

different issue not to be examined by economists? Some economists have responded that the issue of diminishing marginal utility of income (wealth) should not only be used for welfare (distributional) analysis, but it should be used to analyze individual human behavior of nonlinearities between wealth and "happiness". In other words, we are living in a world that some individuals have accumulated so many scarce resources that one additional unit makes them unhappy. A social (public) intervention to prevent such a conspicuous "market failure" of consumption will make these people happier. Of course, such an unhappy individual may, on their own, act in order to get rid of this excess "fat". Philanthropic actions are a characteristic example. It is not an accident that the super-rich of this planet have established their own philanthropic associations to help solve the scarcity problem of the world. Of course, economists are absolutely correct when they point out that vanity is an element of the utility function and this is satisfied when such associations bear the name of their founders, usually along with their wives/husbands.

The relatively new field of the economics of happiness demonstrates that there is a point where more income (consumption) makes people unhappy. This literature links utility, income and happiness to the idea of the relative income hypothesis which according to Clark et al. (2008, p. 100), "… can be dated back to at least Thorstein Veblen (1899), and then James S. Duesenberry (1949)."

The authors smartly mentioned "at least" which allows me to argue that Hesiod was the first to point this out. As stated in the abstract of their paper, "Income may be evaluated relative to others (social comparison) or to oneself in the past (habituation)." This is exactly what Hesiod's analysis does.

Relative comparisons bring the issue to the surface that Robbins and others have tried very hard to avoid: the intensity of scarcity is not the same for all individuals. In other words, it is one thing to allocate scarce means to satisfy infinite ends, but it is another thing to explain why the intensity of scarcity differs between individuals across space (geographically) and time (historically). Hesiod tackled this issue and gave some very interesting answers. His conceptualization of scarcity can be considered as being part of a dynamic explanation, which is examined in the following section.

The Dynamic Definition of Scarcity

Hesiod offers what I call a dynamic definition of scarcity. According to Hesiod, scarcity is the difference between what people want (ends) and what people have (means). As already mentioned, this defines three mutually exclusive states of human condition: (a) abundance, (b) saturation, and (c) deprivation – famine. These three words appear many times in Hesiod's *Works and Days*.

I have already mentioned that Hesiod uses the word *κορεσσάμενος* to describe the state of material saturation. Another word is *ἄρκιος*, which is translated as sufficient or satisfactory. Hesiod uses this term to draw the demarcation line between work and leisure. Spend time on leisure once you have secured sufficient means of life would be the recommendation of Hesiod and not otherwise. The best

word which describes the deprivation is *λιμός*, which is translated as "famine" in English; the same word is used in Modern Greek.

As for the word "abundance", there are many words which can identify a state of abundance. I have counted more than ten words in *Works and Days*. Some are mentioned many times in different parts of the text. At this state, people can derive pleasure from the simple accumulation of wealth, by giving to others or by entering into conspicuous consumption, of which Hesiod is not in favor; moderation and not demonstration is what he suggests. It should always be kept in mind that Hesiod, like Adam Smith, was on a mission: to make the world materially and ethically better.

These three human conditions can be objectively or subjectively defined. They differ from individual to individual. Abundance is defined when the ends are less than the means. In this case, people are wealthy (rich) with a lot of property and plenty of leisure time. Saturation is a state of human condition when the means of life suffice to satisfy all the ends (needs), including the need for leisure time. Deprivation is a state of affairs where individuals and their families starve and the means of life are not sufficient to cover their basic (biological) needs.

The extent of this difference between ends and means measures the intensity of scarcity, which is determined by a number of factors including:

(a) the individual time devoted to work and not to leisure/laziness;
(b) the previously accumulated wealth;
(c) the stability secured by peace and justice; and
(d) the uncertainty of life.

The latter Hesiod attributes to Gods because they are the ones who determine the "natural" phenomena, which affect the production and productivity of work, particularly in farming and seafaring. Thus, Hesiod does not blame only the individual as being responsible for his being destitute, but gives two other reasons attributing them to archons and Gods. Not hard work, but luck as well to be born in a good society without wars and injustices as well as Gods' blessings determines the intensity of scarcity. This issue relates very much to the recent discussion of political philosophy instigated primarily by the work of Sandel (2020), which considers that meritocracy is not so much the result of individual hard work, but the result of chance, which includes whether one was born into a rich or a poor family; in an advanced or less advanced politeia; raised during a war or peace period.

Hesiod suggests that the problem of scarcity must be solved only by hard and honest work with the spirit of fair competition between the various trades and artisans. Any current surplus should become accumulated property so that the future scarcity problem becomes less acute, i.e., the intensity of the scarcity is reduced by decreasing the ratio of ends to scarce means. Hesiod warns that cities cannot progress economically (do not produce more goods) and are in general non-sustainable in the very long term, if they attempt to solve their present scarcity problem by wars, plunder, theft and injustice. Sustainability is also included in the existence of the human race itself. The threat of extinguishing humanity is an

integral part of Hesiod's theory of economic history either by Gods' will or by self-destruction because of wars. The idea that the human race has created the means of its own destruction is as evident in Hesiod's works as it is today with the atomic bomb and climate change.

As already mentioned above, there were many states and races which relied on wars to solve their scarcity problem. As predicted by Hesiod, they disappeared from the face of the earth. Of course, there are many other civilizations (human races) which were able to survive, but they had to adjust to a fairer distribution of the means of life. This is the case with all western powers. Now they must share some of their power with the rest of the world if they want to avoid what was aptly called the "Thucydides Trap".

Hesiod discusses all three mutually exclusive human conditions mentioned above as I shall show below. Unlike Robbins' received view on scarcity, the dynamic concept of scarcity--defined as the difference between ends and means--was used by Hesiod to show: (a) the hard objective condition individuals face when the available means of life do not suffice to cover their basic needs (avoid starvation); (b) the need to accumulate any current surplus to avoid future deprivation of the basic means of life which may result in famine in addition to additional satisfaction people derive by accumulating wealth, or as Hesiod so wonderfully put it: if your soul or heart craves for more wealth; and (c) the subjective feeling of deprivation people experience when their social reference group (neighbors, relatives, economic and social class etc.) has higher means and therefore is able to satisfy more ends.

Points (b) and (c) are the dynamic elements of Hesiod's definition of scarcity, which are lacking from Robbins' definition of scarcity. A part of this dynamic definition of scarcity has been vindicated by the development of the relative income hypothesis and the demonstrative effect of consumption; see Arrow and Dasgupta (2009). However, the most important element of Hesiod's dynamic definition of scarcity is its relation to production (work time) and productivity of labor. The latter is related to technology (use of fire) and new discoveries (iron). Both issues are examined in the following two sections of this paper.

Work, Production, Productivity, Leisure and Laziness

Hesiod's concept of scarcity is related to the uncertainty (Gods' will) of life, but primarily to time allocated to work. It is work that increases production and adds to the accumulation of private wealth. In today's economic jargon, Hesiod suggests that people should maximize their income (wealth) from working hard, subject to the uncertainties of life. Hesiod is very clear on the allocation of individual time between work, leisure and laziness.

Scarcity and the Productivity of Labor

As I have mentioned above, the description of the three human conditions of severe scarcity (famine), saturation and abundance are everywhere in Hesiod's

Works and Days, but the best excerpt which clearly defines scarcity is the one that related it to the productivity of labor. Hesiod defined scarcity (actually, the lack of scarcity) as follows:

Because easily by working one day have for a year and idle be	ῥηιδίως γάρ κεν καὶ ἐπ' ἤματι ἐργάσσαιο, ὥστε σε κεἰς ἐνιαυτὸν ἔχειν καὶ ἀεργὸν ἐόντα [43-44]

Scarcity exists because the productivity of labor is not sufficient to produce what people need. In the above example, Hesiod's extremely high productivity of labor required only one day's work to satisfy all annual needs. This is the essence of scarcity according to Hesiod, i.e., the relatively low productivity of work. Robbins correctly points out that scarcity is a relative concept, but Hesiod shows why this is the case by integrating it into his definition of scarcity. At the limit, scarcity will stop to exist or will become less acute[11] when the productivity of labor will tend to infinity, i.e., people will not need to work, and they will be idle, or as Hesiod put it in the above passage, *καὶ ἀεργὸν ἐόντα*. The word *ἀεργὸν* means that there is no need to work to produce anything because everything will come almost for free like Hesiod's Golden Age as is further explained in Papanikos (2022c).

In the above excerpt, Hesiod does not blame only the individual for the existence of scarcity, but the low productivity. The low productivity is the result of the lack of technology as Hesiod explained in his metaphysical interpretation of the existence of scarcity, which is discussed in the next section of this paper. There existed an initial stage of human development in which people did not work because earth provided all they needed for free. This metaphysical explanation of the existence of scarcity leaves the door open for an optimistic outlook of the dynamic historical evolution of the intensity of the scarcity problem. Hesiod was optimistic about the future despite the hardships of his contemporary iron race. He writes:

Now the iron race exists; never a day without work-tiredness and pain, not a non-tormented night; hard Gods give concerns; but, however, mixed are the goods with bad.	νῦν γὰρ δὴ γένος ἐστὶ σιδήρεον• οὐδέ ποτ' ἦμαρ παύονται καμάτου καὶ ὀιζύος, οὐδέ τι νύκτωρ φθειρόμενοι. χαλεπὰς δὲ θεοὶ δώσουσι μερίμνας· ἀλλ' ἔμπης καὶ τοῖσι μεμείξεται ἐσθλὰ κακοῖσιν. [176-179]

The word *καμάτου* has survived into Modern Greek and means "tired from work", which is another indication of how scarcity can be overcome, i.e., with hard work and pain. In Modern Greek, the two Hesiodic words of *ἦμαρ* and *καμάτου* have survived as one word: *μεροκάματο*, which means "the daily wage

[11]I do not know any economist who will not consider starvation (famine) as an acute manifestation of the scarcity problem. They disagree on the proposed solutions. Some argue that it is a matter of the world distribution of food because the total production of food is sufficient to feed more than the entire world population and avoid episodes of famine and malnutrition. Some other economists argue that such distribution will result in less food for the future and therefore the famine problem cannot be solved by distribution alone. The best long-term solution is to increase production in the areas of the world which suffer from the acute manifestation of the scarcity problem by increasing the productivity of labor. I think on the latter solution, no economist would disagree.

rate". Hesiod believed that he lives in the Iron Age, mixed with good and bad. However, it is up to human beings to exploit the goods and avoid the bad. His optimism is expressed in the two preceding lines of the above passage when Hesiod wished that he was born after the Iron Age because it will be better than the current state of human economic affairs.

Hesiod developed another interesting theory about the productivity of labor. People should start their work as early as possible, at dawn, because it is during the dawn that one can do most of a day's work. Hesiod put it much better as follows:

Because the dawn's work provides one third of the day The dawn moves you on the road, and moves you on the work	ἠὼς γὰρ ἔργοιο τρίτην ἀπομείρεται αἶσαν, ἠώς τοι προφέρει μὲν ὁδοῦ, προφέρει δὲ καὶ ἔργου [578-579]

The words used by Hesiod reveal the economic depth of his thought. The word *ἀπομείρεται*, translated here as "provide", also means to distribute the production of what is destined (*αἶσαν*) to be produced in one day. This way, nature and metaphysics intermingle again. What one can produce in one day because of the uncertainly of life, especially in agriculture and seafaring, is a destiny determined by Gods, but taken this as given, human beings can get a bigger share of what is destined to them only if they start working early in the morning. This is a testable hypothesis whether the productivity of labor is higher early in the morning (at dawn) relative to the rest of the day. Actually, Hesiod's theory of the daily productivity of labor makes it one-third which is an empirical testable hypothesis; one of many that exist in his book of *Works and Days*. One may wonder how Hesiod came up with this number, one of the few which are cited in his book. Of course, his own experience provided the evidence for such claims.

Attitudes towards Work, Leisure and Laziness

Gods play only a partial role in what a man can produce on a daily, monthly and annual basis. The rest is determined by an individual's attitude towards work, leisure and laziness. Hesiod develops a theory which relates scarcity to an individual's own choices in allocating the scarce time among the three alternatives: work, leisure and laziness. He distinguishes the non-work time between laziness and enjoyment (leisure). He was against laziness, especially if people are faced with the severe manifestation of the scarcity problem as is demonstrated by starvation and famine. In this case, only hard and long work can solve the scarcity problem and avoid famine.

The important dynamic element of scarcity is the relation between works and ends. The higher the ratio of works to ends, the higher the manifestation of scarcity. And here comes the most important relation between the two variables: if leisure time is an end in itself, as Hesiod thought it was, then this ratio becomes complex (non-linear) because more work may not increase the satisfaction of ends, but reduce it, once a certain level of satisfaction (bliss point) is reached which includes the satisfaction derived from consuming leisure time. Contemporary economic analysis has made this an important determinant of an individual's co-

decisions between work-time and leisure-time. Hesiod understood this relation very well and there are many passages in his book that illustrated this negative relation between work-time (means) and leisure-time (ends). Early on in his book, Hesiod stated that the intensity of scarcity determines the time left for leisure/ idleness activities:

little time to waste in running around in the downtown (agora) has	ὥρη γάρ τ' ὀλίγη πέλεται νεικέων τ' ἀγορέων τε
he who has not stored in his house abundant means of life	ᾧτινι μὴ βίος ἔνδον ἐπητανὸς κατάκειται [30-31]

People must first bring to their house abundant (*ἐπητανὸς*[12]) means of life (food, clothes, etc.) before they start wandering around in the downtown of the city, i.e., in the agora. They must reach a point of saturation, *κορεσσάμενος*, with the means of life before they engage in other activities. However, reaching the stage of saturation requires a lot of hard work. Hesiod was very straightforward that with the current natural conditions, human beings must work as hard as they can in order to avoid famine (*λιμὸς*), reach saturation (*κορεσσάμενος*) and enjoy abundance (*ἐσθλοῖσιν πολέεσσιν*[13]):

But you always remember my order, work, Perses of divine race, so that famine becomes your enemy, befriended by the wreathed venerable Dimitra so that your storage is full of the means of life	ἀλλὰ σύ γ' ἡμετέρης μεμνημένος αἰὲν ἐφετμῆς ἐργάζευ, Πέρση, δῖον γένος, ὄφρα σε λιμὸς ἐχθαίρῃ, φιλέῃ δέ σ' ἐυστέφανος Δημήτηρ αἰδοίη, βιότου δὲ τεὴν πιμπλῇσι καλιήν [298-301]

Hesiod here clearly suggests that given nature, work and only work is the way to achieve abundance, or in his own words: if the warehouse (*καλιήν*) is not totally filled up (*πιμπλῇσι*) with the means of life (*βιότου*).

In this paragraph, it becomes obvious that Hesiod made a link between the metaphysical conditioning of scarcity and the human being's role in mitigating the scarcity problem by working. However, even this distinction between the destiny determined by Gods and the pragmatic recommendation to work hard is interdependent because the Goddess of Agricultural Production (food), Dimitra, loves people who work. This is not novel to only Hesiod's work. In one of the Aesop's fables, there is a sailor who, after a shipwreck, called upon the Goddess of Athena to save him without himself having to do anything (move his hands and swim). The Goddess told him, "I am with you, but move your hands" (*συν Ἀθηνᾶ και χεῖρα κίνει*). Some attribute this to Homer and others to Euripides. Hesiod made an economic theory out of this.

Thus, metaphysics go hand in hand with the reality of everyday life. If you work (move your hands and the other parts of your body), Gods will help you to produce more. Thus, work is to be praised and idleness to be condemned:

[12]As mentioned above, this is one of the many words Hesiod used to mean abundance. It can also be translated as "rich" and "sufficient".

[13]Another expression meaning abundance. *ἐσθλοῖσιν* means rich and *πολέεσσιν* means very much.

Work is nothing to be ashamed of, idleness is	ἔργον δ' οὐδὲν ὄνειδος, ἀεργίη δέ τ' ὄνειδος [311]

I translate the word *ἔργον* as work, but I think a better interpretation of the meaning of the word would have been "production" or "work-production". People's first priority is to avoid famine. There are many references in Hesiod's *Works and Days* about famine:

Think how you can find solutions to your needs and avoid famine	φράζεσθαι χρειῶν τε λύσιν λιμοῦ τ' ἀλεωρήν [401]

Hesiod suggested in such cases of desperation that hope is not sufficient to solve the acute scarcity problem:

Hope is not sufficient to feed a deprived man who seats in the clubs, when his means of life are not sufficient.	ἐλπὶς δ' οὐκ ἀγαθὴ κεχρημένον ἄνδρα κομίζει, ἥμενον ἐν λέσχῃ, τῷ βίος ἄρκιος εἴη [500-501]

In these cases, people must work and not waste their time in clubs[14] because laziness forces people to beg for their food:

Lest after you become poor in other people's houses beg and get nothing	μή πως τὰ μέταζε χατίζων πτώσσῃς ἀλλοτρίους οἴκους καὶ μηδὲν ἀνύσσῃς [394-395]

People must avoid laziness and napping if their means of life are not sufficient:

Avoid seating in shaded areas and napping During the harvest time when the sun burns the skin Run to bring the seeds into your house Walking up early in the morning so that your means of life are abundant	φεύγειν δὲ σκιεροὺς θώκους καὶ ἐπ' ἠόα κοῖτον ὥρῃ ἐν ἀμήτου, ὅτε τ' ἠέλιος χρόα κάρφει. τημοῦτος σπεύδειν καὶ οἴκαδε καρπὸν ἀγινεῖν ὄρθρου ἀνιστάμενος, ἵνα τοι βίος ἄρκιος εἴη. [574-577]

Hesiod makes the connection between famine and laziness:

Because famine always accompanies the idle man	λιμὸς γάρ τοι πάμπαν ἀεργῷ σύμφορος ἀνδρί [302]

He stated that despite what Gods have decided about an individual's future and chance, working is better:

Whatever is your fortune, to work is best	δαίμονι δ' οἷος ἔησθα, τὸ ἐργάζεσθαι ἄμεινον

[14]Hesiod made two references to the clubs (*λέσχῃ*), but gave no details. I assume that if someone's wealth is sufficient then he can visit these clubs and spend some of his leisure time. It seems to me that he is not against them in general, but only in cases which people have not solved their scarcity problem. The same word has survived in Modern Greek as well meaning the same thing.

[314]

Thus, the acute manifestation of scarcity which brings starvation and famine can be solved only with spending a lot of time to work and no time to leisure and/or be lazy. However, work not only solves the problem of famine, but it can make you rich with a lot of wealth if this is what you desire.

if your soul inside your mind craves wealth, do as I say, and one work after another work undertake	σοὶ δ' εἰ πλούτου θυμὸς ἐέλδεται ἐν φρεσὶν ᾗσιν, ὣδ' ἔρδειν, καὶ ἔργον ἐπ' ἔργῳ ἐργάζεσθαι [381-382]

And in another section of the book:

With works men get a big herd and become rich	ἐξ ἔργων δ' ἄνδρες πολύμηλοί τ' ἀφνειοί τε [308]

Once you have solved the problem of scarcity and your coffins are full of the means of life, then you can enjoy your life (leisure time):

to enjoy the means of life taken from inside your house thriving reaching the bright spring, looking without the others who will have your need	καί σε ἔολπα γηθήσειν βιότου αἱρεόμενον ἔνδον ἐόντος. εὐοχθέων δ' ἴξεαι πολιὸν ἔαρ, οὐδὲ πρὸς ἄλλους αὐγάσεαι• σέο δ' ἄλλος ἀνὴρ κεχρημένος ἔσται. [475-478]

Hesiod used another two words to show the utility individuals derive from consuming the means of life. I translate the word *γηθήσειν* as "enjoyment", which also means rejoice from consuming something; in this case here, by consuming the means of life (*βιότου*). Hesiod's reference to being taken from inside your house means from your accumulated wealth since this is an annual planning of production.

The second word "*εὐοχθέων*" is unique in Hesiod which is also another indication of the deep economic background of his analysis. I translated the word as "thriving" ("prosper" could be another word), but what it literally means is to enjoy yourself from consuming plenty of material goods without the need to toil and suffer.

Now it is leisure time. Hesiod gives an excellent description of an example of how to use and enjoy leisure time, which today can be described as a picnic in the countryside. It is worth citing here the full description (taken from West's English translation of *Works and Days*):

When the golden thistle is in flower, and the noisy cicada sitting in the tree pours down its clear song thick and fast from under its wings in the fatiguing summer season, then goats are fattest and wine is best, women are most lustful, but men are weakest, because Sirius parches their head and knees, and their skin dried out with the heat. Then you want rocky shade and Bibline wine, a milking cake and the goats' last milk, and meat of a scrub-grazes cow that has not yet calved, and of firstling kids. And after it you want to drink gleaming wine, sitting in the shade, having had the heart's fill of food, facing into a fresh westerly breeze. From a perennial spring that runs away and is unclouded pour three measures of water, and the fourth of wine.

Ἦμος δὲ σκόλυμός τ' ἀνθεῖ καὶ ἠχέτα τέττιξ
δενδρέῳ ἐφεζόμενος λιγυρὴν καταχεύετ' ἀοιδὴν
πυκνὸν ὑπὸ πτερύγων, θέρεος καματώδεος ὥρῃ,
τῆμος πιόταταί τ' αἶγες καὶ οἶνος ἄριστος,
μαχλόταται δὲ γυναῖκες, ἀφαυρότατοι δέ τοι ἄνδρες
εἰσίν, ἐπεὶ κεφαλὴν καὶ γούνατα Σείριος ἄζει,
αὐαλέος δέ τε χρὼς ὑπὸ καύματος• ἀλλὰ τότ' ἤδη
εἴη πετραίη τε σκιὴ καὶ βίβλινος οἶνος,
μάζα τ' ἀμολγαίη γάλα τ' αἰγῶν σβεννυμενάων,
καὶ βοὸς ὑλοφάγοιο κρέας μή πω τετοκυίης
πρωτογόνων τ' ἐρίφων• ἐπὶ δ' αἴθοπα πινέμεν οἶνον,
ἐν σκιῇ ἑζόμενον, κεκορημένον ἦτορ ἐδωδῆς,
ἀντίον ἀκραέος Ζεφύρου τρέψαντα πρόσωπα,
κρήνης τ' αἰενάου καὶ ἀπορρύτου, ἥτ' ἀθόλωτος,
τρὶς ὕδατος προχέειν, τὸ δὲ τέτρατον ἰέμεν οἴνου. [582-596]

I do not think that any English translation or an adoption to modern Greek can really present the beauty of this description of a picnic of three thousand years ago.[15] For example, the first line of the above excerpt Hesiod could have said simply, "in August", but instead gave a description of the month which is a scenario for a cinematic play. It is the best description of the month of August in Greece even today. It is really amazing for a village man like Hesiod to give such a description. Not only must people work hard to acquire the scarce means of life, but enjoy consuming them along with other pleasures that usually the scarcity of means cannot buy.

However, Hesiod was aware that human beings are insatiable. Abundance may not be sufficient for some individuals. They might want more and their surpluses can be used to buy other people's property. In this case, Hesiod suggested the accumulation of property by buying other people's property:

Then you can buy the property of others, and not the others yours

ὄφρ' ἄλλων ὠνῇ κλῆρον, μὴ τὸν τεὸν ἄλλος [341]

Here, wealth is indicated by the word *κλῆρον,* another economic term which has survived unchanged into Modern Greek. Why would individuals want to accumulate more wealth if they have solved their scarcity problem? Hesiod developed his theory of deriving pleasure from not only the consumption of goods and leisure time, but from the accumulation of wealth itself for its own absolute pleasure, as well as relative to their neighbors.

Hesiod explained very well the existence of scarcity, but he also gives a metaphysical explanation of why scarcity exists and a pragmatic way out of this, which comes from technology and new discoveries. The metaphysical dimension of scarcity is examined in the next section.

[15]This description of a picnic has attracted the interest of many classicists; see Bershadsky (2011) for a discussion of the Hesiodic picnic and the relevant literature cited.

The Metaphysical Origin of Scarcity

Economics is the science of scarcity which is a permanent characteristic of human existence. However, no economist has ever answered the question: why does scarcity exist?[16] I have not seen even a single hint in an economics textbook why scarcity exists. They assume its existence and then they try to explain how this affects or should affect the allocation of (rare) resources relative to needs. Hesiod's didactic textbook does better. Unlike modern economics textbooks, he offers an explanation of why scarcity exists which is an amalgam of good economic history and mythology. Hesiod stated what all modern economic historians accept: at an unspecified time period (most probably during the Neolithic period), men and women became food producers from food gatherers. Hesiod does not offer a non-metaphysical explanation of this important transition, i.e., some kind of innovation, population growth, climate change, invasions, civil wars etc. However, neither do modern economic historians. The "explanation" of settling down and the domestication of animals is not an explanation, but a definition of food production.

Hesiod's metaphysical explanation of the scarcity problem embeds a pragmatic solution. Technological advancements can mitigate the intensity of scarcity in the future—this is the hope left in Pandora's jar for the future human races to use, and this is what Prometheus' story of stealing the fire from Gods (discovery) symbolizes. Hesiod was optimistic that the future will be better. For the time being, people must work hard to get what was given to them with small toil or for free in the beginning. Also from Hesiod, the evolution of the human race is linked with the discovery of new resources such as iron. This issue is particularly important because it relates the metaphysical explanation of the existence and the intensity of scarcity to the realistic process of mitigating it.

Hesiod goes beyond these "natural" explanations of human behavior. He wants to explain why scarcity exists, but, most importantly, to explain how the human race can obtain more means to satisfy the undisputable fact of indefinite needs, if not at the individual level, definitely at the world level. Hesiod gave a metaphysical explanation in which embeds a pragmatic solution: technology. For the purpose of this paper, technology is defined as knowledge applied to a production process with an aim to reduce the intensity of the scarcity problem analyzed by economics (Papanikos, 1994).

Hesiod developed an unparalleled myth of Prometheus and Pandora which had a long-lasting effect on western thought. Four centuries after Hesiod's elegantly metaphysical explanation of the intensity of scarcity and its pragmatic solution through technology, the great dramatic play writer Aeschylus wrote a trilogy on Prometheus which unfortunately, only one survived. Aeschylus had Prometheus saying:

[16]Many economists confuse the definition of a concept with its explanation. Scarcity exists because the supply of goods and services is less than what people need. This is the definition of scarcity. The verb "exists" must be replaced with the verb "is". This is not an explanation (theory) of scarcity. However, this is not the only tautology in economics. The quantity theory of money is a tautology one because from an identity becomes, metaphysically, a functional (behavioral) relation.

All technologies for the mortals from Prometheus come — πᾶσαι τέχναι βροτοῖσιν ἐκ Προμηθέως [Aeschylus, *Prometheus*, 506]

Two comments should be made. I translated the Greek word *τέχναι* as "technology". It is a mistake to translate it as "arts". The etymology of the word Prometheus suggests forethought in the sense that one should study the things first. This way, technology requires knowledge. The discovery or the making of fire for productive use is not an art but a technology, and that's what Prometheus symbolizes then and now, i.e., the discovery of new things to make people's lives more comfortable.

More than two-and-half millennia later, Percy Bysshe Shelley in 1820 published his drama entitled, *Prometheus Unbound.* Of course, in economics Prometheus was used by David S. Landes in his book entitled, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*, first published in 1969.

To Hesiod it was clear that Prometheus was the personification of technology; the liberator of the human race from the intensity of scarcity. The legacy of Prometheus has been tremendous not only in the modern world, but in the classical world as well.

The myth has a very straightforward economic explanation. Humans' destiny is not in vain. They can mitigate the intensity of the scarcity problem. For Hesiod, in both in *Theogony* and *Works and Days*, Prometheus appeared as a thief who stole the fire from Zeus (Gods). Fire is equivalent to technology. However, why would Prometheus need to do something like this if all goods were in abundance? The story that during a sacrifice to the Gods, Prometheus tricked them by keeping the best pieces of the animal also violates the abundance hypothesis. Why would Prometheus need to pull such a trick if meat was abundant? A non-economic explanation of the beginning of the myth would have been better, but Hesiod did not provide one. For example, Hesiod he could say that Prometheus stole a beautiful mortal girl from Zeus with the help of all mortals (humans). However, this explanation was already used to explain the Trojan War. Instead, Hesiod used another story with a beautiful woman who brought scarcity and sickness to humans. Pandora was the vehicle through which Gods punished the mortals for their "stupidity" to steal the technology of making fire from Gods. However, it is clear that hope is what was left for the humans, and this hope can come by new knowledge which can be applied to improve the conditions of living.

Hesiod used Prometheus' story as a starting point that in the beginning there was abundance, but then Gods created scarcity by hiding the technology (fire) to retaliate because Prometheus deceived Zeus in the distribution of sacrificed animals. He made him choose one out of two packages and the one that looked better had only bones. I guess Zeus lacked the necessary foresight after all! If he had, he would have known that you cannot judge a book (present) from its cover.
Zeus got upset and retaliated against the entire human race by hiding the means of life: technology (fire). Or in Hesiod's own words:

But Zeus wrathfully hid them Because he was deceived by the crafty Prometheus	ἀλλὰ Ζεὺς ἔκρυψε χολωσάμενος φρεσὶν ᾗσιν, ὅττι μιν ἐξαπάτησε Προμηθεὺς ἀγκυλομήτης [47-48]

The first thing Zeus did was to hide fire, which I guess was considered the most important innovation of the human race. Imagine what would happen today if Gods were to hide all energy sources from humans. In Hesiod's own words, Zeus:

For this reason, he planned for people pernicious things by hiding the fire	τοὔνεκ' ἄρ' ἀνθρώποισιν ἐμήσατο κήδεα λυγρά. κρύψε δὲ πῦρ [49-50]

Prometheus, with a very illustrious description, stole the fire from Zeus. Gods then colluded to prepare the most destructive weapon for men: a very beautiful woman in appearance (a sexbomb in modern language), but a satanic mind. Zeus thought that this will destroy men because they are very weak and they will "embrace with tenderness their own destruction". Hesiod's description is really superb. He made Zeus say the following:

Instead of fire I will give them destruction, so that all will be happy in their heart by embracing their destruction	τοῖς δ' ἐγὼ ἀντὶ πυρὸς δώσω κακόν, ᾧ κεν ἅπαντες τέρπωνται κατὰ θυμὸν ἑὸν κακὸν ἀμφαγαπῶντες [57-58]

Then, Zeus called upon Hephaestus, the artisan/the handyman, to create a woman and then all other Gods gave her external and internal gifts, as these were requested by Zeus. The woman was called Pandora (all-gifted) because all Gods gave her gifts. Zeus's purpose was to seduce the men of the human race with her sexy appearance, but with an ugly soul and heart. I very much like Pandora's myth, but I do not understand why Zeus:

… then asked Athena to teach her the works, the assorted loom to waive	αὐτὰρ Ἀθήνην ἔργα διδασκῆσαι, πολυδαίδαλον ἱστὸν ὑφαίνειν [63-64]

The last thing a man would ask a sexy woman is whether she knows how to weave, unless in Hesiod's time this had a hidden sexual connotation. This is really a surprise, but my serious interpretation is that women were productive and Hesiod wanted to emphasize the role of women in this archaic division of labor.

I do not think that Hesiod himself was satisfied with this metaphysical explanation of scarcity, and for this reason he offered another one which has also received a lot of attention. Throughout the centuries it constitutes the backbone of his theory of economic history as I further explain in Papanikos (2022c). As with Prometheus and Pandora, his theory of economic history started with abundance.

Unfairness, Theft and Begging

Hesiod distinguished between ethical (good) ways of solving the scarcity level and immoral (bad) ways of acquiring the scarce means of living. At the level of the individual, Hesiod distinguished three ways of unethical acquisition of the means for living: injustice which favors one individual like Hesiod's brother, theft and begging. All three are examined here.

Injustice and Unfairness

Hesiod relates his ethical behaviour to Gods. Those who steal money are condemned, but those who make money in an honest way are much better.

Money should not be stolen, those which are given by Gods are much better.	χρήματα δ' οὐχ ἁρπακτά, θεόσδοτα πολλὸν ἀμείνω.
Even if violence is used to steal wealth or with lies, as many times happen, when profits deceive people's minds, and the shame is overcome by shamelessness;	εἰ γάρ τις καὶ χερσὶ βίῃ μέγαν ὄλβον ἕληται, ἢ ὅ γ' ἀπὸ γλώσσης λήισσεται, οἷά τε πολλὰ γίγνεται, εὖτ' ἂν δὴ κέρδος νόον ἐξαπατήσῃ ἀνθρώπων, αἰδῶ δέ τ' ἀναιδείη κατοπάζῃ•
easily Gods blacken him, diminishing their business.	ῥεῖα δέ μιν μαυροῦσι θεοί, μινύθουσι δὲ οἶκον [320-325]

I translated the above, using almost the exact words as Hesiod does. In these six verses, there are so many words which, then and now, have a sound economic meaning. The word *χρήματα* meaning "money" is used today in Modern Greek. The word *ὄλβον* means "wealth". The word *κέρδος* is used today to mean "profits", having the same meaning as three thousand years ago. The word *οἶκον* means in this context (family) business.

Hesiod considers that any society that is not ruled by justice alone will in the long term disappear as all races did in the past. This is well documented in his concise theory of economic history and his theory of economic growth. Individuals in such a society can use their power and money to bribe the judges and get other people's property and money. Hesiod described Perses, his brother, as such an individual, but, at the same time, he warns the basileis (who were the judges at the same time) to judge the economic differences between two individuals fairly and to not take bribes. Early on in his text Hesiod calls the judges "gift-eaters" (*δωροφάγους*) which is an excellent way to say that they are bribed by gifts:

… great tributes to the gift-eaters kings,	μέγα κυδαίνων βασιλῆας
who this way legal differences want to judge	δωροφάγους, οἳ τήνδε δίκην ἐθέλουσι δικάσσαι [38-39]

Hesiod makes an entire "lecture" [213-221] to his brother because injustice has no future and it is very difficult even for the kings-judges to bear, and impossible for a single individual to endure it.

This is the essence of Hesiod's practical moral philosophy. People must be good because this is not only what Gods like, but it seems to be the best long-term

strategy. My interpretation is not that Gods punish the injustice, but also the uncertainty of life creates such unexpected difficulties which an individual can bear easier with justice rather than injustice. Unlike many other religions and beliefs, Hesiod here seems to suggest that people pay for their injustice in this world during their current life and not in an afterlife stage. Thus, Hesiod stated that men who straight judge never face famine (*λιμός*):

Never with straight judges, men face famine	οὐδέ ποτ' ἰθυδίκῃσι μετ' ἀνδράσι λιμὸς ὀπηδεῖ [230]

However, there are many other excerpts where Hesiod mentions and condemns criminal (unjust) behavior. One must always keep in mind that Hesiod wrote the *Works and Days* in reaction to the unjust behavior of his brother and of the judges (basileis) of his time. He denounced violence:

And now pay attention to justice, and totally forget violence	καὶ νυ δίκης ἐπάκουε, βίης δ' ἐπιλήθεο πάμπαν. [275]

Unlike in the animal world, God has given justice to the human race, which is much better.

Gave justice to people, which is much better	ἀνθρώποισι δ' ἔδωκε δίκην, ἢ πολλὸν ἀρίστη γίγνεται [279-280]

Not only from a moral point of view is justice is better, but Hesiod developed a theory that in the long-term, injustice and criminal activities lead to the detriment of the future generations.

Hesiod continues to lecture his brother that good behavior is better than a criminal one. The latter might look better in the beginning, but there is nothing that compares with virtue.

Theft

He relates theft to the lack of means of life, i.e., individuals inflicted by scarcity. Hesiod relates this scarcity to laziness. Hesiod writes that,

The idle man who vainly hopes for the lacked means of life, bad thoughts come to his mind	πολλὰ δ' ἀεργὸς ἀνήρ, κενεὴν ἐπὶ ἐλπίδα μίμνων, χρηίζων βιότοιο, κακὰ προσελέξατο θυμῷ [498-499]

This is similar to what Solon, one of the seven sage men of the ancient times, said almost one century after Hesiod's *Works and Days*, which has survived until today: "idleness is the mother of all badness." I am sure Solon had read *Works and Days*, but nobody could tell that his apothegm was inspired by Hesiod's book.

Hesiod has an excellent description of the thief. He is an idle man who sleeps during the day so he can thieve during the night when the hard-working people of the day sleep. The thief enters into their houses and warehouses and steals their

valuables. Hesiod made a beautiful note of that in the following excerpt giving advice to honest people of how to protect their valuables.

and get a sharp-teeth dog, don't spare its food, just in case that the day sleeping man takes your valuables	καὶ κύνα καρχαρόδοντα κομεῖν, μὴ φείδεο σίτου, μή ποτέ σ' ἡμερόκοιτος ἀνὴρ ἀπὸ χρήμαθ' ἕληται [604-605]

I translated the word *χρήμαθ'* as valuables, but the word in Modern and Ancient Greek means "money". In *Works and Days,* it means more than that and may include all useful (valuable) things such as money, goods (food), any form of wealth (utensils, furniture etc.). The day sleeping man *ἡμερόκοιτος ἀνὴρ* is the thief.

Begging

Begging might work one or two times, but it cannot be sustained in the long term. The same can be said for theft and unfairness (injustice).

The idle men are similar to the drones in the bee world who steal the work of the bees which is unethical. Gods and people do not like such behavior.

Gods and people get upset with those who live without work	τῷ δὲ θεοὶ νεμεσῶσι καὶ ἀνέρες, ὅς κεν ἀεργὸς ζώῃ, [303]

However, Hesiod welcomed the good competition. He had a clear view that people derive utility from comparing their wealth to other people's wealth and work hard to surpass them. This is called by contemporary economists, the demonstration effect, as I have already mentioned.

Health and Scarcity

Hesiod's definition of scarcity does not include only the lack of means of life, but relates to health as well. Contemporary economists have developed indices to measure this dimension of scarcity of health. In that initial state of human race, people lived in abundance, they also lived without severe diseases, *νούσων τ' ἀργαλέων,* which resulted in death, *κῆρας.* A few lines below, Hesiod defined the lack of health and the existence of serious sicknesses, day and night:

Human diseases day and night hit people automatically bringing them many bad.	νοῦσοι δ' ἀνθρώποισιν ἐφ' ἡμέρῃ, αἳ δ' ἐπὶ νυκτὶ αὐτόματοι φοιτῶσι κακὰ θνητοῖσι φέρουσαι [102-103]

Leisure and Recreation Time

Good health is necessary to enjoy leisure and recreational activities as was demonstrated above. Assuming good health, they can enjoy the rest of their time off. Thus, scarcity includes the scarcity of work time as well. One day's work is

not sufficient, but as Hesiod explained scarcity manifests itself with the need of people to work hard all year long to provide the means of life.

However, if one has the means of life provided, then he has solved the scarcity problem and he can enjoy himself. Robbins has analyzed this reverse relation between work and leisure and (1932, p. 12) stated, "In the first place, isolated man wants both real income and leisure. Secondly, he has not enough of either fully to satisfy his want of each. Thirdly, he can spend his time in augmenting his real income or he can spend it in taking more leisure. Therefore, he has to choose. He has to *economize*. Whether he chooses with deliberation or not, his behaviour has the form of choice. The disposition of his time and his resources has a relationship to his system of wants. It has an economic aspect" (italics added). I emphasize here the word "economize" because it is very important in defining economics relevant to scarcity.

The Meaning of the Word *Οἶκος* in Economics

Scarcity defines economics as many economists learned from their introductory course. Is this all? Economics is what economists do! Since this is a tautology, I may paraphrase it and state that economics is what Hesiod did in his *Works and Days*! Hesiod did not use the word *oikonomia* which is a synthetic word from oikos and nomos. The word was used later by Xenophon and many others thereafter. On the same token, no ancient Greeks used the word "technology" which is a synthesis of the two words: technai and logos or ecology, which is the synthesis of oikos and logos. However, the word *technai* was used to mean what today is called technology as mentioned above. The protection of the environment was a priority in ancient Greece and especially in ancient Athens when it became too crowded, as many writings have mentioned the many laws created to protect the hygiene of the polis.

However, I would like to offer another interpretation of the word *oikos* (*οἶκος*), which appears so many times in Hesiod's *Works and Days*. I shall argue in this section that the word "oikos" (*οἶκος*) has many meanings; one of these is "business enterprise". Hesiod clearly stated that the purpose of the *οἶκος* (business enterprise) is to make profits (*κέρδος*) or money (*χρήματα*). The two Greek words – *κέρδος* and *χρήματα* – are used today in any contemporary Greek economics textbook. The Greek language has no other direct words to describe profits and money. Hesiod used exactly the same words, as shown below, with the same etymology, the same spelling, and the same intonation. Diachronically, economic jargon at its best!

Not only did the word "oikos" means "a business enterprise", but it also has survived into Modern Greek expressions such as "commercial enterprise" (εμπορικός **οίκος**), "publishing house" (εκδοτικός **οίκος**), "fashion business" (**οίκος** μόδας), "nursing home" (**οίκος** ευγηρίας), a "whorehouse" (**οίκος** ανοχής) and many others which denote any form of institutional economic association in general. Also, the word *οἶκος* stands for something more than a "house" or a "home" made of bricks and mortar. It means all the areas of the world that are

inhabited by people. For example, the word *οἰκουμένη* is an Ancient Greek word from ***οίκος*** and ***μένω*** (stay) meaning the entire known inhabited world, i.e., the universe or an ecumenical world. The latter can be translated with a twentieth century neologism of globalization.

Hesiod used the word *οἶκος* more than ten times in his *Works and Days* and in most cases, as explained below, the meaning of the word makes no sense unless it is translated as "business enterprise". Of course, as is even the case in Greece today, a business enterprise in Hesiod's period was a family business; not relatively small, but nevertheless a family business with all the common characteristics of such business enterprises. Hesiod is talking about a family business of the eighth century BCE, which is comparable with any family business in contemporary Greece in the same sector such as farming, stock-breeding, artisan (technai), artists, commercial seafaring, etc. A Greek family business, then and now, can be a very large company, not only according to Greek standards, but according to present global standards. Many Greek shipping companies that are at the top of the world are, strictly speaking, family businesses.

Hesiod uses another word to describe big business and gives an emphasis to the business meaning of the word, *οἶκος*. In line 377, he uses the word *ἐν μεγάροισιν*, which can have no other meaning, but to mean "a business estate". Hesiod did not mean a house with bedrooms, but the *οἶκος* with all the economic activities and capital of a family business that produced profits by using land, capital of all sorts, labor of all sorts, and managerial skills. They may also engage in trade (including dangerous seafaring) to make more profits and import goods not produced locally. How much better can a contemporary economist can put it, than Hesiod's clear statement of making profits from selling your produce abroad using seafaring:

And then the fast ship to the sea pull, with the freight inside	καὶ τότε νῆα θοὴν ἅλαδ' ἑλκέμεν, ἐν δέ τε φόρτον
Get ready to put to sea, so that in your business bring profits	ἄρμενον ἐντύνασθαι, ἵν' οἴκαδε κέρδος ἄρηαι [631-632]

It is clear from the above passage that the word *οἴκαδε* makes sense only if it is translated as a business enterprise irrespectively if it is a family business, which was the only type of business enterprises that existed in Hesiod's time and is still the dominant form of enterprise in the contemporary capitalist Greek economy.[17] Hesiod continues a few lines below giving his theory of economies of scale in seafaring (emporium):

The maximum the freight, the maximum the additional profits	μείζων μὲν φόρτος, μεῖζον δ' ἐπὶ κέρδεϊ κέρδος [644]

All words of this line you find in any general modern Greek economics textbook, and particularly an introductory textbook of the economics of shipping. The excellent expression, *ἐπὶ κέρδει κέρδος*, from the above passage means additional profits: "add profits to profits", which is the result of a larger freight

[17]This is the reason that I have argued in Papanikos (2015) that it is very difficult to handle tax evasion in Greece because there are so many small family businesses.

inside the ship. This is always true with shipping. Technology is the only constraint to building the largest possible commercial ships. Hesiod knew it.

It is interesting to note that commercial shipping is the number-one activity of contemporary Greek business people. All of them are family businesses, pretty much like in Hesiod's times. As a matter of fact, Greece has one of the highest percentages of the so-called independent (family) business in the world. I mention this because there is a strand of economic historians who claim that the ancient (Greek) economy cannot compare with the "capitalist" economies of the modern world. They are wrong. They reach these conclusions because they make the mistake to compare the wrong "spaces" or "ecumenies". Contemporary Greek capitalist economic activities look pretty much like Hesiod's period which differs from other advanced countries not in the objectives (profit and utility maximization), but in natural and institutional constraints. I can argue that contemporary Greeks follow this long tradition of organizing economic activities, at least if one looks at the Greek commercial shipping throughout the centuries, or if I may exaggerate, over all the historical millennia. One must be very careful and explain all factors that give rise to the characteristics of the Greek economy which tend to persist for so many centuries. In other words, the difference is not so much between economic systems (archaic or modern), but on natural and man-made (institutional) constraints.

Thus, Hesiod is talking about profits and money which can be made by engaging in economic activities taking place in the institution of a business enterprise called "oikos". As mentioned above, Hesiod used the word *οἶκος* many times. The first appearance is early on in line 23 when Hesiod is talking about the fair and unfair competition between the various professions (business). Hesiod's argument is that the fair competition is the one which forces people, assuming justice and peace (no violence), to compete in their economic activities (business) of farming, stock-breeding, building, wielding by copper and iron smiths, logging, entertaining, etc. As in any business, profits can be made with good management:

Your business well managed	οἰκόν τ' εὖ θέσθαι [23]

There is no question that Hesiod talked in this line about business enterprises (various economic activities). He gave the examples mentioned above to indicate what is meant by *οἶκόν τ' εὖ θέσθαι*; he definitely did not mean the utility bills of his family home because he talked on this in another occasion. Later on, Hesiod gave an excellent description how one must organize his farm business. In an informative passage he states:

In your business first get an ox to plough, a woman, not by marriage, so that she follows the oxen	Οἶκον μὲν πρώτιστα γυναῖκά τε βοῦν τ' ἀροτῆρα,
money have in the business everything must be prepared in advance	κτητήν, οὐ γαμετήν, ἥτις καὶ βουσὶν ἔποιτο,
in case you ask from others, they refuse, and you do not have	χρήματα δ' ἐν οἴκῳ πάντ' ἄρμενα ποιήσασθαι,
lost time, decreases your production	μὴ σὺ μὲν αἰτῇς ἄλλον, ὃ δ' ἀρνῆται, σὺ δὲ τητᾷ,
don't postpone for tomorrow and the day-after-tomorrow	ἡ δ' ὥρη παραμείβηται, μινύθῃ δὲ τὸ ἔργον.
because the man who works without profit does not	μηδ' ἀναβάλλεσθαι ἔς τ' αὔριον ἔς τε ἔνηφιν•
	οὐ γὰρ ἐτωσιοεργὸς ἀνὴρ πίμπλησι καλιὴν
	οὐδ' ἀναβαλλόμενος• μελέτη δὲ τὸ ἔργον

full his warehouse	ὀφέλλει•
nor the dilatory; diligence promotes production;	αἰεὶ δ' ἀμβολιεργὸς ἀνὴρ ἄτῃσι παλαίει.
always the neglectful man fights with losses.	[405-413]

The word *οἶκος* is mentioned two times in this passage and of course means a business enterprise, otherwise it does not make sense. Hesiod talked about a woman, and differentiates her from the woman-wife, which he makes a specific note that she is not your wife, but she will work in the fields along with the oxen. My interpretation is that Hesiod knew, as many men know today, wives rarely obey men. Given that he was against the use of violence in general, his suggestion makes perfect sense and many men should follow his advice if they want to have a happy family life. Presumably, if this was a self-sufficient small family farm, Hesiod's wife would work on the fields as is still the case today in Hesiod's village. However, Hesiod advises all men how to choose a wife.

The above passage gives solid business advice of how to increase production, make profits and reduce losses. Everything is in the management of *οἶκος* or the business enterprise.

The word *οἶκος* is also used to mean "family" and especially "family size". When Hesiod discusses injustice, he warns that Gods punish men and their societies as well as their families by making women not able to bear children:[18]

Nor women bear children, diminishing the household size	οὐδὲ γυναῖκες τίκτουσιν, μινύθουσι δὲ οἶκοι [244]

Hesiod talked here about the ecumenical world because the word *οἶκος* is used in the plural form. All households (*οἶκοι*) are affected by Gods' wrath who punish unjust societies. Now, the interpretation of the word *οἶκοι* is difficult because it can mean more than a family and it can include everything, particularly even their business. In a passage discussed extensively in Papanikos (2022a), Hesiod believed that more children are better because they can work in the family business enterprise (*πατρώιον οἶκον*), and in this way they can increase its wealth.

Only one child should be maintaining the family business	μουνογενὴς δὲ πάις εἴη πατρώιον οἶκον
Because this way wealth increases in the estate	φερβέμεν ὣς γὰρ πλοῦτος ἀέξεται ἐν μεγάροισιν.
Dying old another child must be left behind	γηραιὸς δὲ θάνοις ἕτερον παῖδ' ἐγκαταλείπων [376-378]

However, the same expression (*μινύθουσι δὲ οἶκοι*) is used in another passage which can also be interpreted as related to business.

Easily then Gods disgrace them, decreasing their business	ῥεῖα δέ μιν μαυροῦσι θεοί, μινύθουσι δὲ οἶκον
Only for short time wealth follows them	ἀνέρι τῷ, παῦρον δέ τ' ἐπὶ χρόνον ὄλβος ὀπηδεῖ [325-326]

[18]It should be noted that this line may be a later addition to Hesiod's *Works and Days*, but is consistent with what Hesiod described in this section.

The word *οἶκος* was used to describe the houses of the third race, which I interpret as it was used within the concept of universal or ecumenical description of the entire inhabited world:

Whom their weapons were made of bronze, of bronze were their houses	ὧν δ' ἦν χάλκεα μὲν τεύχεα, χάλκεοι δέ τε οἶκοι
They work with bronze; the black iron did not know.	χαλκῷ δ' εἰργάζοντο• μέλας δ' οὐκ ἔσκε σίδηρος [150-151]

However, Hesiod does use the word *οἶκος* to mean "home" (bedrooms and living room). He was very clear and explicit about this. In one occasion, Hesiod was discussing the climatic conditions and especially the cold and rain. He advises that once they do their work people should return to their home to be protected:

Once works are finished go to your home	ἔργον τελέσας οἰκόνδε νέεσθαι [554]

Here Hesiod made a clear distinction between the "space" of the work and the space of the home. These two spaces were not the same. Home is where people go to rest and sleep which is the meaning of the word *οἶκόνδε* here. Exactly the same word is used when Hesiod advised when the seafaring trade should be done, i.e., before the fall and winter so that the weather is good. Once you have done the seafaring on time, Hesiod recommended to return fast to your home to avoid the bad weather:

Bring to the sea your ship with all the freight put inside	ἑλκέμεν ἐς πόντον φόρτον τ' ἐς πάντα τίθεσθαι,
Run then fast again and to your home return	σπεύδειν δ' ὅττι τάχιστα πάλιν οἶκόνδε νέεσθαι [672-673]

Again, it is obvious the separation of the home-space and the business-space. People in the seafaring business make money travelling abroad so to speak and when they finish, they must return to the safety of their home.

The above analysis shows that the word *οἶκος* by Hesiod in *Works and Days* meant both the business enterprise, which uses factors of production to make profits and accumulate wealth, but, at the same time, it was used to mean home where one rests and sleeps. Pretty much like in Modern Greek

Conclusions

Scarcity defines economics as was pointed out by Robbins (1932). However, so thought Hesiod in the 8th Century BCE. Both explained scarcity as a phenomenon, without which there would be no need to do economic analysis or economize. The purpose of this paper was to show that Hesiod was not only the first to make scarcity the foundation of his economic analysis, but he did it much better than Robbins.

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UK Retailers and Plant-Based Alternatives to Meat and Dairy Products

By Peter Jones[*]

Plant-based alternatives to meat and dairy products are one of the fastest growing sectors within the food industry, and in the US some commentators have claimed that plant-based products are a key driver of sales growth for food retailers. This paper looks to explore if, why, and how, the leading food retailers in the UK were introducing plant-based alternatives to meat and dairy products to their retail offer. The paper reveals that the leading food retailers in the UK have highlighted plant-based alternatives to meat and dairy produce within their retail offer, and that a range of such products are available within their stores. Further, the retailers claimed to be introducing plant-based alternatives to meat and dairy products as part of their response to consumer demand and to health and environmental concerns. A number of illustrations demonstrate how plant-based alternatives to meat and dairy products are presented within stores

Keywords: *plant-based alternatives, sustainability, leading food retailers, UK*

Introduction

Plant-based food is one of the fastest growing sectors within the food industry. Deloitte (2019), for example, argued, that the *'global meat and dairy sector is currently going through an unprecedented level of competition and disruption, driven by the growth of viable plant-based alternatives across many categories'* , that *'gone are the days when plant-based alternative products were for the niche consumer and warranted limited shelf space'*, and that *'companies across the spectrum are now investing heavily in acquiring and creating new products and brands which will appeal to the surging consumer demand for plant-based products.'*

Within the US, the Good Food Institute (2022) has claimed that *'plant-based products are a key driver of sales growth at grocery retailers nationwide'*, and more specifically reported that *'retail sales data released April 6, 2021, shows that grocery sales of plant-based foods that directly replace animal products have grown 27 percent in the past year to $7 billion.'* With this in mind, this exploratory paper looks to explore if, why, and how, the leading food retailers in the UK were introducing plant-based alternatives to meat and dairy products into their retail offer. The paper includes an outline of the characteristics of plant-based foods, a brief literature review, an exploration of if, why, and how, the leading food retailers in the UK were introducing plant-based alternatives to meat and dairy products to their retail offer, and discusses some of the paper's findings and offers

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some reflections on the role of plant-based alternatives in promoting a transition to a more sustainable future.

Plant-Based Food

While recent years have witnessed an increase in the availability, and the popularity, of plant-based food, it is not a new phenomenon. Indeed, plant-based diets can be traced back before recorded history, in that early humans ate an exclusively plant-based diet before they began to hunt, transport, and prepare animals for consumption. However, the term plant-based seems to have been coined in 1980, and plant-based foods are generally classified into fruits, vegetables, legumes, grains, nuts and seeds. However, defining plant-based food is not straight-forward and the term plant-based is often used in association with the terms, vegetarian, vegan, and flexitarian and in some ways, consumers' understandings of the meaning of the term plant-based are evolving.

While there is no single accepted definition of the term vegetarian, it is usually used to describe a person who does not eat meat, poultry, fish or shellfish, or any of the by-products of animal slaughter, while lacto-ovo-vegetarians include dairy products and eggs in their diet. A vegan does not eat any products of animal origin, and vegans do not eat any dairy products and eggs, and many of them do not eat honey, as well as avoiding animal-derived materials such as gelatine or vitamin D3 supplements. The term flexitarian is often used to describe people who still consume meat and dairy products, but are looking to reduce their consumption levels.

The British Standards Institute (2020), suggested that *'many foods are labelled as 100% plant-based without a consensus on how that label should be used.'* Further, in an attempt to enable consumers to make informed choices, the British Institute established some simple criteria to define 100% plant-based food. Here the key components are that 100% plant-based foods *'contain no ingredients from animals'*, but that they can contain *'ingredients of neither plant nor animal origin, such as water or salt'*, and that the term applies *'solely to ingredients, and not to production and/or manufacturing processes'* (British Standards Institute 2020b).

While it is difficult to measure the total size of the market for plant-based food a number of estimates suggest that it is growing rapidly. Bloomberg Intelligence (2021), for example, reported that global sales of plant based dairy and meat alternatives reached $29.4 billion in 2020, and that the market could increase to $162 billion by 2030. Putting this figure into wider perspective, this would constitute only 5% of the total food market. Within Europe, Statista (2021) reported that during the period October 2019 to September 2020, sales of plant-based meat substitutes grew by 76% in Germany, 52% in Austria, 36% in the UK and 32% in Spain, though the corresponding figures for France and Italy were much lower at 9% and 1% respectively.

A number of forces are seen to be important in driving this market growth. On the demand side, the growth in plant-based foods has been driven by human health considerations, principally fears that the regular presence of red meat and

processed meat in the diets poses major health risks, a range of environmental concerns including, climate change, the pollution of watercourses, deforestation, and animal welfare issues, focused on the way animals are treated in modern intensive agricultural production systems. On the supply side manufacturers have extended both the range of ingredients and the product range of plant-based foods, to offer consumers more choice and new flavours.

Literature Review

Research on how food retailers have addressed plant-based alternatives to meat and dairy produce, and looked to incorporate them into their product ranges has been limited, but a number of themes, including, marketing strategies and consumer shopping patterns in store, customers' and retailers' perceptions of plant-based foods, and the overall nutritional quality of plant-based food and the nutritional quality of specific plant-based foods can be identified. As such this review provides an academic context and a set of reference for the paper. However, the work on plant-based food within retailing is fragmented and it currently lacks a coherent framework.

Gravely and Fraser (2018) examined the role of supermarkets in plant-based protein consumption in Canada, and more specifically they explored the contrasts between the supermarket's strategies for retailing plant-based products, and the consumer strategies when shopping for these products. The findings reveal that the supermarkets are simultaneously enabling and limiting consumers when it comes to alternative protein consumption by increasing the availability of plant-based options, but assuming basic strategies when it comes to marketing these products in-store. Further, the authors put forward a number of tactics which could facilitate greater uptake of plant-based protein products, including positioning plant-based meat and dairy substitutes on the same shelves as other meat and dairy products and devoting more resources to plant-based product promotions. The authors concluded that *'efforts to increase society's consumption of alternative protein products would greatly benefit from better understanding the supermarket's role in mediating this transition'* (Gravely and Fraser 2018).

In demonstrating how plant-based shopping, cooking and eating practices are enabled and shaped by material reconfigurations in Gothenburg, Sweden, Fuentes and Fuentes (2021) claimed that '*even though plant-based diets are increasingly common, and starting to become normalized, retail environments such as supermarkets are still usually organized according to a meat-based way of eating.'* Further, Fuentes and Fuentes (2021) argued that '*opting for a plant-based diet requires consumers to develop a plant-based mode of shopping in a socio-material landscape shaped and organized by a meat-based diet.'* Trewern et al. (2021) reported that retailers were experimenting with different approaches to positioning vegan/vegetarian ranges and alternative meat products, both in store and online, and that while some placed all these products next to each other, others segregated them in order to cater for both sets of customers.

Beacom et al. (2021), explored plant-based consumption and the motivations for it, in an online survey of over 400 plant-based and non-plant-based consumers in the UK and the Republic of Ireland. The authors found that the primary motivations driving the respondents' consumption of plant-based food were sustainability, health and animal welfare, while barriers to consumption of plant-based were that consumers not seeing a need to change their diet and taste. In conclusion, Beacom et al. (2021) suggested that in order to increase consumer satisfaction and frequency of purchase of plant-based foods, producers and marketers should adopt a market-oriented approach, that labelling on plant-based foods should include clear product information as well as information on the products' sustainability credentials, improvements to the sensory qualities of products, and that appropriate pricing and promotional strategies should be used to increase visibility.

Kopplin and Rausch (2021) looked to investigate the determinants of German consumers' attitudes towards plant-based foods and whether their dietary behaviour is of relevance for the attitude towards plant-based food substitutes. The study revealed that concerns for animal welfare had the largest effect on customers' discretionary behaviour, whereas environmental concerns and health consciousness did not impact dietary behaviour. That said the 1,400 respondents included in the investigation primarily consisted of female students and young professionals in the twenties, and the authors emphasised that the findings of their study need to be interpreted carefully.

Alessandrini et al. (2021) surveyed the nutritional quality of over 200 plant-based meat products available in 14 retailers in the UK. The author's results revealed that most plant-based alternative meat products had a more favourable nutrient profile than their meat counterparts, but that salt content of in plant-based meat products was high, and that manufacturers could improve the nutritional quality of these products by reducing their salt content. Tonheim et al. (2022) looked to assess and compare the macronutrient and salt content in plant-based meat and dairy substitutes available in three online Norwegian grocery stores, which represented retailers holding the majority of the total grocery market share in Norway. The results indicated that while the plant-based meat and dairy products on the Norwegian market varied in their nutritional composition, these products contained lower levels of saturated fats, that meat substitutes contained higher levels of fibre, and that milk and dairy substitutes contained less protein.

Zhang et al. (2020) conducted a survey of plant-based milk alternatives in Australian supermarkets and selected niche food retailers. Their results suggested that there was substantial variability in the nutritional content of plant-based milk alternatives compared with cow's milk, supporting previous works from other geographical locations, and they recommended prudent consumer selection to avoid potential issues with the reduced nutrient intake associated with substitution of cow's milk. Clegg et al. (2021) compared the nutritional content of plant-based alternatives to milk, yogurt and cheese with their dairy equivalents and the impact on nutritional intake when they are substituted into UK diets. The findings suggested that alternative plant-based dairy products may be useful as practical replacements for dairy products, but cannot be considered nutritional replacements.

Curtain and Grafenauer (2019) profiled and compared plant-based meat substitutes with equivalent meat products in four supermarkets in Sydney, Australia, and revealed that plant-based options were generally lower in total and saturated fat and higher in carbohydrate, sugars, and dietary fibre compared with meat.

In two studies based in the UK and Italy, Rondoni et al. (2021a and 2021b) investigated how both the egg industry, retailers, and consumers perceived plant-based eggs. Results from the first study (Rondoni et al. 2021a) suggested that manufacturers and retailers were sceptical that plant-based eggs replicated all eggs' nutrients and functionalities, and that there were uncertainties about how to label and name plant-based eggs, which had important marketing implications. The second study (Rondoni et al. 2021b) looked to elicit associations of consumers to three types of plant-based eggs, and the participants evaluated health, animal welfare and sustainability as the most important attributes of plant-based eggs.

Frame of Reference and Method of Enquiry

This paper looks to explore three simple research questions, namely, if, why, and how, the leading food retailers in the UK had introduced plant-based alternatives to meat and dairy products. To that end, the leading ten UK food retailers, by turnover, as identified by Retail Economic (2022), namely Tesco, Sainsbury's, Asda, Morrisons, Aldi, Co-op, Lidl, Marks and Spencer, Waitrose, and Iceland, were selected for study. Tesco, founded in 1919, is the UK's largest retailer, with some 3,400 stores and over 310,000 employees and it trades from hypermarket, superstore, and convenience store formats and increasingly online. Sainsbury's, Marks and Spencer, Morrisons and the Co-operative were founded in the nineteenth century while Aldi and Lidl, both German based discount retailers, who opened their first stores in the UK in 1990 and 1994 respectively, are relative newcomers to the UK's retail environment. Asda was founded in 1949, Waitrose, founded in 1901, is the food retail division of the John Lewis Partnership, while Iceland, which specialises in the sale of frozen food and prepared meals and vegetables, was founded in 1970. Taken together the ten companies dominate the food retailing market within UK, accounting for over 90% of all food sales.

Within this framework the author adopted a simple twin track approach to data collection. Firstly, an internet search, using the term 'plant-based products' and the name of each of the selected retailers, was conducted during February 2022 using Google as the search engine. Secondly, the author undertook a basic observational survey of the plant-based alternatives to meat and dairy products offered for sale in each of the selected retailers' largest stores in Cheltenham, a town with a population of some 115,000 in the South West of England. More specifically, a walk-through survey, based around combining structured visual observations was undertaken, and the authors recorded the plant-based items available in store, the shelf space devoted to them and any promotional and information material associated with them. The information gathered from the internet search and the store survey formed the empirical material for the paper. The author is aware of the limitations of the chosen approach, not least that it

draws on internet sources and a personal observation survey conducted in a particular space and at a particular time, and in that it does not look to collect primary information from retail decision makers, suppliers or customers, but he believes it to be fit for purpose in an exploratory paper.

Findings

On their corporate website, the majority of the selected retailers highlighted their plant-based alternatives to meat and dairy products, although the number and range of the products they reported having introduced varied. Rather than describe how each of the retailers' highlighted their introduction of plant-based alternatives to meat and dairy products, the aim here is to identify a number of general themes, including strategic business commitments to health and sustainability, the retailers responses to consumer demand, the listing of plant-based products, details of own brand plant-based ranges, and issues relating to accessibility and price. These themes are often interwoven as illustrated below.

In outlining the *'Waitrose Agriculture Plan'*, the John Lewis Partnership (2022), for example, recognised the impact of climate change on food production and the need to end farming's role as a key driver of greenhouse gas emissions, and emphasised the need to *'reduce our dietary reliance on meat and embrace more plant-based alternatives.'* However, while the company argued that *'there are no clear plans for how livestock farmers can adapt to these production changes with existing business models'***,** it claimed that *'Our Waitrose Agricultural Strategy will enable us to start facing a number of these challenges head-on and enable us to help create a more sustainable food system'* (John Lewis Partnership 2022).

Tesco (2022) reported its recognition that *'plant-based food had become one of the biggest culinary trends of the last decade'*, and that *'in anticipation of growing demand, we have been undertaking significant product innovation work in the area of plant-based and alternative proteins, both in developing and launching our Own Brand ranges and offering some of the UK's leading plant-based brands.'* Further Tesco (2022a) claimed *'we want to make choosing plant-based food as easy as possible. In many of our larger stores we have colourful displays of plant-based products in the meat and prepared food aisles, offering flexitarians an immediate alternative, as well as dedicated sections exclusive to plant-based products.'* In outlining its commitment to *'grow Asda plant-based sales by 100%'* by 2023, the company claimed it would *'continually engage with and support initiatives to address the UK's nutrition and obesity challenge.'*

In addressing consumer demand, Marks and Spencer (2022) reported *'to meet the growing demand for meat alternatives, and also support customers exploring plant-based eating….. M&S is expanding its popular Plant Kitchen range with some delicious new additions all benchmarked for taste against their meaty counterparts.'* The company claimed that *'our Plant Kitchen range means you'll never have to compromise on taste. Expertly developed by our chefs, every product is rigorously benchmarked so it tastes just as good or even better than its meat or dairy counterpart'* (Marks and Spencer undated).

The majority of the selected retailers listed their plant-based alternatives to meat and dairy products, sometimes combined with their listings of vegan products, and some highlighted their own brand plant-based ranges. Sainsbury's, (2022), for example, listed 781 vegan and plant-based products, and Asda (2022) listed 60 plant-based products, while Tesco (2022b) invited customers to *'discover hundreds of plant-based products.'* More specifically, Aldi (2022) advertised its own label *'Plant Menu'* products as part of its *'Vegan Range'*, with the message *'we'll show you how easy it is to make a plant-based diet tasty and exciting!'* Sainsbury's (undated) listed 31 products in its *'Plant Pioneers'* range, including *'Plant Pioneer No Duck Spring Roll'*, *'Plant Pioneer No Prawn Toast'*, *'Plant Pioneer No Steak Bake'*, and '*Plant Pioneers Chocolate & Caramel Pots.*'

The Co-op (2021a) reported that one of the *'5 steps we've taken towards our sustainability ambitions'*, was *'cutting the price of our GRO range to make the plant-based choice more affordable'*, and more specifically, the Co-op (2021) claimed *'we don't think people should be priced out of eating plant-based. So, this year we cut the price of our vegan GRO range to match its meat and dairy counterparts. Whether you're vegan, vegetarian or just looking to introduce more plant-based foods into your diet, we want to make it easier for you to do that.'* The Co-op (2021b) also claimed that it was the company's *ambition to make our plant-based range, GRO, even more accessible to our members and customers, helping them make decisions that collectively will have an impact on the world we all share. Emissions from our operations and our own-brand products are where we have the greatest responsibility and can make the biggest difference.'* Morrisons (2021) claimed *'we continue to make plant-based products more accessible to our customers and have expanded our plant-based offer, increasing our V Taste range by 50%.'*

The store survey revealed that all ten of the selected retailers had introduced plant-based alternatives to meat and dairy products as part of their offer, and while the scale and range of plant-based products varied between retailers, they formed a small proportion of overall retail offer in all stores. Once again, rather than describing the plant-based range within each of the selected retailers' stores, the aim here is to identify a number of general themes, as illustrated below, A number of the retailers carried their own plant-based brands. Tesco's *'Plant Chef'* products, for example, included *'Roast Vegetable'* sandwiches, *'Houmous Harissa'*, *'Mushroom and Fettucine Pie'*, *'Mushroom Pizza'*, *'Meat Free Southern Fried Chicken'*, *'Lincolnshire-Style Cocktail Bangers'*, *'Meat Free Cottage Pie'*, *'Pistachio Mousse'*, and *'Chocolate Orange Cups.'*

In a similar vein, the Marks and Spencer's *'Plant Kitchen'*, range included *'No Chicken Kiev'*, *'No Beef Burgers'*, *'Green Thai Curry'*, *'Woodfired Hot and Spicy Pizza'*, *'Chocolate and Raspberry Ripple Ice Cream'*, and *'Sticky Toffee Pudding.'* In Morrisons' *'Good To Go'* section, *'Plant Revolution'* products included *'Falafel and Spicy Houmous Wrap'* and *'No Chick Shawarma'*, while elsewhere in the store the range included *'Charred Corn and BBQ Jackfruit Pasta'*, *Butternut Coconut Curry'*, *'Vegetable Paella'*, *'Sweet and Sour No Chicken'*, and *'No Chick Southern Fried Chicken'*. The Sainsbury's store stocked a number of *'Plant Pioneers'* products, including *'No Chicken Kiev with Sticky*

Rice', *'Lasagne'*, *'Fishless Fingers'*, and *'Cumberland Shroomdogs.'* All own brand products prominently display their brand name, and the packaging of some the selected retailers' own brand plant-label products have a distinctive colour. The Marks' and Spencer *'Plant Kitchen'* packaging, for example, has a distinctive green/blue colour, while some of Sainsbury's individual own label *'Plant Pioneer'* products are packed on the store's shelves in small green cartons.

At the same, some stores also stocked other brands of plant-based products. Alpro's oat, soya, and coconut alternative milk drinks, for example, were stocked by most, though not all, of the selected retailers. Other proprietary plant-based brands were available in some of the selected retailers' stores. The Sainsbury's store, for example, stocked *Fry's* brand, *'Lightly Seasoned Chicken Style Strips'*, *'Smoked Hot Dogs'*; *'This'* brand's *'This Isn't Bacon Plant Based Rashers'*, *'This Isn't Pork Meat Balls'*, *'This Isn't Bacon Lardons'*, and *'This Isn't Chicken Pieces'; 'Beyond Meat'* brands of *'Beyond Meat'*, *'Beyond Meatballs'*, and *'Beyond Mince'*; and the *'Garden Gourmet'* brand *'Sensational Plant-Based Cumberland Sausage'*, and *'Plant-Based Mince.'*

In some of the selected retailers' stores shelf edge labelling and occasionally more prominent signage was used to direct shoppers' attention to plant-based alternative meat and dairy products. In the Marks and Spencer store, for example, an eye-catching plastic sign projected out from the shelves into the aisle, and carried the twin messages *'Our Plant Kitchen Range Makes Eating More Sustainable and Truly Delicious'*, while a shelf edge label carried the message *'Eat More Sustainable Plant-Based Food In Your Diet With Plant Kitchen.'* In the Asda store above the in-store kitchen, a large sign advertised *'Plant Based Street Food'*, and the plant-based products on sale included *'Spicy Veggie Roll'*, *'Coconut Hosomaki'*, and *'Edaname.'*

Within the selected retailers' stores, plant-based foods were positioned in two ways. Firstly, some plant-based products were positioned on shelves close to their meat and dairy counterparts but not side by side on the same shelves as meat and dairy products. In, Sainsbury's for example, both the *'Plant Pioneers'* brand *'Slightly Salted Alternative Butter'*, and the plant-based butter from the proprietary brand *'Flora'*, were on shelves adjacent to the traditional ranges of butter and spreads. In the Marks and Spencer store, *'Crackd'* the *'No Egg Egg Replacer'*, described as being designed *'to create scrambled egg, Yorkshire pudding and great pancakes'*, was positioned next to the conventional eggs. Secondly, in some of the selected retailers' stores were grouped together in dedicated chiller and freezer cabinets. In the Tesco store, for example, a number of plant-based dairy alternatives, including *'Chocolate Dessert'*, *'Pistachio Mousse'*, *'Caramel and Chocolate Little Pots'*, and *'Chocolate Orange Cups'*, were positioned together in a dedicated chiller cabinet, and in the Aldi store a freezer cabinet was given over to plant-based products including, *'Yellow Thai Curry'*, *'Onion and Rosemary Sausages'*, and *'Indian Inspired Curry.'*

Discussion

The findings reported above provide responses to the paper's three simple research questions of if, why, and how the leading UK food retailers are adding plant-based alternatives to meat and dairy products to their retail offers. Firstly, the majority of the selected retailers highlighted their introduction of plant-based alternatives to meat and dairy products and evidence collected in the observational survey of all the retailers' stores revealed that the plant-based alternatives were being added to their retail offer by the leading food retailers in the UK. Secondly, information drawn from the selected retailers provided some insights into why these retailers were adding plant-based alternatives to their retail offer. Thirdly, the information drawn from both the retailers' websites and the observational survey, provided a number of illustrations of how the leading food retailers have added plant-based alternatives to meat and dairy products to their retail offer.

In responding to these three research questions the findings suggest that the leading UK rood retailers are following their US counterparts in adding plant-based alternatives to meat and dairy produce, and that in doing so, there are some indication that leading food retailers were responding to consumer demand, and to health and sustainability concerns, though concerns about animal welfare were conspicuous by their absence. The results from the store survey would seem to be consistent with Trewern et al.'s (2021) findings that supermarkets were experimenting with the placing of plant-based meat and dairy alternatives, in that in some stores plant-based products were found adjacent to their meat and dairy counterparts while elsewhere plant-based alternatives were in dedicated cabinets and on separate shelves. At the same time, Beacom et al.'s (2021) recommendations that a market-oriented approach should be adopted by retailers can be seen to reflected in part, in the signage and labelling of plant-based alternatives to meat and dairy produce in the majority of the stores surveyed. That said, promotional strategies designed to increase visibility and the provision of information on the sustainability credentials the plant-based alternatives to meat and dairy produce, as also recommended by Beacom et al. (2021), were generally much more limited at the store level.

More generally, the issues of sustainability and plant-based alternatives to meat and dairy produce is contested. On the one hand, the conventional view is that intensive animal farming *'may be the most environmentally damaging industry on Earth'*, and as *'a major threat to global sustainability'* (The Global Food Institute undated), any substantial move to a more plant-based diet should be seen as a contribution to a more sustainable future. Alae-Carew et al. (2022), for example, argued that 'a *global transformation towards sustainable food systems is crucial for delivering on climate change mitigation targets worldwide. In high- and middle-income settings, plant-based meat and dairy alternatives present potential substitutes for animal sourced foods, and a pathway to transition to more sustainable diets.'*

On the other hand, while Lusk et al. (2022) recognized that plant-based meat alternatives could have significant economic, environmental, and animal welfare

impacts if they replaced traditional animal-based meats and reduced the demand for livestock production, they called such a scenario into question. More specifically, Lusk et al. (2022) constructed, and calibrated, an economic model to estimate how a reduction in the price of plant-based alternatives, or an increase in demand for such alternatives, would affect cattle production in the US. Their results suggested that shifts in the prices of, and the demand for, plant-based meat alternatives, would have *'minor environmental and climate benefits.'*

Further, and drawing more on politics, and political economy, than economics, Clay et al. (2020), demonstrated how plant-based milk companies *'inherit and strategically deploy positive framings of milk as wholesome and convenient, as well as negative framings of dairy as environmentally damaging and cruel, to position plant-based as the better alternative.'* Clay et al. (2020) argued that *'by encouraging consumers to reach for plant-based as a way to cope with environmental catastrophe and a life out of balance'*, producers of plant-based milk alternatives are promoting *'a neoliberal ethic'* and that *'they individualize systemic problems and further entrench market mechanisms as solutions, thereby reinforcing the political economy of industrial agriculture.'*

More generally, Clay et al. (2020) suggested that plant-based milk alternatives *'provides a window onto the broader trend of plant-based food'*, and Clay et al. (2020) argued that as plant-based meat and dairy products increase and diversify, so it *'is crucial to consider how they might enable more democratic food futures'*, and that a shift to *'fexitarianism presents a potentially open, inclusive, and democratic form of consumption that could drive food system change in just and sustainable ways.'* Further, Clay et al. (2020) suggested that it is important to explore different pathways to plant-based diets and argued that plant-based milk alternatives can be made within the home, that food products so produced *'can give rise to environmentally beneficial, socially just, ethical, and nutritious ways of feeding people*', though *'assuring that they do, requires attention to processes of production, distribution, and consumption.*'

Conclusion

This paper has outlined if, why and how, the leading food retailers in the UK, have added plant-based alternatives to meat and dairy products to their retail offer. The paper revealed that the leading ten food retailers in the UK had highlighted the plant-based alternatives to meat and dairy produce within the retail offer and that a range of such products were available within their stores. The retailers claimed to be adding plant-based alternatives to their retail offer as part of their response to consumer demand and to health and environmental concerns. A number of illustrations demonstrated how plant-based alternatives to meat and dairy products were presented within stores. This exploratory paper it has its limitations, as outlined earlier, and it does not seem appropriate to conclude with any managerial recommendations, rather the paper can perhaps best be seen offering a mirror which can offer retailers a preliminary opportunity to reflect on the addition of plant-based alternatives to meat and dairy produce, to their retail offer.

At the same time, the paper provides a platform for a wide range of future research agendas. At the corporate level, research might be undertaken with senior retail executives to help to develop greater understanding of the forces driving food retailers to introduce plant-based alternatives to meat and dairy products, to examine how food retailers are developing new relationships with suppliers to introduce new plant-based ranges, and to explore how and why decisions are made on the positioning of plant-based alternatives vis-à-vis their traditional counterparts within stores. There are also research opportunities at store level which might include work on if, and how, store managers were experimenting with the positioning of plant-based products, and on how the impact of positioning on consumer buying behaviour was monitored and evaluated, and examining the staff training and development programmes designed to enhance, both employee and customer awareness of the benefits of plant-based alternatives to meat and dairy products. At the consumer level many research questions arise but two provide an illustration of possible research agendas. What are customer's motives in looking for, and buying, plant-based alternatives to meat and dairy products? To what extent does a price differential between plant-based alternatives to meat and dairy products and their traditional counterparts, influence buying behaviour.

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Demand Models, Revenue Curves and Profit

By Moshe Eben-Chaime[*]

In this short paper some common conventions regarding revenue curves are questioned and revenue is contrasted with profit. It turned out that obeying the law of demand – non-increasing demand function, is insufficient to characterize the revenue curve. Non-increasing demand function may result in increasing and/or decreasing revenue curves, concave and/or convex revenue curve and even curves with multiple local extreme points. Fortunately, a sufficient condition is found, which enables to better characterize the revenue curve. Based on this result, it is shown that the quantity that maximizes the profit differs from the quantity that maximizes the revenue. Further, the difference can be substantial and the profit is more sensitive to quantity changes than the revenue.

Keywords: *demand, revenue, profit, firms*

Introduction

Economists "think of the economic system as being coordinated by the price mechanism" (Coase 1937). This price mechanism associates quantities with prices and is stabilized at a price in which an equilibrium is reached between demand and supply. Revenue is the multiplication of the price times the quantity sold and is expressed as a function of the price. The provision of products, including services, involves costs. Consequently, a necessary condition for the survival of a provider, in the long run, is that the total cost does not exceed the revenue. Of course, providers aim not at survival but at profit maximization – maximizing the difference between the revenue and the total cost. Firms are providers, of products and/or services, and as Coase (1937) noted "the distinguishing mark of the firm is the supersession of the price mechanism." This is because: 1) the price mechanism does not account for the costs and 2) the costs are independent of the retail price. Nevertheless, firms, and providers in general are affected by the price mechanism through the revenue. Accordingly, there is a need to integrate firms' coordination with that of the economic system. In previous studies, either specific demand functions are assumed or certain assumptions are made about the revenue curve without specifying a demand function. In many studies the profit is maximized but in other studies the revenue is maximized. In this note the revenue curve and its relationship to the demand model are examined. Some surprising observations lead to a more careful definition.

Other central issues are the schedule of the decisions and the decision variables. The decision variables are prices and quantities – providers should decide how much to offer for sale and at what price. However, there is often a long-time leg

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between the decisions; e.g., when products are shipped by sea transport from overseas, or, and even to a larger extent, when infrastructure has to be built or expanded. Further, the selection of quantities often has a substantial ramification, regarding costs, in particular. Prices are set long after, when the quantities and the consequences of their selection can hardly be changed, if at all. Hence, quantities' determinations are no less significant and there is a need to understand their implications.

The paper is organized as follows. In the next section, relevant literature is briefly reviewed. Then, the revenue-demand relationships are examined and discussed, profit is considered in the fourth section and conclusions a direction for future research are offered in the last section.

Literature Review

As noted, the revenue, which is a major determinant of providers' profit, connects providers with the economic system. The price mechanism coordinates the economic system by associating the demanded quantity with the price, whose product: price times the corresponding demand, is the revenue. The simplest and most common approach to model the revenue is to assume a specific demand model and the most popular demand model is a linear function. So popular that one wondered: "I never understood as a first-year student why we called the demand curve a "curve" when it was a straight line"[23]. The popularity of the linear demand function in the literature is also prominent; e.g., in Crockett (2013), in the surveys of Huang et al. (2013), Aust and Buscher (2014) and Kumar et al. (2016) and in more recent studies, e.g., Huang et al. (2016), Duan and Ventura (2020), Bos and Vermeulen (2021), Hauck et al. (2021) and Li and Liu (2021). The linear model is popular because it is simple. Choi (1991) noticed the difficulty to derive analytical results with nonlinear models. Similarly, Huang et al. (2013) explain this use of the linear models, because it gives rise to explicit results and it is relatively easy to estimate the parameters. Oddly enough, Desiraju and Moorthy (1997) drew a non-linear function in their introduction, but diverted to a linear function in the analysis that follows. However, Choi (1991) showed that many results reverse when the linear demand is replaced by nonlinear functions, while Lau and Lau (2003) showed that slight changes in the demand curve could lead to significant changes in optimal solutions. Further, Huang et al. (2013) noted that in most practical cases the assumption of a linear demand function does not correspond to reality. Hence, in this study, the linear function is avoided. Other models include the power and exponential functions. Duan and Ventura (2020) criticized the linear, power and exponential demand functions and proposed the logit function as an alternative.

Another approach is to make certain assumptions about the revenue curve without specifying a demand function. Zusman and Etgar (1981) assumed that, "in the range of the analysis", the revenue curve's first derivative is positive while the second derivative is negative. Namely, the curve is increasing and concave.

[1]https://econ101help.com/why-is-the-demand-curve-a-straight-line/.

Besbes and Zeevi (2009) assumed that the revenue function is concave. While this approach enables profit maximization, it is often used to maximize revenue only, e.g., Besbes and Zeevi (2009, 2015).

In the next section, the concavity assumption of the revenue curve and its aptness to popular demand model are examined and in the section that follows, the profit function is examined.

Demand and Revenue

The *law of demand* (Marshal 1892), namely, the demand $D(p)$ is non-increasing in the price, p, is a convention. In addition, it is explicitly assumed that both the price and the demand are non-negative. When it comes to the revenue curve, concavity is commonly assumed. To a lesser extent, but still common is the assumption that the demand is an invertible function of the price. While Besbes and Zeevi (2009) proclaimed that "These assumptions are quite standard in the revenue management literature …", their validity, concavity of the revenue curve, in particular, are still relevant questions.

Consider, first, the second most popular demand function, the power model: $D(p) = \beta \cdot p^{-\alpha}$, where both α and β are strictly positive. The corresponding revenue curve is: $R(p) = p \cdot \beta \cdot p^{-\alpha} = \beta \cdot p^{1-\alpha}$. If $\alpha < 1$, $R(p)$ is monotonically increasing in p and concave, while if $\alpha = 1$, $R(p) = \beta$, the $R(p)$ independent of p. However, if $\alpha > 1$, $R(p)$ is monotonically decreasing in p and convex.

Figure 1. *Revenue Curve with Exponential Demand, $\alpha = 0.95$, $\beta = 100$*

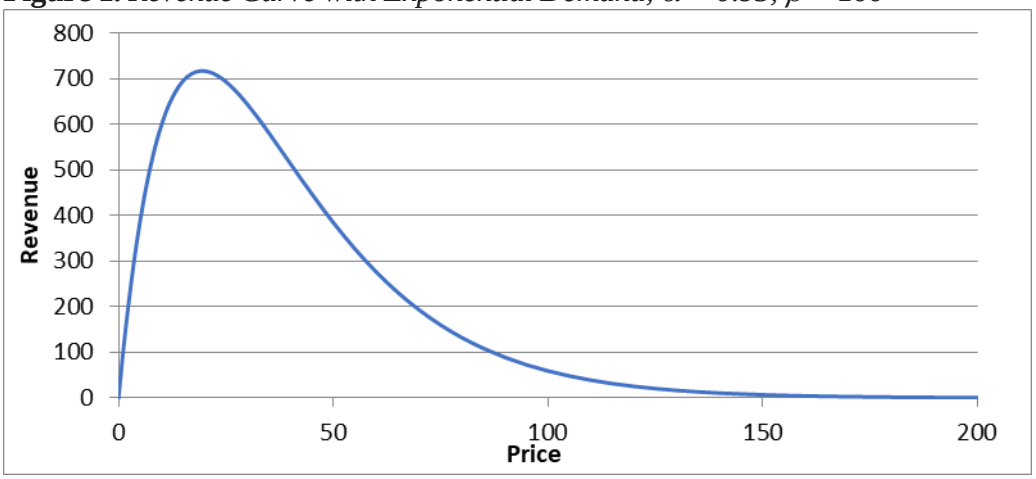
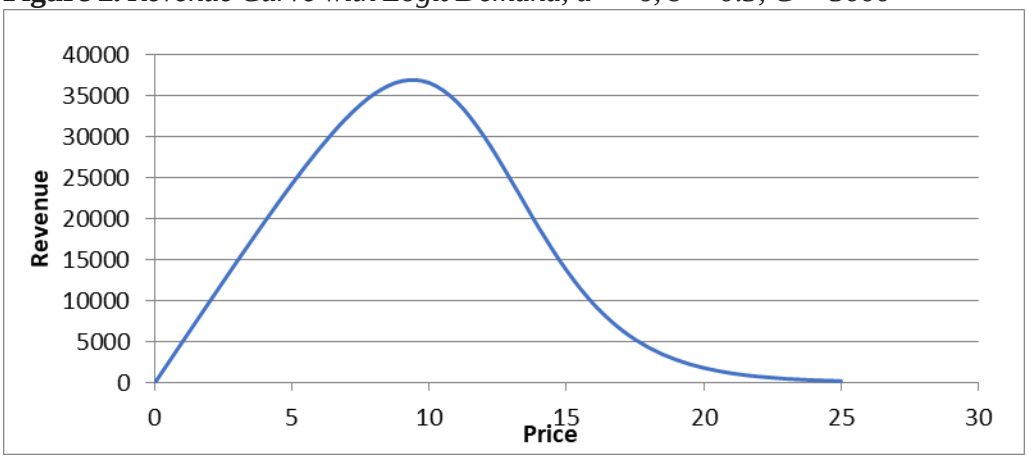


Figure 2. *Revenue Curve with Logit Demand, a = -6, b = 0.5, C = 5000*



The next two most popular demand function are the exponential function: $D(p) = \beta \cdot \alpha^p$, where $\beta > 0$ and $0 < \alpha < 1$, and the logit function: $D(p) = C\frac{e^{-(a+bp)}}{1+e^{-(a+bp)}}$, where $a < -2$, $b > 0$, and $C > 0$ denotes the market size. Both obey the law of demand and examples of corresponding revenue curves are displayed in Figures 1 and 2. Clearly, the revenue curves are only partially concave. This may not affect the results of previous studies because both curves are uni-modal and concave up to the maximal point and to some range after.

Next, consider the function presented in Table 1 and Figure 3. This is a piecewise linear function – the values in Table 1 are the breakpoints of the curve, which are connected by straight lines. This function certainly obeys the law of demand and is invertible, too. However, the revenue curve of a linear demand function is a quadratic function. Consequently, the revenue function, which corresponds to Table 1 and Figure 3, is the upper envelop of a series of quadratic functions and is not uni-modal, but has a single global maxima and few local maxima, as can be seen in Figure 4.

Table 1. *Piecewise Linear Demand Function*

P	0	2	4	5	6	8	12	20
D(*p*)	28	12	6	5	4	3	2	1

Figure 3. *Piecewise Linear Demand Function*

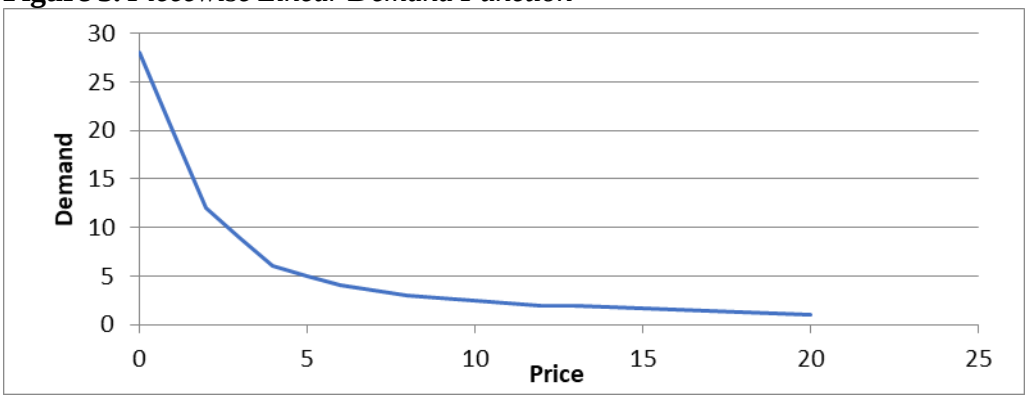
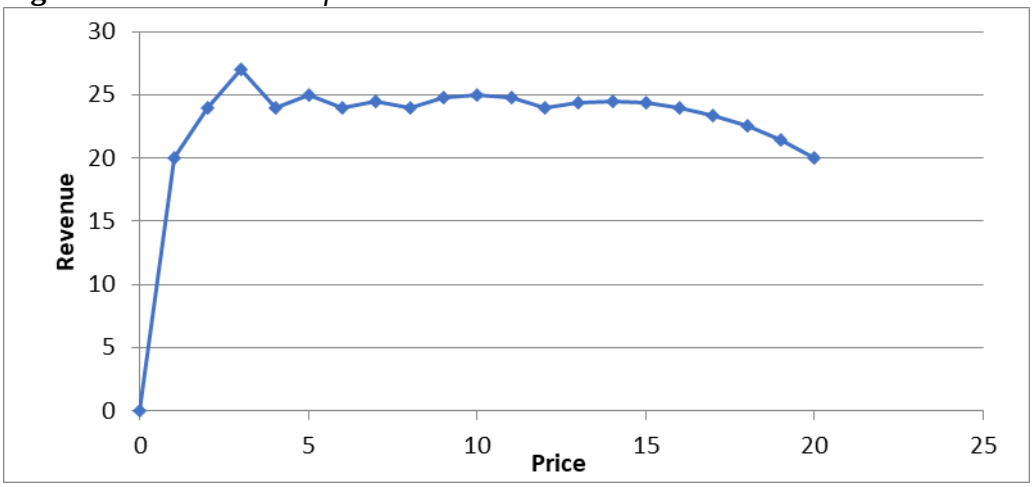


Figure 4. *Revenue Curve for the Piecewise Linear Demand Function*



In sum, thus far, the revenue curve may be neither increasing nor concave and not even monotone. Evidently, a non-increasing and invertible demand function is insufficient to fully characterize the revenue curve. Nevertheless, the following observation does hold.

Proposition 1: When the demand function is non-increasing in p, the revenue curve, $R(p)$, cannot be both increasing and convex in p.

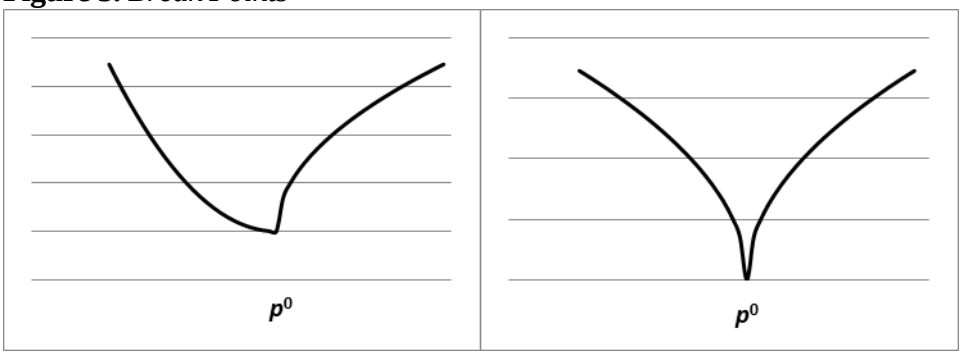
Proof: Suppose $R(p)$ increases for some p^0, that is $R(p^0 + \varepsilon) > R(p^0)$ for some $\varepsilon > 0$. Since $D(p)$ is non-increasing in p: $R(p^0 + \varepsilon) = (p^0 + \varepsilon) \cdot D(p^0 + \varepsilon) \leq (p^0 + \varepsilon) \cdot D(p^0)$. Hence, the increase in $R(p)$ is no bigger than a linear increase at rate $D(p^0)$.

Further, the quote from Besbes and Zeevi (2009) in the beginning of this section is incomplete. The complete statement is: "These assumptions are quite standard in the revenue management literature, resulting in the term *regular* affixed to demand functions satisfying these conditions; see, e.g., Talluri and van Ryzin (2005, §7)." However, the list of regularity assumptions in (Talluri and van Ryzin 2005) is longer. In particular, the first assumption is that the demand function is continuously differentiable. With this addition, the following observations hold, too.

Corollary 1: When the demand function is continuously differentiable and non-increasing in p, once $R(p)$ decreases for some p^0, it decreases for any $p > p^0$.

Proof: Suppose $R(p)$ decreases up to p^0 and increases from p^0 onward. Then, by proposition 1, $R(p)$ is non-convex from p^0 onwards – see Figure 5. Consequently, $R(p)$ is not differentiable at p^0, contradicting the assumption that $\partial R(p)/\partial p$ is well defined for any value of $p \geq 0$, including p^0 – the breakpoint in both parts of Figure 5.

Figure 5. *Break Points*



Corollary 2: When the demand function is continuously differentiable and non-increasing in p, there exists a single point, p^R, where the revenue, $R(p)$, is maximized.

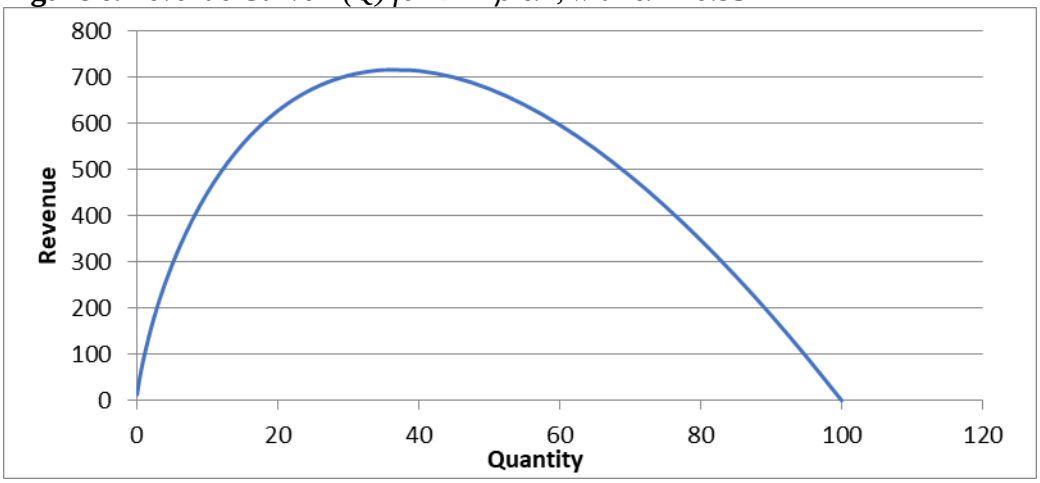
The proof of corollary 2 is straightforward and hence omitted.

Functions which are not continuously differentiable are piecewise linear functions; e.g., Table 1 and Figure 3. This shows the significance of the continuously differentiable assumption, which might be considered restrictive. However, it is only a necessary condition and other conditions might do, too.

Profit vs. Revenue

The economic system aims at equilibrium, while firms, as noted, aim at profit maximization. Profits equals total revenues minus total costs, but the costs depend on the quantity, not on the sale price. In addition, the demand is exogenous and firms have a limited control on its value. As noted by Zusman and Etgar (1981), in real world situations the quantity is always monitored, while the demand is seldomly fully monitored. Indeed, what providers, e.g., firms, always do is to determine the amount, Q, which is produced and offered for sale. Since there is one to one relationship between prices and quantities, the quantity may be legitimately regarded as the control variable. Namely, $R(Q) = Q \cdot p(Q)$. It then follows that $p(Q)$ is also continuously differentiable and non-increasing in Q, and proposition 1, corollary 1 and corollary 2 hold for $R(Q)$ as well. The revenue curve, $R(Q)$, which corresponds to Figure 1 is shown in Figure 6, for example.

Figure 6. *Revenue Curve R(Q) for $D = \beta \cdot \alpha^p$, with $\alpha = 0.95$*



It should be understood, however, that $R(Q)$ is an upper-bound on the revenue. As noted, the demand is seldom monitored. Therefore, the right price for the quantity offered is not known. Whether the price is too high or too low, the actual revenue will be smaller. Hence, lower revenue is the likely result.

The profit $\Pi(Q) = R(Q) - C(Q)$, and it is assumed that the total costs, $C(Q)$, is non-negative and non-decreasing in Q. Then, either one of the following cases may occur:

1. The cost curve lies above or on the revenue curve. This implies non-positive profit: $\Pi(Q) \leq 0$, for all $Q > 0$.
2. There exist a quantity $Q' \geq 0$ for which the cost is smaller than the revenue: $C(Q') < R(Q')$, and hence, $\Pi(Q') > 0$.

Rationality dictates positive quantity only when positive profit can be expected; i.e., case 2: there exists $Q > 0$ for which $R(Q) > C(Q)$. Adding an assumption about the cost function leads to the following observation.

Proposition 2: When $C(Q)$ is non-negative, non-decreasing and convex in Q and $R(Q)$ is uni-modal with a maximum point at $Q^R > 0$, the maximum profit is obtained at a quantity $Q^{\Pi} \leq Q^R$.
Proof: $R(Q)$ is monotonically increasing and concave, at least for $Q < Q^R$. Thus, the convexity of $C(Q)$ implies that it may intersects $R(Q)$ at most twice and the profit is positive between the intersection points: $Q^1 < Q < Q^2$, and non-positive elsewhere. Further, the concavity of $R(Q)$ implies that $R' = dR(Q)/dQ$ is non-increasing in Q**.** The maximum of $R(Q)$ is obtained at Q^R where $R' = 0$, while that of the profit is obtained at Q^{Π} where $R' - dC(Q)/dQ = 0$. The results then follow since $dC(Q)/dQ \geq 0$ because $C(Q)$ is non-decreasing.

While both components of the profit are considered as functions of the quantity, they are highly independent. An implication of this independence is that

changing the cost function changes only Q^{Π}, not Q^R. To illustrate, consider Figure 6 where $Q^R \approx 35$ and suppose the cost function is linear. When the variable cost is \$5/unit, $Q^{\Pi} \approx 28$, while when the variable cost is \$8/unit, $Q^{\Pi} \approx 24$. Moreover, Q^{Π} is 20% less than Q^R, in the first case, and more than 30% less in the second case. The revenue associated with Q^{Π} is about 3% less than the maximum in the first case and about 6.8% less in the second case. However, while the profit associated with Q^R, is about 2.7% less than the maximum in the first case – similar to the revenue change, the difference grows to about 9.25% in the second case. These examples indicate that the difference between Q^{Π} and Q^R, that is between revenue and profit maximization can be substantial and that the profit is more sensitive to quantity changes than the revenue.

Summary

In this note, the relationship between the demand model and the revenue curve has been examined and then, revenue was contrasted with profit. It has been found that more caution is needed when the revenue curve is considered. The curve is not necessarily concave, it might be decreasing, and might even have multiple local extreme points. However, when the demand function is continuously differentiable and non-increasing in the price, then if the revenue curve is not monotonically decreasing, it is first increasing and concave. Based on the last observation, it was shown that the quantity that maximizes the profit differs from the quantity that maximizes the revenue. Further, the difference can be substantial and the profit is more sensitive to quantity changes than the revenue.

An implication of these results is that accurate estimations and forecast of both the revenue and the cost curves are required in order to maximize the profit. A primary prerequisite with regard to the revenue curve is to relax, or to give up the assumption that the demand function is known. In general, the quantity sold is the minimum between the quantity offered to the demand, but the real situation is more complicated. A quantity is determined first and then, a price is set. If the price is too high, a surplus will be created. Often, a price discount can be offered and then additional units are sold, but then, different prices determine the revenue. If, on the other hand, the price is too low, the whole quantity will be sold and a shortage might be sensed. Making additional supply is harder than altering prices and takes time, but can still be done, in some cases, and might be accompanied with price increase. Then, again, the revenue calculation is affected. Accurate modeling of the revenue and cost curves are challenges which are left for future work.

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E-waste Awareness Among Young Generation

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Environmental pollution is becoming a high-priority concern, as it threatens the natural resources of many countries. In this context, electronic waste (e-waste) pollution is expected to play an important role in the ecosystem. E-waste is an emerging type of pollutant, defined as the various forms of electrical and electronic material that have stopped being of value to their users or no longer satisfy their original purpose. In our study, the aim was to measure the awareness of young generations regarding the e-waste concept and to analyze how much young people are familiar with the regaining activities. To achieve the goal of this study, an e-waste survey of 9 multiple choice questions was formed in an online survey platform. This paper provides a panorama of the awareness, actual motives for change and disposal method, attitudes and other factors potentially explaining the intention to recycle, and deterrents to recycling.

Keywords: *e-waste, recycling, mobile phone, environment, statistics*

Introduction

With the rapid development of technology, a newer model of electrical and electronic devices is released at every moment and new models are marketed to the consumer as "better". This situation causes consumers to buy new devices before the end of the device's lifespan. However, due to reasons such as the high cost of repair when the device in use fails, and the preference for a new one instead of repairing, the service life of electronic devices is getting shorter day by day. All electrical and electronic devices such as refrigerators, televisions, small household appliances, lighting equipment, mobile phones, computers, tablets, cameras, food vending machines, which have lost their technological or functional feature and completed their useful life, are considered electronic waste (e-waste). Along with the shortening of the service life of the specified electronic devices, there is also a significant increase in the amount of e-waste generated. The substances contained in the resulting e-waste can harm both the environment and human health. Therefore, proper management of e-waste and planning of recycling activities are important. With the recycling of e-waste, precious metals such as copper, gold, silver, glass and plastic are obtained, thus both environmental impacts are minimized and raw material needs are provided.

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The e-waste concept and regaining activities examined in this research has been the subject of many previous studies. In one of these studies, Shahabuddin et al. (2022) reviewed the concept of electronic waste and discussed the regaining activities starting from collection to pre-treatment and recycling. The study also investigated the recent developments, statistics and operational challenges. According to the study (Shahabuddin et al. 2022), Europe has the highest collection rates of e-waste, while Asia, America, Oceania, and Africa have lower rates, respectively. In addition, Shahabuddin et al. (2022) stated that the e-waste materials produced are worth $ 57 billion, and only $10.0 billion worth of e-waste is recycled and recovered sustainably, where the remaining materials cause high CO_2 emission. These statistics and previous researches indicated that it is important to understand the e-waste concept and raise awareness for sustainability activities.

The aim of this study is to measure the level of awareness of individuals aged 18-25 in Turkey about electronic waste and e-waste sustainability studies. In the study, first of all, the concept of e-waste, the content of e-waste and waste recovery methods are explained; e-waste recycling regulations in various world countries and Turkey are included. In the following parts of the study, the methods, findings, and results of the survey study conducted to measure the awareness of individuals aged 18-25 on e-waste and waste recycling studies are included. At the end of our study, discussion and suggestions were shared.

Literature Review

Today, the rapid progress of technology has led consumers to prefer the product with the newest technology to the product they have. With the shorter life of new devices, the frequency of electronic device replacement has increased. Therefore, there has been an increase in the amount of electronic waste generated. According to the Global E-waste Monitor (Forti et al. 2020), which was created by examining the data for 2019 within the scope of the United Nations University (UNU) Sustainability Program, 44.4 million tons of e-waste worldwide in 2014 has occurred. In 2019, the amount of waste increased to 53.6 million tons. The report, prepared with the contributions of the World Health Organization (WHO), shows that while the amount of e-waste per capita was 6.4 kg in 2014, it increased to 7.3 kg in 2019. According to this increase in the amount of electronic waste in five years, it is predicted that the total amount of waste will be 74.7 million tons and the amount per person will be 9 kg in 2030 (Forti et al. 2020). The increase in the amount of electronic waste causes an increase in the damage to both the environment and the health of living things due to the elements and chemical materials contained in the device. However, the production of electronic devices requires a very high human resource and raw material usage. It is known that 239 kg of fossil fuel, 22 kg of chemicals and 1.5 tons of water are used even when producing only one computer (National Conference of State Legislatures 2018).

Due to the rapid development of technology, with the increase in the circulation of electronic devices day by day, the problem of electronic waste has

become a problem that is evaluated on a global scale. Especially in countries where the production and use of electronic devices is high, there is a significant increase in the amount of e-waste generated within a year. The Global E-waste Statistics Partnership was established by the International Telecommunication Union (ITU) and the United Nations University (UNU) in order to monitor the annual amount of e-waste. The e-waste generation map per capita for 2019, published in cooperation with ITU and UNU was created. It is found that the highest production with 17-21 kg of waste is in the USA, Canada, Switzerland, European Union countries and Australia. With the increasing amount of e-waste, many countries, including Turkey, have started sustainability studies in this area in order to control the increasing amount of waste and gain economic benefits from recycling activities. Countries that have enacted recycling regulations can be found also on the Global E-waste Statistics Partnership (GESP 2020).

Kumar (2019) suggests that it is important to better understand young generation's behavior in EEE consumption. In China and India, young adults represent "the new generation" that contributes significantly to the EEE consumption growth. Thus, it becomes imperative that this new generation understands the importance of responsible and sustainable e-waste management and becomes an instrument of social and behavioural change in future.

European Union

When the e-waste production in European countries is evaluated, it was seen that the total waste amount of all European countries at the end of 2019 was 12 million tons. According to the study, it has been determined that among the countries included in the European Union, the countries with the highest annual e-waste production are Poland in Eastern Europe, Sweden in Northern Europe, Italy in Southern Europe and Germany and France in Western Europe (Forti et al. 2020). Two directives, the Waste from Electrical and Electronic Equipment Directive (WEEE) and the Restriction of the Use of Certain Hazardous Substances (RoHS), have been created by the European Union in order to record the e-waste production and recovery activities of the member countries and to ensure e-waste control. It is stipulated that all electrical and electronic products to be produced and sold in the member states of the European Union comply with these directives.

EU directives classify e-waste into 10 categories (Gill 2010). Waste electrical and electronic equipment (WEEE) is defined as a mixture of materials and components that originated from mobile phones, computers and many more types of electronic equipment (Zhang 2011). The first WEEE Directive (Directive 2002/96/EC) entered into force on February 13, 2003 (European Commission 2003), but the European Commission later proposed revising the Directive in order to tackle the fast-increasing waste stream. WEEE Directive 2012/19/EU entered into force on August 13, 2012 and has been considered operative since February 2014 (European Commission 2012).

China

With a total of 10.1 million tons of e-waste generated in 2019, China represents 74% of the total amount of e-waste generated in the East Asian region and is the country with the highest e-waste production in the world with this ratio (Forti et al. 2020). The reasons why China is the country with the highest global e-waste production can be considered as the country's strong position in the production of electrical and electronic devices, being one of the countries with the densest population in the world, and the high demand for electronic devices in the country. However, it is seen that electronic waste in the country generally consists of households, municipalities and institutions that have completed their useful life, defective electronic devices produced by manufacturers and waste devices imported from other countries (SEPA 2006). It should also be noted that China had established different types of policy, starting in 2000, as preliminary steps before the Chinese WEEE Directive came into force in January 2011 (China State Council 2011).

E-waste Management in Turkey

Turkey is one of the countries that have established national legislation for the inclusion of e-waste in recycling studies. It is seen that the concept of e-waste was officially included in the 2002 addition to the Solid Waste Control Regulation for the first time (Salihoğlu and Kahraman 2016). The first study on the management process of e-waste in Turkey was carried out in 2004 within the scope of the Martha Project in cooperation with the Dutch Government (Atasever 2015). After this project, the Ministry of Environment and Urbanization started to work for the management of electrical and electronic wastes by a national standard compatible with health and the environment. A draft regulation was created by the Ministry by harmonizing the WEEE and RoHS Directives of the European Union with the national legislation. The final version of the draft was published in the Official Gazette No. 28300 on May 22, 2012 under the name of the Waste Electrical and Electronic Equipment Control Regulation (TÜSİAD 2015).

According to the analysis made by the Global E-waste Statistics Partnership (GESP),[1] the total amount of electrical and electronic devices put on the market in Turkey in 2019 was 1273 thousand tons, and the total amount of e-waste consisting of these devices was 847 thousand tons. While 18% (152 thousand tons) of the generated e-waste is collected and included in the recovery process, 125 kilo-tonnes of these wastes have been registered and included in the process.

Methodology

The concept of electronic waste is impacting our lives negatively in many ways. The components of this kind of waste materials are harmful for both the environment and human health. Since the e-waste statistics are increasing every

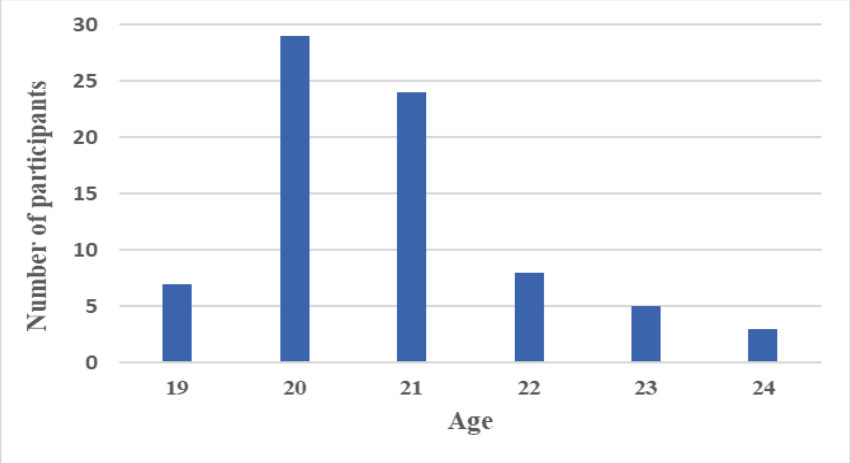
[1]GESP (2020): https://globalewaste.org/.

year, understanding the e- waste concept and regaining these waste materials are becoming significantly important. In this study, the aim was to measure the awareness of young generations regarding the e-waste concept, and to analyze how much young people are familiar with the regaining activities. To achieve the goal of this study, an e-waste survey of 9 multiple choice questions was formed in an online survey platform. The survey was among volunteers aged between 18-25 in two cities of Turkey, Istanbul and Ankara. Ankara is the capital city and Istanbul is the most crowded city of Turkey. Both cities are examples of the most developed cities, having a high number of young educated people. Therefore, they were chosen to reach more suitable participants for the survey. The survey was conducted online via a survey link, which was directed to 120 people through their mobile phones as text messages. 87 participants out of 120 people answered questions, creating a 72% response rate. While creating the survey, it was based on measuring the level of knowledge of individuals about e-waste and their attitude towards recycling activities; the questions were prepared on the basis of previous studies in the literature. At the beginning of the questionnaire, the aim of the study was mentioned by giving written information about the study to the participants. At the end of the survey, the results were collected on the online survey platform as graphics and numerical tables, which were then used in the final analysis. The data collected by survey instrument helped us to make some descriptive statistics. Validity of this instrument can be found also in many works as well as the study of Sadik et al. (2017) that we mention in the literature review. They also focus on the student's awareness about e-waste in Bangladesh.

Results

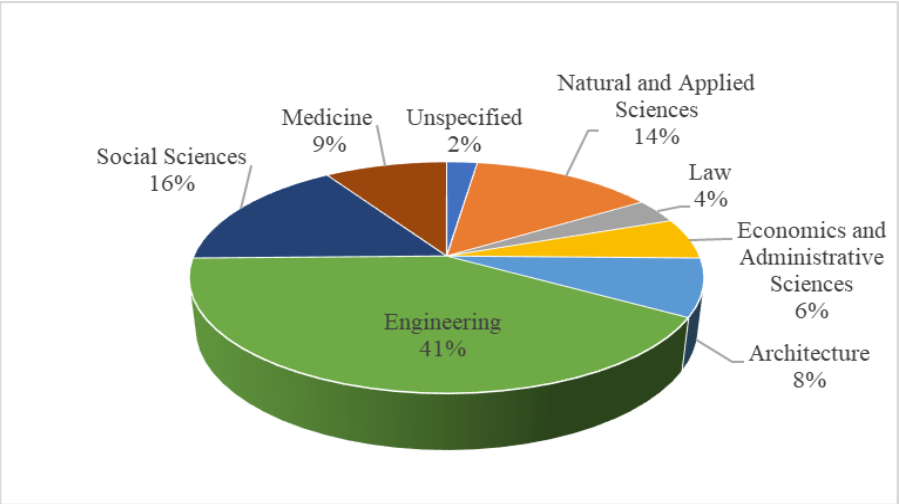
Participants' distribution in age and area of study are shown in Figure 1 and Figure 2. The majority of the survey participants are 20 years old with 33%; It consists of individuals in the age group of 21 with 28% and in the 18-age group with 13%. A total of 87 people participated in the survey and it is seen that 24-year-old individuals have the lowest rate of participation.

Figure 1. *Age Distribution of Participants*



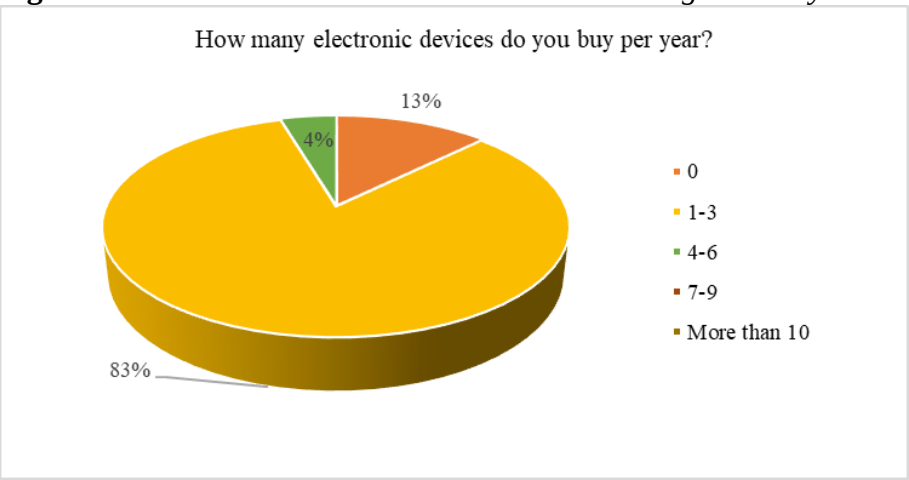
When the education/occupational distribution of the participants is examined, it is seen that the individuals with an engineering background have the highest participation with a rate of 41%. According to the analysis, the participants include people working in the fields of social sciences, natural sciences, medicine, architecture, economics/administrative sciences, and law.

Figure 2. *Area of Study of Participants*



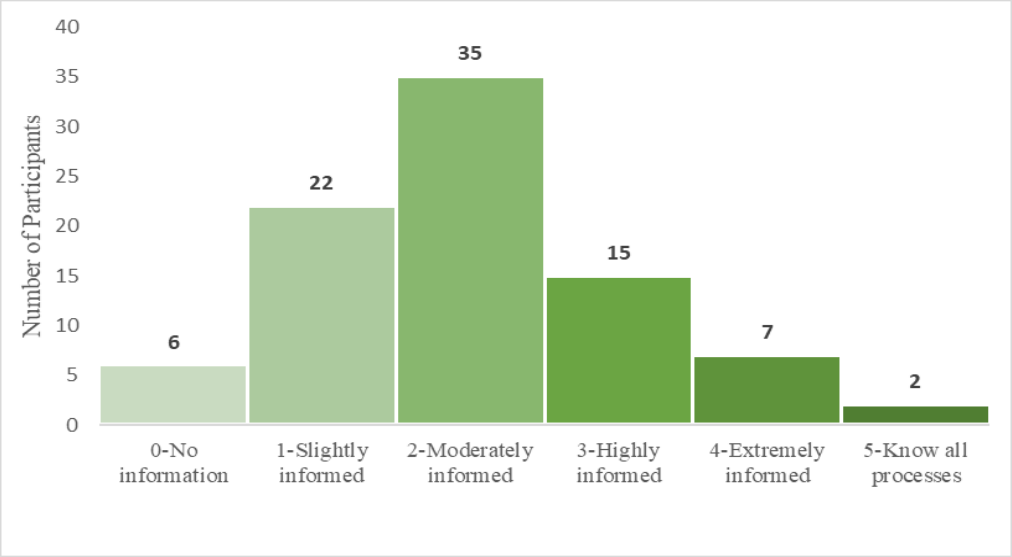
In the survey study, it was first aimed to analyze the electronic device purchasing behavior of consumers. The participants were asked how many electrical/electronic devices they buy in a year and the answers are shown in Figure 3. While 83% of the participants stated that they buy 1-3 electrical/ electronic devices per year, 4% of them purchase 4-6 devices per year; 13% stated that they have not purchased any device for a year. 7-9 and more than 10 device purchase options presented among the question options were not marked by any participant. Considering that the people participating in the study are individuals between the ages of 18-25, it is seen in Figure 3 that despite their tendency to follow technology, they only buy a few devices per year.

Figure 3. *Annual Electric/Electronic Device Purchasing Tendency*



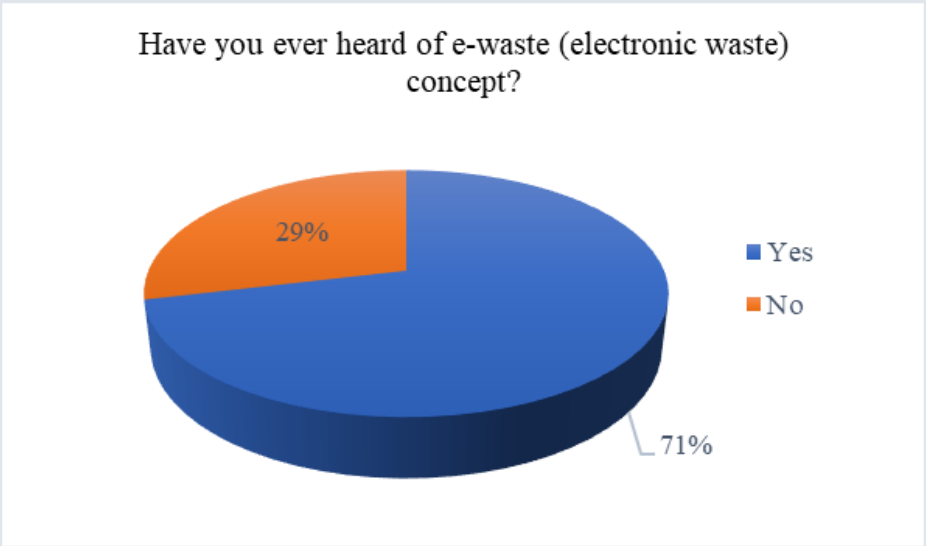
In the second question of the study, the level of knowledge of the materials in the electrical and electronic devices purchased by the consumers was measured with a scale in the range of 0-5. The answers to the question answered by all participants are shared in Figure 4. The majority, which constitutes 40% of the participants, stated that they have some knowledge of the materials found on the devices; the following 25% marked the option "1- I don't know much". The sum of the people who stated that they had above average and quite knowledge about the materials contained in the electronic device constitutes 25% of the participants. While 7% of the participants marked the answer "0- I have no knowledge", 2% of them marked the highest scale and stated that they had knowledge about all stages. When the answers of all the participants are evaluated, it is seen that 59 participants, who make up the majority of 68%, have knowledge about the materials used in electronic devices. This high rate can be explained by the high number of people with technical professions, especially considering the education/ occupational groups of the participants.

Figure 4. *Knowledge Levels of Participants Regarding Electronic Device Components*



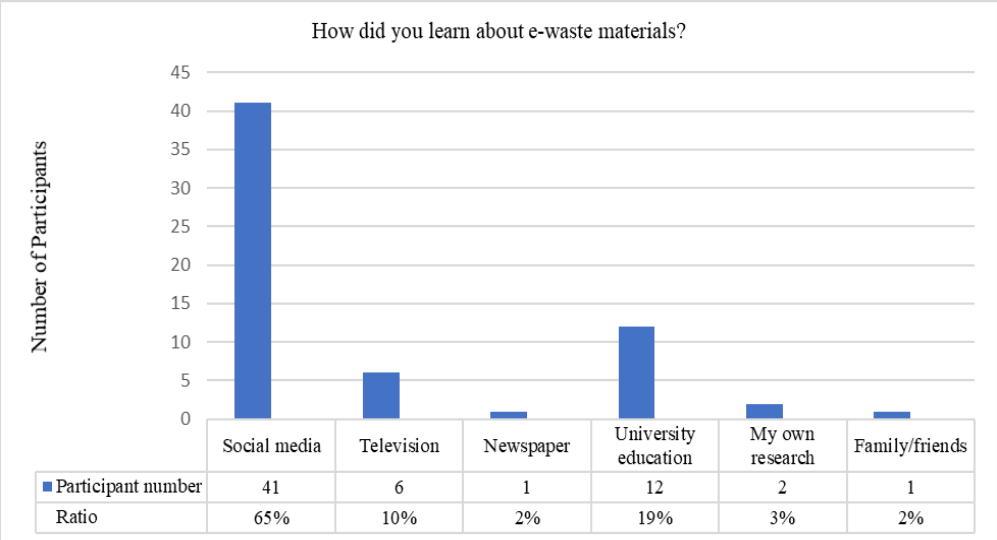
In the third question of the survey study, the participants were asked questions about the concept of electronic waste and the harmful effects of these wastes. While a majority of the 87 participants, 71%, stated that they had heard of the concept of e-waste before, 29% answered that they had not heard of such a concept before (Figure 5).

Figure 5. *Awareness of E-waste Concept*



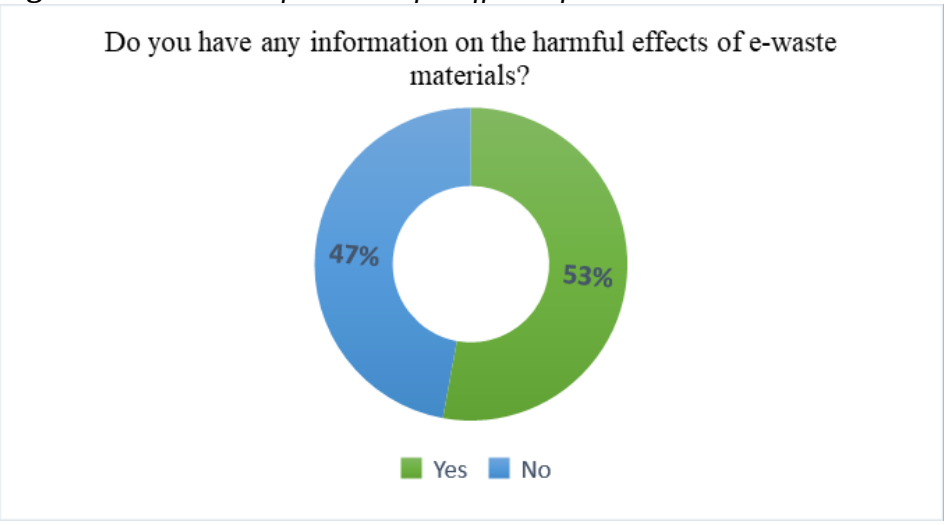
Participants who answered yes to the question were asked the question through which channel they learned the concept of e-waste. Social media, television, newspaper, university education/lecture and "other" options were presented to the participants. Of the 63 people who answered the question, 61% chose the concept of social media, 19% chose university education/course, and 10% chose television. It is seen that only one participant selected the newspaper option. A free response was requested from the participants who marked the "Other" option; 3% stated that they learned about e-waste through their own research, while 2% stated that they learned from their family/environment. When the answers are evaluated, it is seen that traditional channels are ineffective in announcing the e-waste issue to people between the ages of 18-25, and social media has a very important role. The distribution of the answers is shared in Figure 6.

Figure 6. *Distribution of Sources in Learning E-waste*



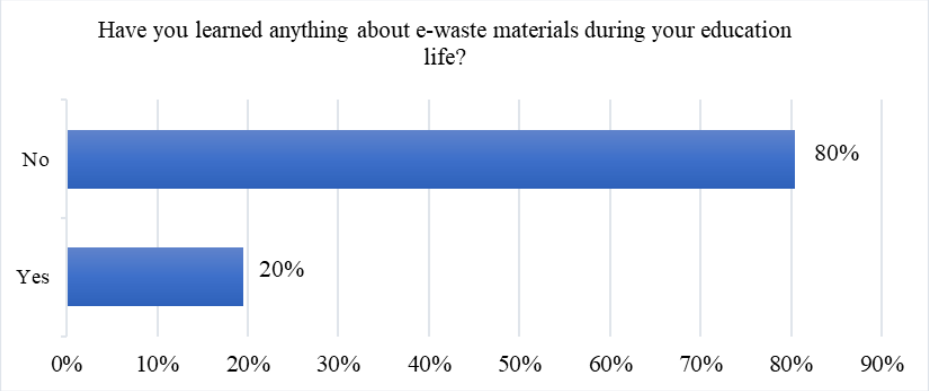
In the fourth question of the study, the participants were asked whether they had knowledge about the subject in order to measure their awareness of the harmful effects of e-waste. While 53% of the participants stated that they were aware of the harmful effects, 47% stated that they did not know about the subject (Figure 7). The answer rate of "Yes" given to the question was "Have you heard of the concept of e-waste before?" The fact that it is lower than the positive answer given to the question shows that everyone who has heard of the concept of electronic waste is not actually aware of the harmful effects of this waste. This situation indicates that while explaining the concept of e-waste to consumers, it is also necessary to mention the negative effects of waste on health and the environment.

Figure 7. *Awareness of the Harmful Effects of E-waste*



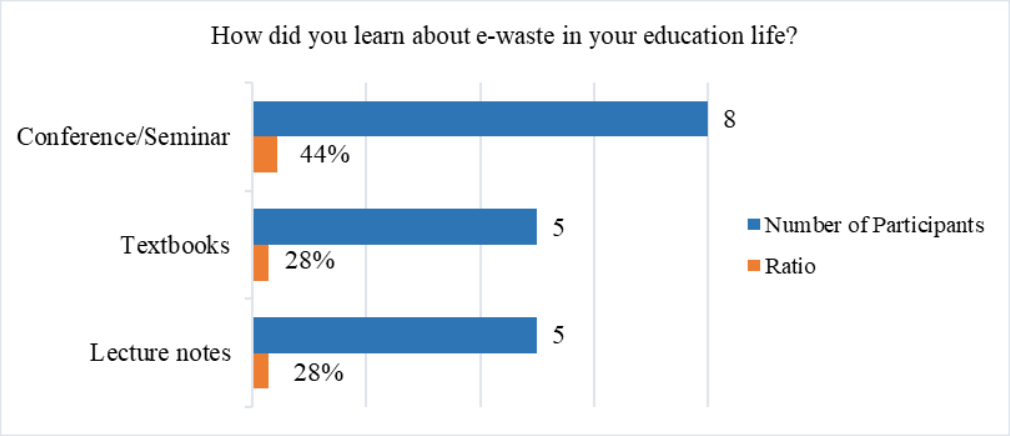
In the fifth question, in order to analyze whether the participants from different education/professional groups received any training on e-waste during their education, the participants were asked whether they learned a subject related to this concept during their education. While 20% of the participants answered "Yes" to the question, a large majority of 80% stated that they did not receive information about this issue in their education life (Figure 8).

Figure 8. *E-waste Awareness Formed During Education Life*



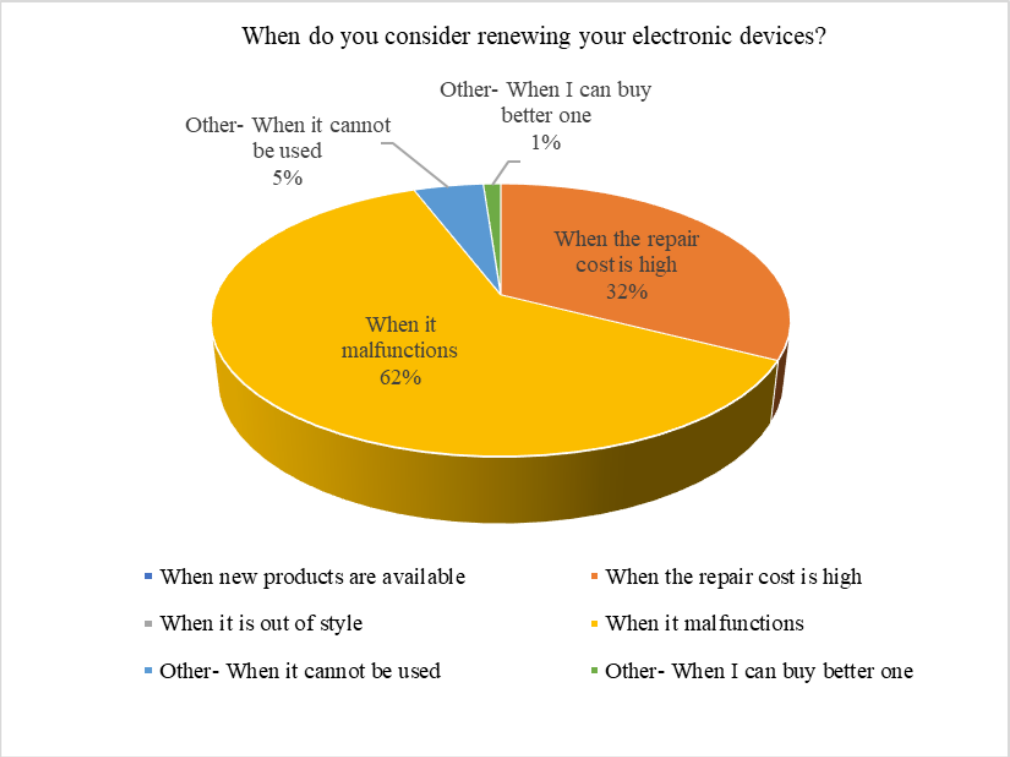
Those who answered the question positively were asked the question on which educational material they learned about e-waste. While 44% of the participants answered that they learned through face-to-face events such as conferences and seminars; Half of the remaining 56% of the participants stated that they received information from lecture notes and the other half from textbooks (Figure 9). It is seen that the common material in the process of teaching e-waste-related subjects in education life is organizations based on face-to-face and mutual communication.

Figure 9. *The Sources Where Participants Learn About E-waste Materials in Education Life*



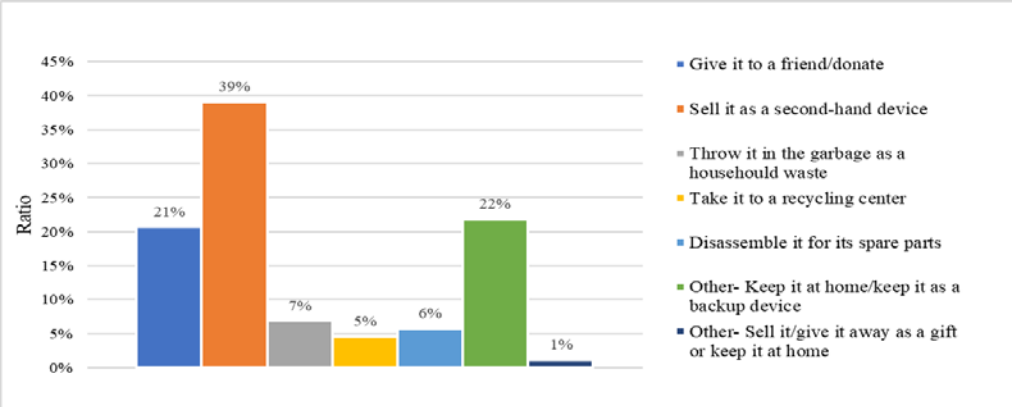
In the continuation of the study, the habits of the participants to change electronic devices and how they behaved when the devices became waste were examined. In the sixth question, participants were asked when they changed their devices in order to analyze the reasons for changing their electronic devices. “When new models are available for sale”, “When the repair cost is high”, “When outdated”, “When it breaks down while using” and “Other” options are presented in the question options; Those who marked the answer “other” were asked to explain. In the question answered by 86 participants, 62% of the respondents said that they would replace their electronic device when it malfunctioned; A portion of 32% stated that they would replace it if the repair cost was high in case of malfunction. When the answers are examined, it is seen that none of the participants changed their device when it became obsolete or when new models were put on sale. In this case, it is deduced that the participants do not change their devices only with the concern of following the technology. While the people who marked the other option make up 6%; Among the answers given were “When it becomes unavailable” and “When I can get a better quality” options. The percentage distributions of the response are shared in Figure 10.

Figure 10. *Reasons to Renew Electronic Devices*



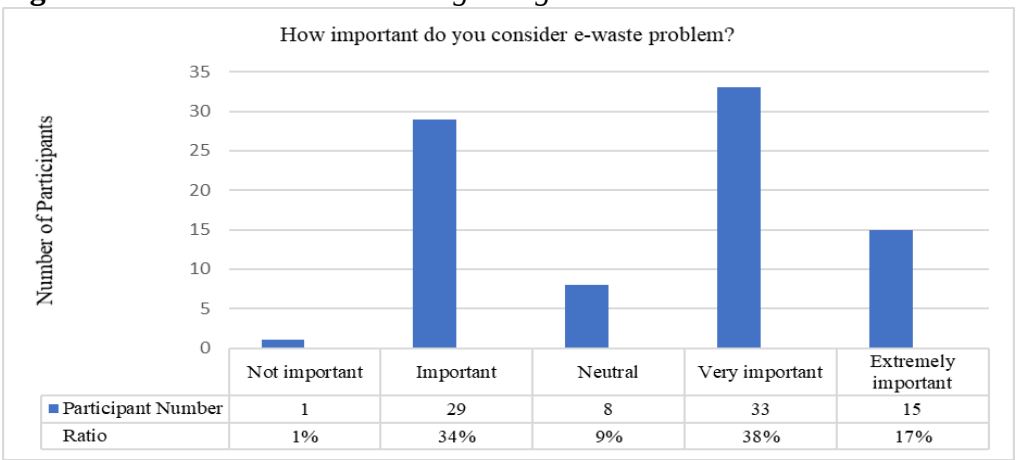
In the seventh and eighth questions of the study, how the participants manage their electronic device waste and their attitudes towards the recycling process were examined. In the seventh question, the participants were asked how they, as a consumer, changed their electrical and electronic devices. In the multiple-choice question consisting of six options, the participants who chose the "Other" option were asked to specify details. The answer to the question answered by all participants was "I sell it as a secondhand device" at a rate of 39%. When the distribution of the answers is examined, it is seen that 29% of the participants did not include the devices in any acquisition process. 22% of these participants answered the question as "Other-I keep it at home/I keep it as a spare device", while 7% stated that they consider electronic device waste as a household waste and throw it away. 21% of all participants answered the question as to give or donate the device to their friend. When the other answer options of the question were examined, it was seen that the participants who took their waste device to the recycling center made up only 4% of the total. Response distributions are shared in Figure 11.

Figure 11. *The Ways Participants Handle Their Used Devices*



In the eighth question, it was investigated whether the participants saw the harmful effects of e-waste as a problem and their attitudes. The participants were presented with five answer options and asked to mark the option that came closest to them, and their response distribution is shown in Figure 12. 90% of the 86 respondents to the question rated the e-waste problem in the "important" to "extremely important" range. However, a segment representing 9% stated that they saw the problem as "neither important nor unimportant", while the remaining 1% interpreted it as "not important". The rate of people who describe e-waste as an important problem is higher than the rate of people who state that they know about the harmful effects of e-waste. In this case, it can be interpreted that consumers are aware of the problem created by electronic waste, even if they do not fully know the harmful effects of e-waste on human health and the environment. However, when evaluated together with the behavior of consumers after changing their electronic devices, it is seen that the vast majority know the harmful effects of e-waste and consider the problem of e-waste as important, but still do not include their devices in the recycling process. It is deduced that consumers should be encouraged more about recycling and disposal activities in order to spread the sustainability studies supported by the Waste Electrical and Electronic Equipment Control Regulation and the Zero Waste project in the society.

Figure 12. *Consumer Evaluation Regarding the E-waste Problem*



At the last stage of the study, the participants were asked whether they knew about Earthday. While 63% of the participants stated that they had heard of Earth Day before, the remaining participants stated that they did not know about the subject.

Discussion

When examining the situations in which the individuals participating in the study change their electronic devices, it is seen that 62% of the participants change their device when it fails, and 32% when the repair cost is high after the breakdown. It is seen that only a fraction representing 1% change their device when newer models are released. When e-waste studies in the world literature are examined, it is seen that similar studies have been carried out in England and Bangladesh. In a study conducted by Ongondo and Williams (2011) at 5 universities in England, the behaviors and attitudes of university students towards mobile phone waste recycling were examined. The survey question, which analyzes the reasons for students to change their mobile phones, was answered by 2,287 participants, and 58% of the people stated that they changed their phone when it malfunctioned, and 41% stated that they changed it due to the update request of the operators. According to the research (Ongondo and Williams 2011), people who make changes to keep up with the latest technology make up 16% of the total. When the study by Ongondo and Williams (2011) is compared with the e-waste awareness research, it is seen that the rate of consumers who change when the device fails is close to each other and consumer concerns are generally common. Zheng et al. (2021) examined the factors affecting the behavior of people in the evaluation of electronic waste. In this regard, a literature review and first findings were presented.

Sadik et al. (2017), in a study conducted with 1055 people in three cities of Bangladesh with different demographic characteristics, the question of when they changed their electronic devices was asked to people aged 16-22. According to the results, the majority of respondents replace their electronic device in case of malfunction or if the cost of having it repaired is too high. In this case, it was seen that the results of the research conducted in Ankara and Istanbul were compatible with the results of the study conducted in England (Ongondo and Williams 2011) and Bangladesh (Sadik et al. 2017). The similarity of the results can be explained by the fact that the age groups of the people participating in all three studies are close and they exhibit similar purchasing behavior.

When the level of knowledge of the people participating in the e-waste awareness survey about the materials used in electrical/electronic devices was analyzed, it was seen that the majority of 68% had some or more knowledge. While 40% of the participants stated that they had some knowledge about the subject, a segment representing 25% stated that they did not know much; a portion of 7% said that they had no information.

When the awareness level of the people participating in the study on the issue of electronic waste was examined, it was determined that 71% of the participants knew the concept before. When the study in Turkey is compared with the study

conducted in Bangladesh with participants in the similar age group (Sadik et al. 2017), it is seen that the e-waste awareness analysis in both studies reveals similar results. Sadik et al. (2017), it was seen that approximately 60% of 1055 participants had an opinion about e-waste. Although the majority of the participants in both studies stated that they knew the concept of e-waste, the percentage of people who were not familiar with the concept was still considered to be quite high. Therefore, the results of both studies were found to be compatible with each other.

In the second stage of the e-waste awareness analysis, it was examined from which channels the participants learned about e-waste. When the results were evaluated, it was determined that the majority of 65% learned the concept of e-waste through social media. Some of the remaining participants stated that they learned the concept from university education and courses, and some of them learned from television. The number of people who learn about the subject through the newspaper, social environment or their own research is quite low. This shows that social networks are the most efficient tool to reach young people between the ages of 18-25. According to the results, it is commented that traditional mass media such as television and newspapers do not have sufficient effect on transferring important issues such as electronic waste to future generations. When the level of awareness about the harmful effects of e-waste is measured, it is seen that 53% of the participants in Turkey know about the harmful effects, while this rate was determined as 63% in the participants in Bangladesh (Sadik et al. 2017). When all the results of e-waste awareness are evaluated together, e-waste awareness in Turkey is relatively high compared to Bangladesh, while the rate of people who know about the harmful effects of these wastes on human health and the environment is lower. This situation makes us think that the e-waste issue in Turkey is not adequately transferred to the younger generations and there is a problem in accessing the right information. Considering that people in this age group access information mostly through social media, authorized institutions and organizations should take action to transfer sufficient and accurate information; it is recommended to address future generations through reliable sources.

In a part of the study, the role of education channels in informing the young population in Turkey about e-waste was examined. The rate of people who stated that they learned about e-waste in their education life was only 20%. This rate, Sadik et al. (2017) in Bangladesh, it is seen that approximately 40% of the youth between the ages of 16-22 living in Bangladesh received information about e-waste during their education life. It is thought that studies on e-waste in Turkey are not as common as plastic, paper, glass and similar waste projects, since people who do not receive training on e-waste have a higher rate than those in Bangladesh. However, it is commented that the education curriculum and resources created on electronic waste in Turkey are rarer than the subject of environmental pollution, and therefore fewer young people are able to access them.

In the next stage of the study, people who stated that they learned about e-waste in their education life were asked which resources they used, while the most common response in Turkey is recorded as conferences and seminars with a rate of 44%; the majority of respondents in Bangladesh (Sadik et al. 2017), 57%, answered textbooks. While 30% of the participants in Bangladesh stated that they

learned e-waste in lessons based on participation, 13% stated that they learned by practicing in the lessons. When these results were analyzed, it was seen that the study in Turkey was not compatible with the previous study. While the main source of information on the subject for the participants between the ages of 18-25 in Turkey is extracurricular interactive activities; it is seen that written sources such as textbooks and lecture notes have a lower rate. Accordingly, organizations based on mutual interaction are in a more effective position to inform young people living in Turkey; however, it is seen that these organizations should be supported with written sources by creating course materials related to the subject. However, it is thought that only theoretical training will not be sufficient to inform young people about e-waste. In order for future generations to adopt and take action on the e-waste problem, it is recommended to implement practical training practices, as in Bangladesh.

When the opinions of the participants on the e-waste problem were examined, it was determined that 90% of the majority saw e-waste as an important problem, while a segment representing 10% did not find the problem important. While 17% of the participants described e-waste as "Extremely important", 38% as "Very important" and 34% as "Important". According to the results, the majority of young people between the ages of 18-25 see the problem as an issue that needs to be intervened. When a question about Earth Day was asked in order to measure the environmental awareness of the participants, it was seen that 63% of the participants had knowledge about the subject. When the results are evaluated together, it is understood that most of the participants are aware of environmental issues and are aware of the importance of e-waste on the environment.

The results found are in Bai et al. (2018) compared with the research conducted in China. In the research, consumers' attitudes towards mobile phone use and disposal of waste phones were examined. The research was conducted in a total of 71 cities from different classes; a sample was formed with a total of 820 participants from different education levels, gender, age and income groups. In the study, in order to measure the level of awareness towards environmental and resource conservation activities, the participants were asked whether this would cause environmental pollution if mobile phones were not included in the recycling. According to the results of the research, it was seen that the participants did not show a high awareness of environmental protection activities, and consumers needed more information about the recycling of mobile phone waste. Bai et al. (2018), it was seen that people in the 20-25 age group had the highest participation rate and all participants predominantly had a university degree; however, the results were found to be different from the research in Turkey. When the results are compared, it is deduced that consumers between the ages of 18-25 in Turkey have a higher level of awareness about environmental activities.

In the e-waste awareness research, the attitudes and behaviors of the participants towards e-waste recycling processes were examined. Respondents were asked how they handled their old device waste when they replaced their electronic devices. As a result of the examination, it was seen that only 4% of the participants took the waste device to the recycling center. However, the majority constituting 39% stated that they sold the device as second hand, 22% of them

kept the waste device at home, and a portion representing 7% stated that they disposed of the device as any household waste. This shows that the participants, who have a high level of knowledge about electronic wastes and the harms of waste, do not have enough information about the recycling processes or do not take action on recycling.

When e-waste evaluation habits in other countries are examined, according to the study conducted by Ongondo and Williams (2011) on mobile phone waste management in England, approximately 56% of the students keep the waste phone at home, 19% give it to someone they know, 9% It is seen that the rest donated for recycling. According to the study, while the majority of people who keep the waste device at home keep the device as a spare, about 30% of them do not know what to do about the waste device. Bai et al. (2018), on the other hand, according to the study on mobile phones in China, it was seen that 79% of the participants store their unused phone at home, 36% give it to their acquaintances as a gift, and about 15% sell it as a second-hand device through different channels. When the attitudes of consumers in China towards recycling are examined, it has been determined that only 5% of the consumers send the device back to the manufacturer and the majority have a negative attitude towards recycling activities. Finally, Sadik et al. (2017) with students in Bangladesh, it was seen that 47% of the students hid their waste electronic device, 34% repaired and donated it, and 20% threw it away as any waste. According to the study, the rate of people who do not properly dispose of the waste electronic device was calculated as 80% (Sadik et al. 2017).

When compared to the studies in the literature, it is seen that the majority of consumers both in Turkey and in other countries do not dispose of their electronic waste in accordance with the standards, and the rate of people who are actively involved in the recycling process has a very low rate. For this reason, it was determined that the study conducted in Ankara and Istanbul gave results in line with the studies in the literature. It is thought that the majority of the people participating in the study prefer to sell unused electronic devices for economic income, therefore they are more selective about throwing them away or storing them at home. However, due to the low recycling rates as a result of the research, young people between the ages of 18-25 should be made more aware of the recycling of e-waste and should be encouraged for recycling. According to the study conducted by Ongondo and Williams (2011) in England, it was seen that each incentive application has a different effect on students' inclusion of mobile phones in the recycling process. According to the analysis, the most effective incentive is cash payment, followed by the application of coupons, an easy-to-apply recycling service and the establishment of suitable recycling points. In Turkey, starting similar incentive practices that appeal to the young population, taking into account the research in the literature, will motivate future generations for recycling practices.

Suggestions

In this survey, the awareness levels of young people on e-waste concept and regaining activities were studied. Considering the results of this survey and previous literature studies, it was inferred that although most young people were aware of the effects and consequences of not regaining e-waste materials, there are still some applications need to be implemented by authorities to increase this level of awareness. Here are some improvement points and suggestions emphasized:

- In order to prevent the increasing number of e-waste materials, consumers should be informed properly about the content of the electronic products they buy.
- Authorized institutions should include topics on e-waste materials, their harmful effects and regaining procedures in the school and university curricula.
- The media sources mostly used by young people, specifically social media platforms, television and magazines should be used more effectively to inform a large number of young consumers. The content and accuracy of information should be inspected by authorized institutions.
- Consumers should be informed about the Turkish Regulation on Control of Waste Electrical and Electronic Equipments and responsibilities of all parties should be clarified.
- Authorities should collaborate with non-governmental organisations and educational institutions. E-waste bins should be placed and waste collection centers should be built to places such as dormitories, schools and campuses, where young people have easy access.
- Manufacturers and authorized institutions should start incentive programs to encourage young people to actively contribute to regaining activities. Consumers should be encouraged by financial support, especially by highlighting applications such as cash payments, bonuses, discounts and/ or coupons.

Conclusions

Today, with the acceleration of technological activities, electrical and electronic devices are frequently renewed and both functional and technological lifetimes of devices are shortened. As consumers prefer to buy new devices instead of having them repaired, the number of electronic devices that have completed their useful life and become waste is increasing day by day. The density of the substances contained in the waste devices poses a threat to the environment and human health. In addition, when the materials in the waste devices are recycled, the raw material needs of the countries are met economically. For this reason, many countries, including Turkey, are working to reduce the production of e-waste, to properly recover the produced waste and to dispose of non-recoverable waste in a standard way. Consumers play an active role in the recycling process of

e-waste. It is especially important for future generations to correctly understand the risks of e-waste on both the environment and human health, and to take precautions in advance for the coming years.

In the survey conducted on the basis of volunteerism, it was seen that despite the legal regulations and social responsibility projects implemented in Turkey, the awareness level of individuals between the ages of 18-25 on electronic waste and e-waste sustainability studies should be increased. Consumers in the relevant age group are theoretically aware of the risks posed by e-waste, but the majority of them do not actively contribute to recycling studies. It is of great importance that future generations reach a higher level of awareness about e-waste, in order to create permanent values for health, the environment and the country. For this purpose, joint studies should be carried out by authorized institutions, non-governmental organizations and educational institutions; more information should be provided and incentives should be implemented so that individuals in the relevant age group manage their waste appropriately.

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