To Whom it May Concern:

This paper is a sequel to the paper "Why U.S. Rural Residents May Have Felt Let Down by Long Run Economic Policies," that is currently under consideration by your journal. The analysis is relevant to everyone who struggles to understand why trickle-down does not occur, despite many people's hopes and beliefs that it should.

The paper delivers a new type of mathematical structure for two-sector economic modeling. We develop a broad-brush microeconomic model of the global economy, that includes money and revenues. The model emphasizes the interactions of demand elasticities with the money in circulation, sectoral revenues, and technological change via increases in productivity. Technological change in the model is exponential and systemwide. It need not reside only in production functions. Utility functions are not necessary in the model, with their associated implications that low-income persons have chosen this status.

We show how necessity sectors can fail to enjoy the financial rewards of economic growth at the leading edge, because necessity-sector business revenues do not grow in the way that revenues grow in leading edge sectors. To the extent that necessity industries (or sectors) are located in one region or another, such as farm regions, the whole region can become impoverished while other regions may not appreciate what is happening. The model also can explain staffing shortages in necessity industries, embedded within urban and suburban regions where housing becomes so expensive that low-income staff cannot afford to live in reasonable proximity to their jobs.

Not addressed directly in the paper is the following: Technical education as a cultural meme for a way out of poverty means that impoverished regions fall farther behind, with the brain drain, and that technical education is emphasized over moral education. This limits investment in non-financial aspects of the culture and can lead to unethical behavior throughout the system. The internet as a source of information downplays the value of human mentorship and can encourage behaviors that demoralize those who believe that moral probity is the backbone of civil society.

We prefer that the two papers be published separately, this one second, but we are open to discussing the best option for offering this material to the profession. Thank you for your consideration.

A LONG-RUN SECTORAL GROWTH MODEL, WITH MONEY

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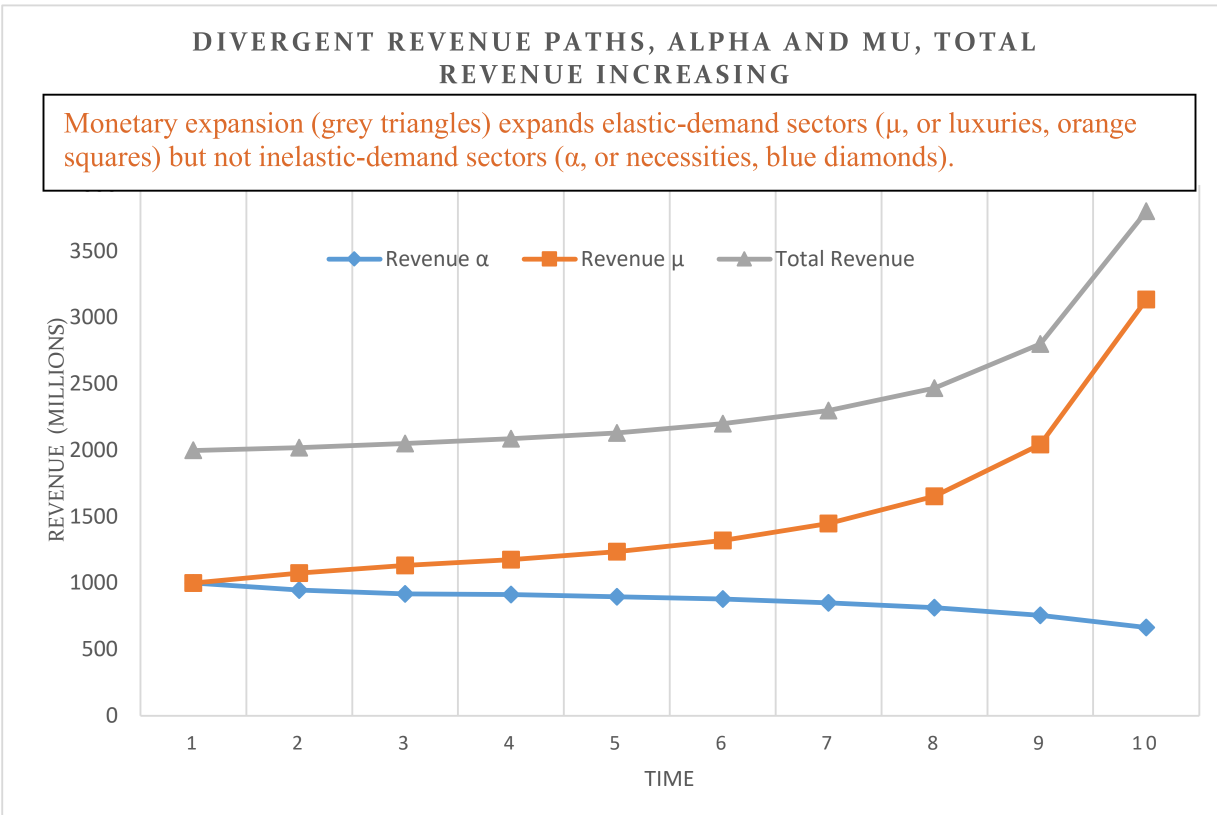
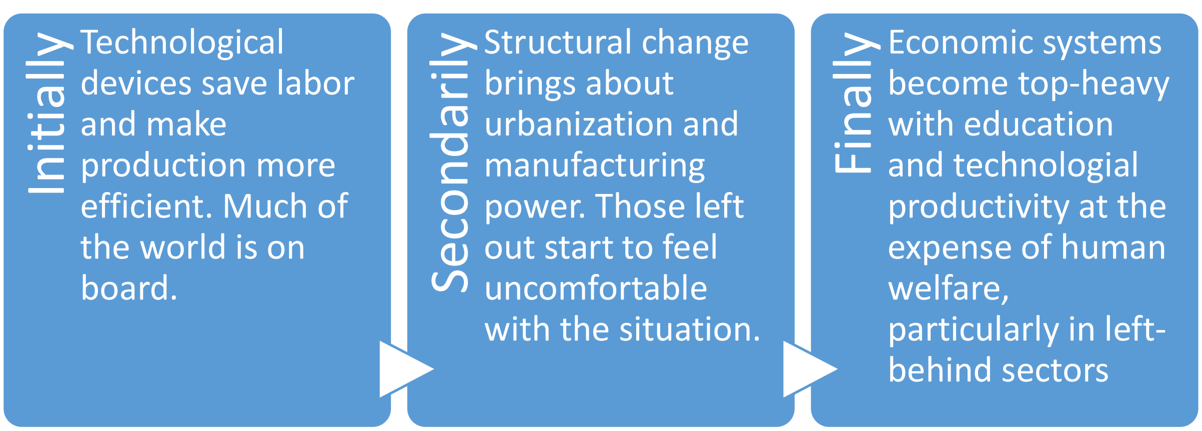
A Long-Run Growth Model: Productivity Increase in Two Sectors, with Money and Revenues





A Long-Run Sectoral Growth Model, with Money

ABSTRACT

As poverty traps persist locally and globally, and staffing shortages worsen, we must explore the particular impact of market systems on the supply of necessity goods and services. This paper offers a framework for doing so. The model separates necessity industries from luxury industries, clarifying the process that generates free-market bias toward luxury industries, with little hope for intersectoral trickle-down as productivity increases.

The model was designed to explain long-run urbanization and urban bias. It emphasizes the interaction of exponentially-increasing productivity with empirical demand elasticities, rather than exploring capital deepening, investment, and utility functions. We provide a sectoral (including rural-urban) approach to the distribution of incomes and wealth, rather than a capital-labor approach. In the model, sectoral revenues drive the long run path of business and economic activity, rather than marginal analysis and equilibrium. Policy suggestions include tightening the money supply; allowing price collusion in necessity sectors; or economic planning.

Key words: Growth, Technology, Dualism, Poverty, Agriculture

JEL Codes: O41, Q17, E10

1. INTRODUCTION

This paper presents a model of diverging revenue paths. It is a two-sector microeconomic model of the macroeconomy, with money. The model suggests that as resources move into leading edge sectors, the consequences are adverse for necessity sectors. This analysis affirms and explains the “left-behind” narrative that some analysts believe does not exist. If we wish to eliminate poverty and its associated discontent and dysfunction, up to and including violence, suicide, and addiction, we must come to grips with this economic reality.

The mathematics is straightforward. It shows how a law like Engel’s law operates to concentrate revenues within luxury industries, at the expense of revenues to necessity industries, with the agricultural sector being our primary example. Johnson [1991] concurs with this role for Engel’s law, although his policy conclusions are different from those suggested here. The resulting divergence of sectoral growth paths is both cumulative and international, with no tendency to return to equilibrium.

The reason is that – in a wealthy market system with productivity advance over the long run – revenues and resources enter industries with elastic demand and exit industries with inelastic demand. This might be acceptable if consumers preferred the product of the industry with elastic demand. But food, a necessity – based on farm, or agricultural, commodities – is fundamentally more important to human beings than most other types of material possessions.

2. PLACEMENT OF THE MODEL IN THE LITERATURE

None of the prevailing advanced-country growth models explore rural poverty in the way we do here. One-sector economic growth models [Acemoglu, Ed., 2004] explore an economic system as though all parts of it move together, unlike our two-sector model. City-growth models explore how income inequality develops via agglomeration externalities [Sattinger, Ed., 2001; Aghion and Williamson, 1998]. There is usually less interest in the causes of rural poverty in these models. Typically, technological change and endogenous technological change models place technological change as an agent in the production function [Romer, 1990]. Rapidly increasing productivity, if included, occurs by feedback mechanisms in advancing sectors rather than exponentially throughout the system as in the current model.

Gollin's [2014] summary of dual-economy models indicates that it is customary to postulate some type of market imperfection that maintains duality. Non-equilibrium economics [Berger, Ed., 2009], although focused primarily on city growth, is where we start to see issues of divergence, rather than of market imperfections, addressed in the literature that acknowledges sectoral differences. Yet even these models ignore the role of money in directing economic growth and change. In them, circular cumulative causation generates positive feedback which increases a region's advantage faster than equilibrium can be restored. That literature concentrates on real effects, such as the productive efficiencies of economies of scale, clustering, and supportive institutions, whereas the present work stresses money, or revenue, effects.

In the context of leading-edge industries and their associated networks of resources [Krusell, Ohanian et al., 2000; Aghion and Williamson, 1998, 47; Ewers, 2007; Fujita and Thisse, 2002], we can reference the dynamics of a closed two-sector model, where the manufacturing sector and urban regions grow, so that regional income-shares diverge [Emerson 1992, 71-72; Sachs, 2005, 56, 62, 70; Lal, 2013, 111, Berger, Ed., 2009]. Equilibration does not occur because the forces for divergence run ahead of the forces for convergence.

The present analysis does not require market imperfections in order to maintain and increase duality. That is, duality in the sense of urban bias, alongside rural and informal-sector disadvantage. We model a long-run worldwide declining revenue share for agricultural industry, when countries are open to trade and markets operate efficiently. Our model owes much to the global consequences of income-inelastic demand, as contrasted with the properties of income-elastic demand. Gale Johnson [1991,87] points out the importance of Engel's law in agricultural economics and suggests that productivity-increase might send the industry into oblivion if food were not so important a product.

While the impact of this analysis may be most obvious in a rural-urban divide, the argument is also quite general, as it refers to necessity and luxury sectors or industries systemwide.

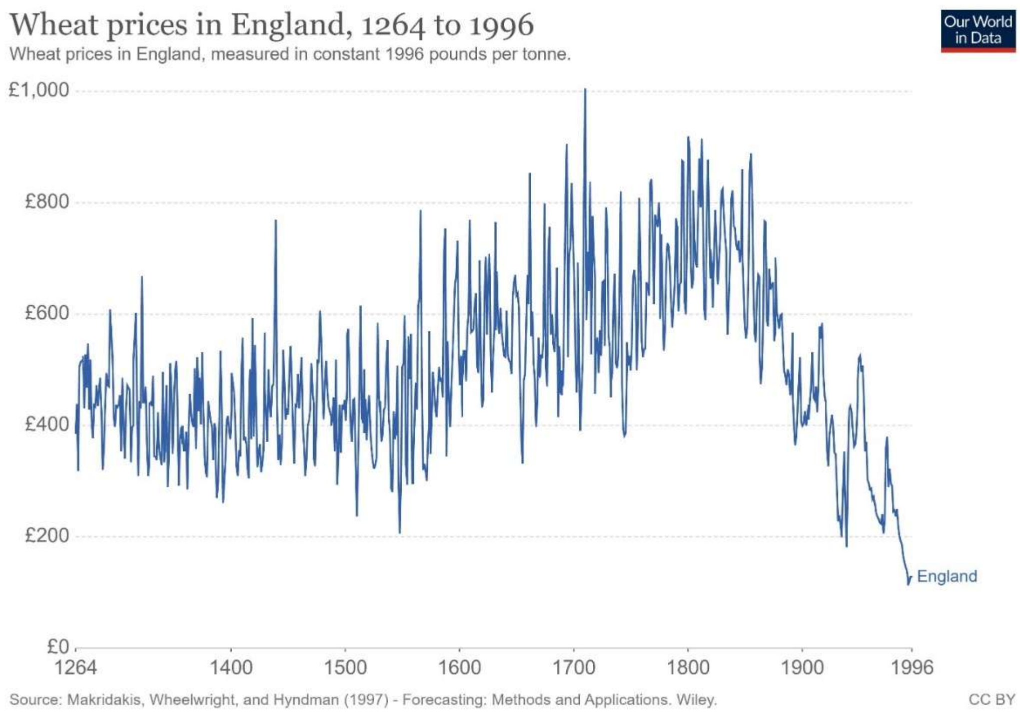
2.1. The General Result

The conclusion regarding the relationship between necessity industries and luxury industries applies in general, not only in the experiences of an agricultural sector (farming) and an urban-based manufacturing or industrial sector. It is stated technically, as follows: With increasing productivity in a market system, industries facing income-*in*elastic demand lose revenues over the long run to industries facing income-elastic demand. Figures 1 and 2 offer supporting evidence.

An analytical path toward this analysis may be found in Emerson [2025], where the idea of money-magnet industries (facing elastic demand, both income-elasticity and price-elasticity, and increasing revenues) and resource-losing industries (facing inelastic demand, both income-elasticity and price-elasticity, and decreasing revenues) was introduced.

With reference to Figure 1, recall that the Industrial Revolution took place in England from 1760 to 1840. Repeal of the Corn Laws in England took place in 1846, opening grain markets in England to the free market, or, as was argued at the time, to the capitalist ideal [Britannica.com, 2019]. Figure 1 suggests this had a profound impact on the price of wheat in England, where the secular trend in prices starts to decline in the mid-1800s.

Figure 1: Wheat Prices in England, 1264 to 1996.

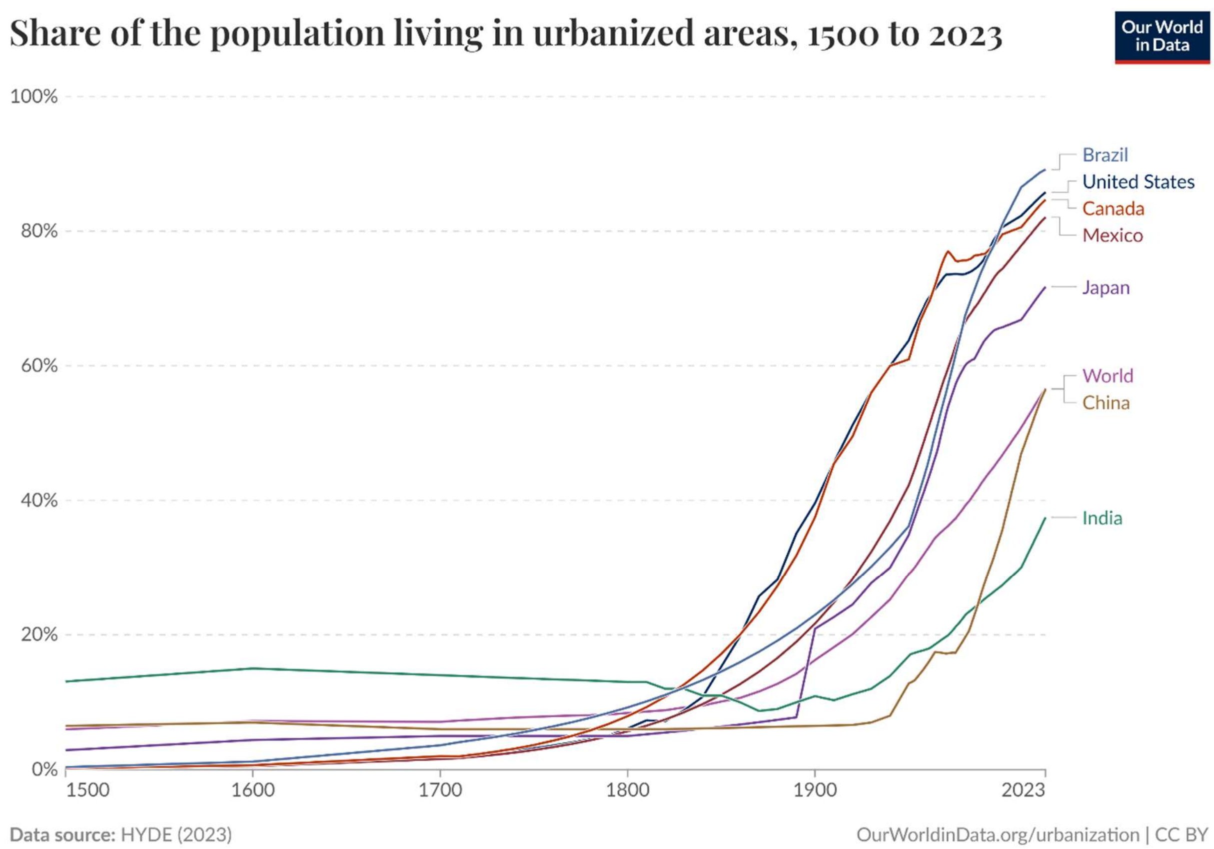


Source: Our World in Data: Food Prices (Roser and Hitchie, 2020); From Makridakis et al., 1997.

Wheat prices in England experienced a long-run trend decline starting around 1846. The figure is suggestive of the change in power structure and relative revenues from landowners to industrialists that occurred in England during the nineteenth century. In conjunction with figure 2 on the next page and figure 3 on page twenty-one, this is suggestive of roles for the Industrial Revolution and international free-market pricing in encouraging urbanization as a global phenomenon.

According to the customary analysis, as necessity industries become more productive over time, resources are freed to produce more things that people enjoy. This analysis sees mostly adjustment challenges and is not alarmed when necessity industries such as farming lose revenue share and resources relative to the rest of the economy. The loss of local labor for the seasonal harvest is not usually stressed in growth models, although we may assume that, before urbanization, a surplus of "hands" lived locally and was only needed for seedtime and harvest. These hands were presumably free to pursue other locally-enriching activities during winter and any summer off-season.

Figure 2: Urbanization is a global phenomenon



Source: HYDE (2023) – with minor processing by Our World in Data (2025): Urbanization.

Yet, in reality, as sectoral revenues decline and workers leave rural regions, so sectoral wealth in the form of access to well-equipped hospitals, doctors, libraries, lawyers, police and emergency services, universities and schools with many resources, also decline. Long-run declining revenues to one of the world's most important industries – farming – is a consequence of market pricing [Johnson, 1991].

Regional wealth suffers, even as individual wealth appears to be similar, systemwide [Dickie and Gerking, 1989]. The closed dual-economy model can deliver results such as these.[1]

3. A LONG-RUN TWO-SECTOR MODEL OF ECONOMIC GROWTH, WITH MONEY

The model presented here is an analysis of long-run economic growth; fluctuations may occur around the general trend, over periods of a year or a few years, for example if market conditions change temporarily. Markets for specific commodities, especially in the short run, may not follow the general sectoral trend for their industry. Our model assumes a long-run trend of increasing productivity, while understanding that short-run and local conditions may not follow the long-run trend at all times.

The role of increasing productivity in economic growth can be described as follows: "Most economic historians would surely endorse Paul Romer's view… that technological progress lies at the heart of long run economic growth," [Crafts, 2003]. And, "It has been shown, both theoretically and empirically, that technological progress is the main driver of long-run growth." [Chien, 2015]. In addition, "Technological progress itself is one of the major engines of economic development. It is also an important source of [earnings] inequality whenever it is not neutral, that is, if it affects differently the productivity of the various types of labour." [Aghion and Williamson, 1998, 80].

Thus, technological change is understood to be an important driver of long-run economic growth. What drives the direction of technological change has been a topic of debate. However, empirical results support a major role for demand [Schmookler, 1976]. Schmookler argues that the potential for economic gain (making money or, perhaps, saving money), which we argue is largely determined by demand for a product, determines the amount of inventive activity directed toward the making of that product.

Therefore, inventiveness and inventions will likely cluster in high-revenue industries and regions, where funds that may be directed toward innovation are plentiful. Inventive behavior will find fewer opportunities in low-revenue industries and regions, where funds for innovation are harder to acquire. (It has already been suggested that Engel's law implies high city revenues and declining agricultural revenues, in so far as cities generate many jobs and rural regions generate few jobs [Emerson, 1992]. More generally, leading-edge industries tend to draw in resources, while older, more-established or trailing-edge industries tend to lose resources.)

Rather than capital accumulation or capital deepening, we focus here on technological change as a driver of economic growth. We suggest that the main drivers of human inventiveness are the interactions of demand with opportunities for financial gain. [Schmookler, 1976; Chien, 2015]. The drivers of growth emphasized here are the interactions of demand – i.e. money spent – with technological know-how and, related, productivity advance. The model is a two-sector microeconomic model of the macroeconomy, with money. Its examination of wealth and incomes emphasizes different sectoral revenues rather than different factor incomes. As such, it can easily examine the impact of sectoral revenue on regional wealth, especially when similar economic activities tend to cluster in similar geographic areas or regions.

The technology variable, φ, is the total level of technological know-how in the system. φ grows exponentially. An advantage of this formulation is that φ grows exponentially without the need for endogenous feedback mechanisms. Another advantage is that φ (knowhow) can grow across all aspects of an economic system and, related, society. For example, sales techniques can improve, as can methods of media manipulation in pursuit of a goal. We show how demand conditions direct the kinds of new knowledge that are developed. Often, new knowledge serves advancing sectors rather than trailing sectors, potentially to the disadvantage of the whole system, which does depend on necessity (often revenue-trailing) sectors.

3.1 Technological know-how

Technological know-how spreads in a way that income (and the resources it can buy) does not, because two people can possess the same knowledge, as they cannot own the same income. Many types of technological advance proceed exponentially [Roser et al., 2023]. In the two-path sectoral growth model, technological know-how increases exponentially over time and spreads to both revenue-losing industries (sector α in the model), and revenue-gaining industries (sector μ in the model). It is economywide, or systemwide.

4. THE MATHEMATICS OF A LONG-RUN SECTORAL GROWTH MODEL

In the model, productivity advance interacts with different elasticities of demand for the outputs of the two sectors, and so direct the path of revenue-change.

4.1 Assumptions

The assumptions (following the letters preceding the relevant paragraphs below) downplay conventional sources of growth – savings, investment, and capital accumulation. Yet, the model shows that an increase in the level of technological know-how, *by itself*, as time passes, can generate diverging revenue paths for our two sectors, α and μ. α is the necessity-goods industry, represented by agricultural industry, and μ is the rest of the economy, approximated by an industrial sector including the latter's derived demands for services.

(a) $MV = K_1$, a constant. This assumption abstracts, initially, from the complications of working with money. MV is the quantity of money in circulation, approximated by the monetarists' equation, Money Supply (M) multiplied by the velocity of money (V).

The next two assumptions follow from the properties of consumers' demand. According to Johnson (1991, 81), "income elasticities [for food] decline as real per capita incomes increase." And (p.87) "there is no reason why [the income elasticity for food products] cannot approach zero."

To explain: the whole class of agricultural goods (especially food) are not substitutes in consumption for the whole class of other goods. We will eat food until we are comfortable, and then we will buy computers, but we will not weigh the choice between food and computers, no matter their relative prices, if we are starving.

Adam Smith (Smith in Heilbroner, 1986, 223) explains it this way: "The rich man consumes no more food than his poor neighbor. In quality it may be very different, and to select and prepare it may require more labour and art; but in quantity it is very nearly the same." He continues that the wish to satisfy other types of wants can expand almost endlessly.

Therefore:

(b) $\Sigma Q_{i\alpha} = K_2$. Price and income elasticities of demand for the sectoral output of sector α are infinitely *in*elastic, so that $\Sigma Q_{i\alpha}$, the sum of all quantities, Q_i, produced in sector α, is constrained by demand conditions to remain constant.

(c) $P_{i\mu} = K_3$, but only in the time period in question. Price and income elasticities of demand for the sectoral output of sector μ are infinitely elastic, so that $P_{i\mu}$, prices, P_i, in μ, are constant or infinitely elastic, in each time period, as each appears to producers. Each price can decline over time, as output increases while the money in circulation remains constant ($MV = K_1$). We can jusify this assumption by reminding ourselves that "wants are infinite" when it comes to luxury goods, as opposed to necessity goods, where we may consume only what we need.

Technological know-how can spread in a way that revenue does not, because two individuals can possess the same knowledge, although they cannot own – and spend – the same income.

The variable that represents productivity increase,[2] and explains the two distinct growth paths in the model, is the "overall level of technological know-how in the system", φ, and its exponential increase over time [Our World in Data: Technological Change, 2025; Our World in Data: mooreslaw, 2025]. Quantification of φ is beyond the scope of this paper, although we envisage the time period t = 0 to have occurred at least 11000 years ago, per Fogel [1999] which puts the first agricultural revolution at about 9000 years BCE.

Therefore:

(d) $\varphi = Ae^{rt}$, where φ is the level of technological knowhow across the system, A is an arbitrary starting point, e is a mathematical constant, r is a constant rate of growth, and t is time. Productivity increase is represented by increases in "the general level of technological know-how in the system", φ, as it increases over time.

To avoid confusing the analysis by the inclusion of population growth, and its associated increasing demand for food:

(e) Population remains constant. (It can be shown that population increase does not alter the conclusions.)

While there may be inter-regional barriers to factor-movements (in the real world), the analysis does not require them. Therefore:

(f) Markets are reasonably efficient, so that similar types of goods, services, and factors receive similar prices and incomes system-wide.

A departure from convention in microeconomic modelling follows:

(g) In working with the equations, there is no separation of the price from the quantity of output, nor the factor price from the quantity of factor inputs, although the discussion addresses conceptually how prices and quantities may change, together or separately.[3]

The model also references empirical demand characteristics rather than theoretical utility functions.

4.2 Equations

Each variable in the equations below is measured for the same time period as the others. Time enters the equations via φ (= Ae^{rt}). Prices and quantities, except for $\Sigma Q_{i\alpha}$ (= K_2), also change with the passing of time.

In order to investigate how α loses factors (and how μ gains them), a very basic production function is applied to each sector. Factor prices are represented by the variables ξ_i and the physical quantity of factor inputs by the variables F_i. Calling all factors F avoids complications from working with different categories and qualities of factors [Robinson, 1954]. Revenues can buy many different quantities and qualities of factors. We do not need to specify the particulars in order to explore the impact of declining (or increasing) revenues on access to resources.

(1) $$(\Sigma P_i Q_i)_\alpha = (\Sigma \xi_i F_i)_\alpha \varphi \quad = (\Sigma \xi_i F_i)_\alpha A e^{rt}$$

Equation 1 states that output of α (in monetary units) is a product of inputs in α (in monetary units) and φ, the level of technological know-how in the system; φ is an exponential function of t; however, demand conditions constrain $\Sigma Q_{i\alpha}$ to be a constant quantity (no population growth, so no increase in quantity demanded of agricultural commodities). Prices in α can change and are expected to decline as output increases following productivity increase. $MV = K_1$ so all prices decline on average.

(2) $(\Sigma P_i Q_i)_\mu = (\Sigma \xi_i F_i)_\mu \varphi = (\Sigma \xi_i F_i)_\mu A e^{rt}$

Equation 2 states that output in μ is a product of inputs in μ, and φ. There is no demand constraint on output $(\Sigma Q_i)_\mu$ in μ. $P_{i\mu}$ also may decline over time as output increases, but we assume elastic demand and constant prices, for now. In the real world, we may see technological prices remain about the same while functionalities of technological devices increase. Ae^{rt} is the same exponential function in both equations 1 and 2, because φ operates systemwide. We assume φ represents "embodied knowhow" and can apply across all aspects of the economic system, including the use of techniques to manipulate consumers' purchases, or "demand." We assume an infinite well of potential knowhow, only some of which is developed, becomes embodied and is therefore represented by φ.

(3) $(\Sigma P_i Q_i)_\alpha + (\Sigma P_i Q_i)_\mu = MV = K_1$

Equation 3 states that total output, (that is, output of α plus output of μ,) measured in monetary units, or revenue units, equals the money circulating in the economic system, assumed constant. (See Assumption a, above.)

4.3 Factor Markets

We can, also, look at the role of factors and factor-shares in the dynamics of this model, in the stylized situation where $\Sigma Q_{i\alpha} = K_2$ and one demand (in sector α) is infinitely *in*elastic, and the other (in sector μ) is infinitely elastic.

(4) $(\Sigma \xi_i F_i)_\alpha = (\Sigma P_i Q_i)_\alpha / \varphi = (\Sigma P_i Q_i)_\alpha / A e^{rt}$

For the RHS of this expression, we can see intuitively that, since r is constant, A is unchanging, and t increases, the numerical value of the denominator increases. The numerator, revenue in α, declines because the quantity is assumed constant and the price level declines over time, owing to more output with the same money in circulation. A simple numerical example suggests that 2/4 can change to 1/5. Thus, equation 4, the expression telling us what happens to total factor incomes in α over time, tells us that they decline, over time.

The price level (the average of the P_i variables) tends to go down as output increases, due to increasing productivity. It follows that, even though we want quantity demanded to continue to equal quantity supplied in sector α, there is likely to be inertial pressure for the quantity supplied in α to increase beyond the quantity demanded, OR for prices to stay higher than the new, lower, market price, or both. (Quantity in α, $\Sigma Q_{i\alpha}$, is constrained to be constant in the model.) We know that modern agricultural policy includes both price supports (the real-world equivalent of keeping $\Sigma P_{i\alpha}$ up) and destroying excess food (the real-world equivalent of keeping $\Sigma Q_{i\alpha}$ down).

We have shown that certain non-market events, such as price supports, are likely to occur, if the revenue to the *in*elastic sector is not to decline. This suggests that market forces do indeed tend to reduce revenue in sectors and industries facing *in*elastic demand, especially over the long run. Supporting evidence was offered in Figures 1 and 2 above.

We suspect that the interactions among *sectoral* elasticities (interactions among prices and changing quantities by sector) and economic growth have not been much explored in the literature. For example, a USDA [2019] table of elasticities estimated each elasticity for individual commodities, such as rice or milk, rather than for groups of commodities, let alone for a whole sector of commodities.[4]

4.4 Elasticities

In some economic models, it is customary to separate income effects from price effects in working with prices and quantities demanded. We avoid this complication by assuming an elasticity, E_E, that encompasses all influences on quantities via prices. We do not explore the different impacts of price changes, income changes, and the prices of other goods on quantities demanded. We believe that rapid changes in income are likely to cause income effects to dominate over price – and other – effects on demand elasticities, as may have occurred in Middle Eastern oil countries after the oil price rise of 1973.

In the model, as productivity increases and conditions change, we simply observe how revenues change in response to price and quantity changes, caused by whatever individual market circumstance may arise. We expect that the overall sectoral response will follow the long run trend – impoverishing growth for necessity sectors and enriching growth for luxury sectors. The model is intended to mirror empirical observations, specifically for labor markets but the argument also applies to other types of inputs to production. We attempt to make analysis easier, by keeping the mathematical properties simple while still consistent with empirical observations.

4.4.1 Working with elasticities: In the conventional analysis, for price elasticities, E_p

$E_p = (\Delta Q/Q)/(\Delta P/P)$. Or, $E_p = (\%\Delta Q)/(\%\Delta P)$.

For income elasticities, E_I

$E_I = (\Delta Q/Q)/(\Delta I/I) = (\%\Delta Q)/(\%\Delta I)$.

An overall elasticity, E_E, representing the total change in quantity, in response to the changes in all other variables including price and income, can be represented by:

$E_E = (\%\Delta Q)/(\%\Delta E) = (\Delta Q/Q)/(\Delta E/E)$

E_E represents the total elasticity response of quantity to changes in demand, in each of our sectors.

We assume E_E includes only changes in prices and quantities (Quantity as it responds to the impact of Everything – typically changes in incomes, own-prices and other-prices – on the demand-elasticity facing the sector).

In the model, demand for α, (the product of sector α) is infinitely *in*elastic. $\Sigma Q_{i\alpha}$ does not vary with any other influence on Q, unless we change the value of E_E. Demand for μ (the product of sector μ) is infinitely elastic

4.5 Dynamics of the model

In economics, sometimes we do not know the functional form of our postulated mathematical relationships. That is true in this case, so we will speak to increases and decreases in revenues, prices, and quantities rather than specifying a functional form.

Let us call revenue (= P_iQ_i) for each good, in each sector, R_i. Equation 3 now reads

(5) $(\Sigma R_i)_\alpha + (\Sigma R_i)_\mu = MV = K_1$

$\Sigma R_{i\alpha t}$ declines, because $\Sigma Q_{i\alpha}$ is constrained to be constant and $\Sigma P_{i\alpha}$ declines (the general price level declines as output increases, MV also assumed constant). $\Sigma R_{i\mu t}$ increases, because $\Sigma P_{i\mu}$ is constant and $\Sigma Q_{i\mu}$ increases (output increases, systemwide).

This means that $\Sigma R_{i\alpha t}$ declines and $\Sigma R_{i\mu t}$ increases, yet both still add up to $K_1 = MV$, a constant.

So, from one time period to the next, the following is true:

$$(6)\ (\Sigma R_{i\alpha t} - \Sigma R_{i\alpha(t-1)}) + (\Sigma R_{i\mu t} - \Sigma R_{i\mu(t-1)}) = K_{1t} - K_{1(t-1)} = 0 \qquad (MV = K_1,\ \text{constant})$$

Each K_1 is the same, so we can say that, in general, the loss of revenue in α equals the gain in revenue in μ. We have avoided the role of φ in this circumstance, because we explore what happens to revenues from sale of the output and not what happens in factor markets. The change in revenues is represented by

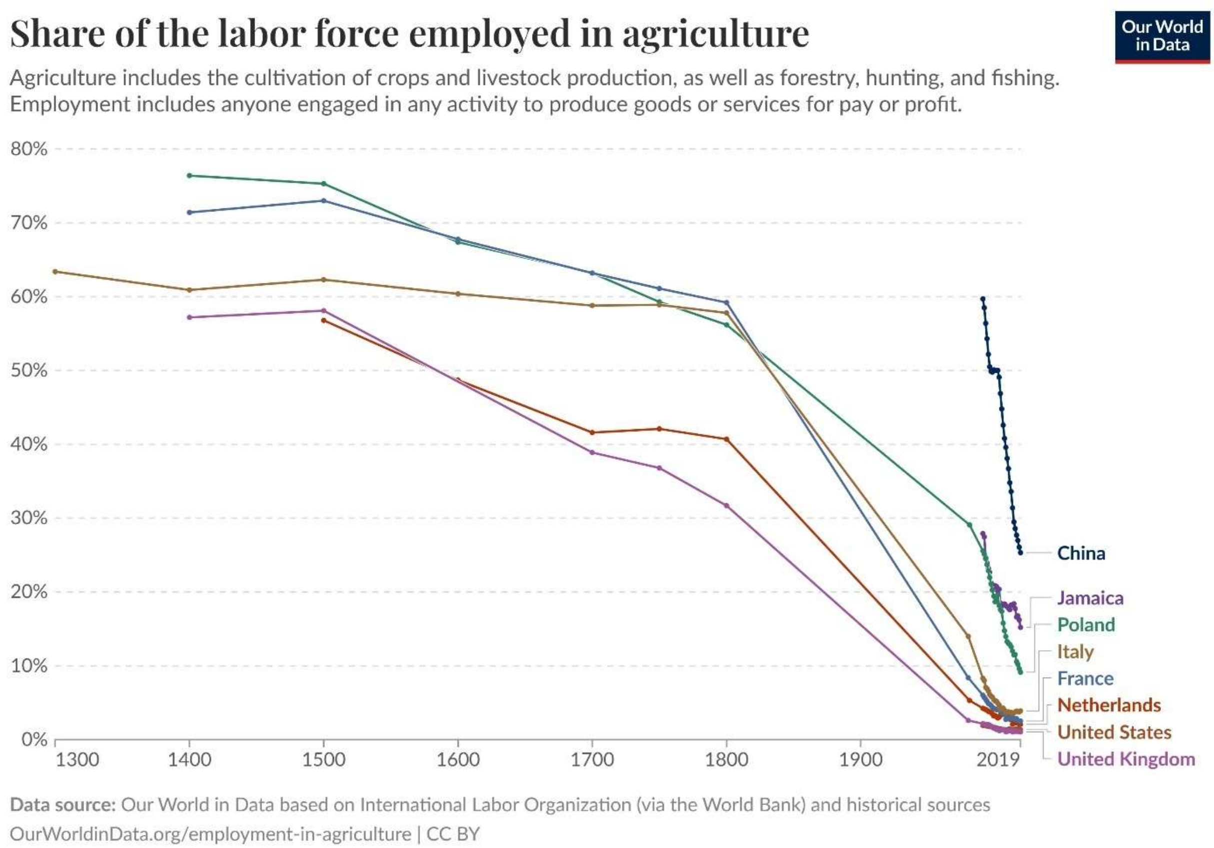
$$(7)\ \int R_{i\alpha t} - \int R_{i\alpha(t-1)} = -\left(\int R_{i\mu t} - \int R_{i\mu(t-1)}\right) \quad \text{or} \quad \Delta R_{i\alpha t} = -\Delta R_{i\mu t}$$

For an interval, say $t_{20} - t_{10}$, we can identify the changes in revenues over time as follows:

$$(8)\qquad (\Sigma R_{i\alpha(t20)} - \Sigma R_{i\alpha(t10)})) + (\Sigma R_{i\mu(t20)} - \Sigma R_{i\mu(t10)}) = K_{1t20} - K_{1(t10)} = 0$$

We can say "relative revenue" declines for sector α. This result is not in doubt, for advanced industrialized countries in the real world. See Figure 3, Percent Employed in Agriculture, 1500 to 2000. We wish to emphasize that our model affirms the "left-behind" narrative that some analysts believe does not exist. Our model offers a free-market explanation for this narrative and strongly suggests that global policy-makers pursue aims other than competition for ownership of the kinds of cutting-edge technologies that can destroy civil society, encourage violent opposition, and destroy ecosystems, if not the whole planet.

Figure 3: Percent of Labor Force Employed in Agriculture, 1300 to 2019, for Several Countries, including the United Kingdom, the United States, the Netherlands, and France.



Source: Our world in data: employment in agriculture, 2025

What happens is that resource-losing industries do not share in advancing-sector growth because they shed resources as they keep up with technological advances, AND any sector-specific inputs (including workers) tend to retain the low real incomes that they had prior to productivity-advance. They then get priced out of markets for other goods and services, when those prices are bid up by wealthier sectors. This situation is exacerbated by policies designed to keep the money supply expanding, and institutionalizing a low rate of inflation. These properties of the model will become clearer as the argument proceeds.

As productivity increases, if we expect quantity demanded to equal quantity supplied in necessity sectors, we will see some changes in market conditions for inputs, including factors of production, since demand remains constant at $(\Sigma Q_i)_\alpha$. Specifically, productivity increases so that demand for inputs declines. As time passes and φ increases in our model (representing productivity increase, systemwide, over time), the only way to maintain $\Sigma Q_{i\alpha}$ at its constant level, is for factors used in α, $(\Sigma \xi_i F_i)_\alpha$, to decline, in physical numbers or monetary value, or both. This follows from the relationship between $(\Sigma \xi_i F_i)_\alpha$ and φ. Rearranging (1):

$$(9)\ (\Sigma \xi_i F_i)_\alpha = (\Sigma P_i Q_i)_\alpha/\varphi \quad = (\Sigma P_i Q_i)_\alpha/Ae^{rt}$$

That is, total factor income in α (= $\Sigma \xi_i F_i)_\alpha$ is derived from the ratio of $P_{i\alpha}$ to φ (second expression, because $\Sigma Q_{i\alpha}$ is constant). Then, as φ increases and factor prices decline (all prices decline, on average), the only way for revenue in α to maintain its level, would be for factors (LHS) to leave the sector, α, AND for the price in α (RHS, third expression) to increase.

Similarly for Sector μ, rearranging (2):

$$(10)\ (\Sigma \xi_i F_i)_\mu = (\Sigma P_i Q_i)_\mu/\varphi \quad = (\Sigma P_i Q_i)_\mu/Ae^{rt}$$

When we look at what happens in factor markets, we use the following equations:

$$(11) \qquad (\Sigma \xi_i F_i)_\alpha/\varphi + (\Sigma \xi_i F_i)_\mu/\varphi = MV = K_1$$

Multiplying by φ, we get

(12) $(\Sigma\xi_i F_i)_\alpha + (\Sigma\xi_i F_i)_\mu = MV\varphi = K_1\varphi = K_1Ae^{rt}$

In equation 12, total factor income in α and in μ is derived from the product of total revenue and φ, which is represented by the expression Ae^{rt}. Thus, total factor income is an exponential function of the money in circulation (assumed constant and equal to K_1). Therefore, the nominal value of total factor income increases over time. This formulation of the situation highlights a role for other inputs in establishing the price level in factor markets. That is, in addition to competition among the customary factors of production – land, labor, and capital – there will be competition among all types of inputs, for a share of the production (sold as output) revenues. This includes intermediate inputs and will be addressed further in the discussion below.

Let us call factor income ($\xi_i F_i$) for each factor, in each sector, I. Integrating with respect to t, from (12),

(13) $\int I_{i\alpha} + \int I_{i\mu} = \int MV = \int \varphi \, dt = \int K_1Ae^{rt} \, dt$

The integral of K_1Ae^{rt} dt is

$K_1A(1/r)e^{rt} + C$ [Symbolab extension, 2025]

Therefore, we get

(14) $tI_{i\alpha t} + tI_{i\mu t} = K_1A(1/r)e^{rt} + C$

K_1, A, and r are all assumed constant. Factor Income I is not necessarily a function of t, because each factor is independent of t, and each wage can depend on many things, not t in particular, so that when we integrate I with respect to t, we multiply I by t. In general, we have said, the price level will decline (MV held constant), and relative sectoral income to α will decline and can purchase fewer inputs relative to what it could have purchased before. The relationship of individual factor incomes in α to the passage of time is more complex, since factor productivity increases with time.

Factor mixes will likely change in favor of technological devices, as they become less expensive relative to workers. Emerson (1992) explored preliminary data relating outmigration of workers to "increases in numbers of tractors in the self-managed sector" in Algeria. Outmigration from a region was statistically significant in relation to this variable, unlike the results for variables more-often suggested, such as population pressure.

Let us explore factor-incomes in the model. In equation fourteen, the expression on the RHS grows exponentially with t. That is, total factor income grows exponentially with t. Individual factor incomes may not. Each I equals each R divided by φ, which latter increases and, in this model, is assumed the same in both sectors, and the same across each sector. Since C is an arbitrary constant, it will disappear when we perform an interval calculation (Gow, 1960).

Multiplying equation 14 through by r and subtracting the beginning time from the ending time, we get

$$(15) \qquad r(tI_{i\alpha t} - tI_{i\alpha(t-1)}) + r(tI_{i\mu t} - tI_{i\mu(t-1)}) = K_{1t}Ae^{rt} - K_{1(t-1)}K_1Ae^{r(t-1)}$$

$I_{i\alpha}$ (= $R_{i\alpha}/\varphi$) declines, while $I_{i\mu}$ (= $R_{i\mu}/\varphi$) increases, and the total of all factor (or input) incomes (= $(\Sigma R_{i\alpha} + \Sigma R_{i\mu})/\varphi) = \Sigma I_{i\alpha} + \Sigma I_{i\mu} = MV = K_1$) remains constant. That is, in factor markets, K_1 remains constant, but t changes. This means that the change in total factor incomes is an exponential function of the (constant) quantity of money in circulation. And it changes in a different way from the change in revenues! (See equation 8 above, for the way that revenues change.)

We can explain this in terms of derived demand. Sales revenue buys inputs, and input types are used across the whole system. Therefore, their value is related to the rate of technological advance across the whole system. If there are more items (advance in productivity), the overall price level is lower (Money circulating is constant). This is a lower value of output over time, in exchange for money, on average. Similarly, as more inputs are created, they also have lower prices on average. Unless inputs increase in proportion to increases in outputs, the price level in input (or factor) markets is unlikely to be closely related to the price level in output markets. *We have, here, decoupled factor-incomes from output-prices, because we look at the purchasing power of revenues rather than at relative factor-prices, as other two-sector models may do.*

We also note that the intersectoral growth model has the potential to handle a situation where there are many inputs to production, including intermediate goods and not just factors of production such as land, labor, and capital. For example, if the "factor income" equation in the model could be set up to include intermediate goods as well as factors of production, we will see that the available revenues are spread even more thinly across inputs than if revenues purchase only the primary factors.

With regard to sectoral outputs and incomes (or sectoral revenues), rather than individual markets within sectors, we can argue that the price level will tend to be lower in the necessity sector as it loses revenues and there is a gradual adjustment of all types of inputs out of the sector. (Note in particular that the calculation of the CPI does not include rural prices.) And, in the luxury sector, the price level will tend to be higher as factors (or inputs) are attracted into the sector.

None of this factor-movement analysis is controversial, except for the idea that the differences move apart more quickly than adjustments can occur, so that necessity sectors continue to suffer lower factor-prices including the wage to labor, and luxury sectors continue to bid up input prices across the whole system, to the detriment of necessity sectors and workers. Non-equilibrium models have similar properties of divergence [Berger, Ed., 2009]. This paper argues, in particular, that monetary expansion exacerbates this situation; also, that some inputs are sector-specific, including specialized labor such as agricultural workers [Emerson, 1992]. These inputs can suffer particularly from lower compensation, relative to other products and workers.

How do we explain the decoupling of incomes from revenues, in terms of National Income Accounting? National Income Accounts hold $\Sigma P_i Q_i$ and the sum of human (worker or other factor-owner) incomes equal. Clearly, the relationships among revenues and incomes change as output increases, but the National Income Accounts will still hold the totals of Revenues equal to the totals of Incomes. We suggest that accounting conventions have been defined in such a way that the accounts will come out equal, but conceptually, something else may be going on. This perhaps has to do with the role of Value-Added in the National Income Accounts, or perhaps that of Investment [Baumol & Blinder, 2000, 541-545].

Investment and capital depreciation are hard to value in GAAP (Generally Accepted Accounting Principles), and in National Income Accounting as well. How do we determine a value for a depreciating asset that may have been purchased under one set of financial circumstances but now exists in another? At least one accountant [Mosso, 2009, 71] argues that national financial meltdowns could better be foreseen and mitigated if updated measures of business wealth were in place. In particular, he states that, "All balance sheet assets and liabilities, and changes in them, must be measured at fair value." He implies that, currently, they are not necessarily so valued.

In the next section we explore the relationship of revenues to elasticity, showing how we can solve the above equations for price and quantity, given some hypothesized values for the elasticity of everything in each sector, and the assumptions of nearly constant Q in sector α and nearly constant P in sector μ. We then discuss the implications of these results, including offering explanations for the left-behind narrative in real-world situations, rather than in the stylized situation of the model so far.

4.6 Elasticities, Prices, and Quantities by Sector

In our model, demand is represented by empirical values for demand elasticities, simplified to E_E, the elasticity of everything with respect to the relationship among prices and quantities. We do not reference utility functions in the model. Theoretically, all human beings, both rich and poor, could have similar preferences for quality and quantity of necessity goods. Their preferences for luxury goods might depend more on their individual personalities.

The elasticity formula, in general, looks like this:

$E_d = (\Delta Q/Q)/(\Delta P/P)$

Rearranging, we get Revenue (= PQ) = $E_d Q^2 \Delta P/\Delta Q$

In the limit, $\Delta P = dp/dt$, and $\Delta Q = dQ/dt$

Therefore, referencing our "everything" elasticity,

(16) $R_i = E_e Q_i^2 (dP_i/dt)/dQ_i/dt$

This formula could apply for each good, each sector, and each industry. We will reference our two sectors, α and μ, each comprised of many goods (i).

$R_{i\alpha} = E_{e\alpha} \Sigma Q_{i\alpha}^2 (dP_{i\alpha}/dt)/dQ_{i\alpha}/dt$ $R_{i\mu} = E_{e\mu} \Sigma Q_{i\mu}^2 (dP_{i\mu}/dt)/dQ_{i\mu}/dt$

According to the previous discussion, over an interval the revenue lost in α equals the revenue gained in μ. Theoretically, we can solve for the same interval in both α and μ, referencing, say $E_{E\alpha} = 0.9$ for α and $E_{E\mu} = -0.1$ for μ. We solve $R_{i\alpha}$ for ΔP ($\Delta Q_{i\alpha} = 0.01$ or empirically determined) and $R_{i\mu}$ for ΔQ ($\Delta P_{\alpha} = -0.01$ or empirically determined), then set the two results equal to one another. This should give us the relationship between price and quantity in each sector, so that we can put some real-world numbers into our equations. These theoretically determined values should give us a different perspective on relative valuations than the customary real versus nominal distinction. We would be exploring "value in use" versus "value in exchange." [5] For example, do these calculations yield similar results to what we get from price indices? Performing such an experiment is beyond the scope of the current paper.

4.7 Consequences for the sectoral analysis

We have set up a dynamic situation where the revenue in α plus revenue in μ equals the constant money in circulation and revenue gains in μ are offset by revenue losses in α We have avoided separating the price from the quantity, thus avoiding focusing on "value in exchange" as though it were "value in use" in our analytical framework. [5]

In the model thus formulated, the general price level must decline as output increases (MV assumed constant). If some goods are not profitable, other goods will be produced, and the general price level, including the average price in sector α, will still decline. We can now see that, when productivity increases systemwide, prices in α ($P_{i\alpha}$) decline, and revenue to α declines. This is true when we hold the quantity of money circulating constant.

In the model so far, all prices decline on average, but factor prices will only decline on average if more factors come into being.[6] Or, we could argue that a constant crop of factors now competes with other, manufactured, inputs for producers' money. It would be surprising indeed if there were a one-to-one correspondence between an increase in output and an increase in factors. Thus, factor prices (or, the general price level in factor markets) will likely not change proportionately with output prices (or, the general price level in output markets). This is extremely likely to be true in the case where increasing productivity over time implies more output per worker, over time.

That is, if one worker now doubles his or her output, but the quantity of money doesn't change, then the price of the output will be halved while the worker retains the same wage. Of course, this change will then ripple through the system. If the new (extra) output is not sold (in a necessity industry, such as that for agricultural commodities), the sector sheds resources, especially workers. One or a few jobs remain where once there were many. Then, there are likely to be many workers competing for these high-productivity and, in the ensuing months, relatively high-wage jobs. The final effect, we argue, is detrimental to society's most important industries – necessity industries. We define necessity industries, in this context, as industries with inelastic "everything" demand for their output.

Output quality is affected because competition for sales in a revenue-losing environment affects the product's input quality. To compensate for fewer or lower-quality inputs, farmers may produce output (food) that is no longer nutritious or natural. This can have adverse consequences for human health. Webb and Block, (2012) discuss the possible impact on the obesity epidemic of the production of cereals and high fructose corn syrup rather than legumes and fruit.

Feedback loops exacerbate the situation – more inventions designed to capture market share bring the price, and therefore the sector's revenues, down further. Further cuts in quality are necessary in order to produce food that can ensure a profit when the sector faces a new, lower, market price.

Thus, in our two-sector model, there are diverging fortunes for luxury industries (revenues expanding) and necessity industries (revenues declining). Nor is there likely to be a one-to-one correspondence *between changes in output prices and changes in factor prices, as there is in the neoclassical two-sector model with two consumption goods.* Or, even if there were, the necessity sector loses purchasing power regarding those factors, relative to the luxury sector.

In the present model, we can argue that the general level of factor prices declines, as (or if) the number of factors increases, system-wide, because factor-inputs compete with one another and with intermediate goods for the attention of business managers who allocate revenues.

We will probably see a mismatch between the need for factors and the system's demand for output. For example, there will likely be too many workers system-wide [W. Arthur Lewis, 1954] compared to an initial state, and now the workers must distinguish themselves in some way or another in order to be hired. Today, we can update the Lewis model from one where unemployed workers have a zero marginal product to one where they have a negative marginal product – they require food and water, at a minimum, and offer no productive work in return. Therefore, the productive economy must subsidize them or appear remarkably cruel.

It is reasonable to assume that numbers of workers, including worker-hours, do not increase as quickly as productivity (quantities of output) increases. It takes longer to produce a well-functioning human being than to increase machine productivity in business. A role for education in labor markets may be inferred from the fact that business owners in a high-revenue industry have discretion over who is hired. Yotopoulos and Nugent [1976, 232-3] find a role for job-competition in U.S. labor markets. If job-competition is based on paper qualifications, this will likely lead to over-education, diploma mills, and displacement of good workers, with little formal education, by others with more education. Discrimination may become relatively costless because there appear to be many qualified applicants for a position.

The pattern of behavior will look like this: Holding MV constant, factors move from α to μ, as the revenue in α declines and cannot support as many well-paid (and apparently well-qualified) factors as before. Prices decline but factors prefer higher pay, other things equal, especially if re-training costs are minimal. This phenomenon can explain selectivity of migrant streams [Connell et al., 1976; Emerson 1992] and an appearance of skill-biased technological change [Sattinger, Ed., 2001].[7] In μ, by contrast, as φ increases over time, product revenue to μ $(\Sigma P_i Q_i)_\mu$ increases, and total factor incomes $(\Sigma \xi_i F_i)$ in μ also increase. The quantity and educational quality of workers in μ increases, which parallels what happens in the real world. We can call this skill-biased technological change; or we can call it a tendency for high-revenue industries to attract money and resources, including educated workers who are paid to increase productivity and revenues. We would also expect that more of other resources – not merely workers – including commodities and intermediate goods, and other factors such as land, would be attracted to the advancing (μ), or luxury, sector.

4.8 When MV increases

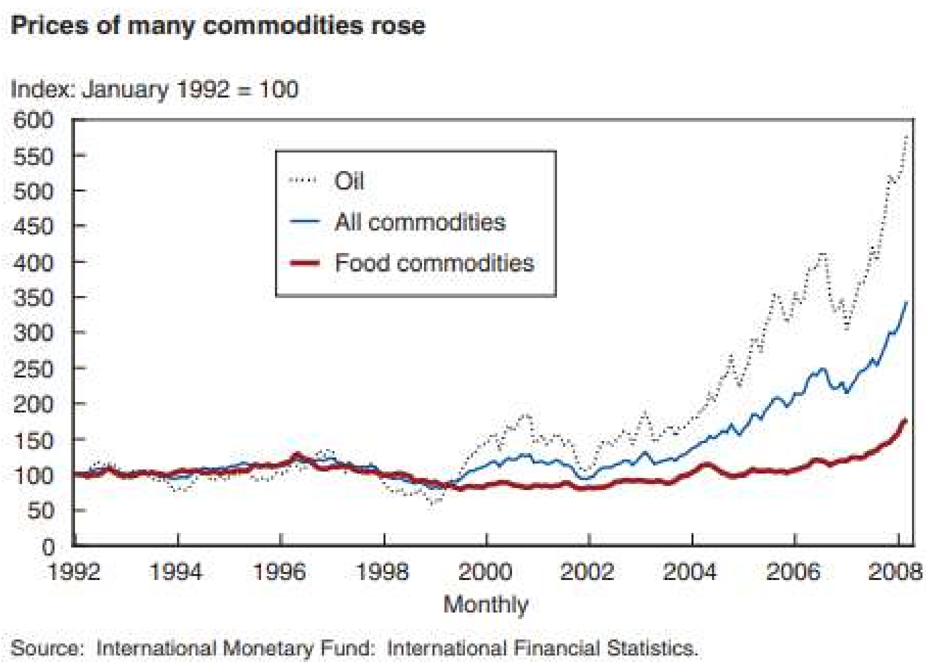
It is harder to see that sector α is worse off, when the quantity of money circulating increases. Yet, the model as established does have this result when the assumption that $MV = K_1$ is relaxed.

For the impact of an increase in MV on this system, we let $MV = \mathscr{M}$ (curly M) increase over time. $\mathscr{M}$ equals $M_0 e^{st}$, where s is another constant growth rate, different from r. M_0 is the initial money in circulation, which does not change as $\mathscr{M}$ grows. φ already increases over time. The impact of two growth rates on revenue, and therefore factor, disadvantage in necessity sectors is greater than the impact of only one growth rate. Here is a simple example, re-creating equation 14:

$$(17)\quad \int R_{i\alpha} + \int R_{i\mu} = \int MV = \int (M_0 e^{st})$$

Now, we see more (monetary) total revenue growth, even as nothing else has necessarily changed. $\Sigma Q_{i\alpha}$ is still assumed constant, and $\Sigma P_{i\alpha}$ will still decline relative to the overall price level. This is illustrated by Figures 4 and 5. Although many commodity prices rose, agricultural inputs rose less in price than others, so that we may assume their relative price declined.

Figure 4, Prices of Many Commodities Rose, But Prices of Food Commodities Rose Least



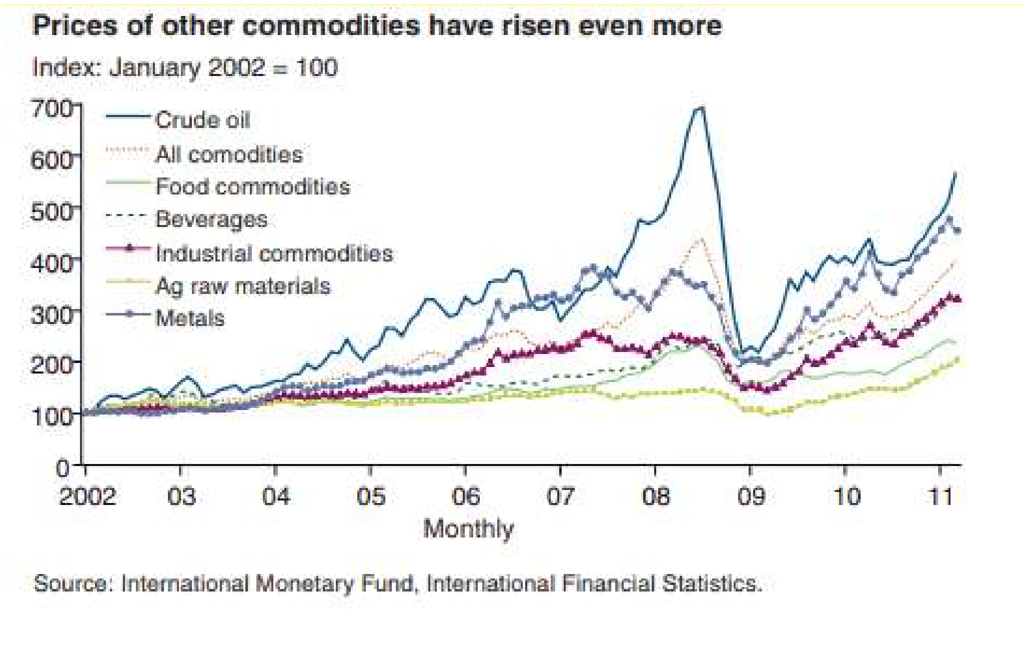
From USDA ERS (Trostle, 2008)

Therefore, $R_{i\alpha t}$ still declines relative to $R_{i\mu t}$. Or some non-market intervention must occur, to maintain farm incomes (= $(\Sigma P_i Q_i)_\alpha$ = desired healthy farm revenues). We show this, as follows:

When we integrate $M_0 e^{st}$ dt, we get:

(18) $\int M_0 e^{st} = M_0(1/s)e^{st} + C$ [Symbolab, 2025]

Figure 5, Food Commodities Prices and Agricultural Raw Materials Prices Rose Less than Other Commodity Prices



from USDA ERS (Trostle, et al., 2011).

Therefore, $R_{i\alpha t}$ still declines relative to $R_{i\mu t}$. Or some non-market intervention must occur, to maintain farm incomes (= $(\Sigma P_i Q_i)_\alpha$ = desired healthy farm revenues). We show this, as follows:

When we integrate $M_0 e^{st}$ dt, we get:

(18) $\int M_0 e^{st} = M_0(1/s)e^{st} + C$ [Symbolab, 2025]

For an interval, say t20 – t10, we can identify the changes in revenues as follows:

(19) $(tR_{i\alpha t20} - tR_{i\alpha(t10)}) + (tR_{i\mu t20} - tR_{i\mu(t10)}) = (M_0e^{st20}/s - M_0e^{st10}/s)$

The second expression is positive ($R_{i\mu(t20)} > R_{i\mu(t10)}$) and ($t_{20} > t_{10}$); the RHS is positive, unlike the case where MV = K, when the RHS is zero. $Q_{i\alpha}$ is still assumed constant; $P_{i\alpha}$ remains the same or declines unless the increase in the quantity of money circulating exceeds the increase in output. Thus, unless we have inflation, the revenue to α remains constant or declines and all the gains from the increase in $\mathscr{M}$ accrue to μ.

It looks as though all the revenue increase that arises from expanding the money supply ends up in the leading edge, elastic-demand sector, μ. The inelastic-demand sector remains impoverished or perhaps even becomes poorer. This is a version of Keynesian economics that looks like, not an unemployment equilibrium, but a situation where there is a low-revenue sector that stagnates and a high-revenue sector that grows. We have here modeled one of the puzzles of the poverty literature, whether local or global. (Why do poor people stay poor? What is "Urban Bias" [Lipton, 1980]?)

In such a case, demand from the growing (wealthy) sector bids up all prices, including non-sector-specific necessity input prices, and hence causes individuals and businesses still in necessity industries to be priced out of the market for non-sector-specific necessity goods. Plenty of examples of this phenomenon are mentioned in the literature [Sachs, 2005]. Housing prices are a good example, right now.

With regard to sector-specific fertilizer prices, also mentioned by Sachs, we must change the argument slightly and suggest that poor countries' farmers find it hard to compete with wealthier countries' farmers, who are often subsidized and can afford to bid up fertilizer prices on world markets.

In the more-general case, desired healthy revenues require non-market intervention for a sector or industry facing inelastic demand.

4.9 Inflation

This is where the price level increases enough that the nominal value of revenue in α increases instead of decreasing. Some analysts can argue that revenues to inelastic-demand sectors increase, so that, with price inflation, these sectors are not worse off than elastic-demand sectors. We need to explore the consequences of price inflation on a sector where revenue-share is decreasing, even as nominal revenues increase. We need to discover whether or not workers and business owners in inelastic sectors are still worse off, as some of them may think.

Our main line of attack is now to distinguish between price-elasticities of demand and income-elasticities of demand. If our two sectors can experience wealth (or income, or revenue) increases in different ways within one nation state, as we suggest, then it is arguable that luxury sectors receive an increase in relative income when there is price inflation, while necessity sectors do not. We could then say that luxury sectors can afford more luxury goods while necessity sectors cannot afford more of anything.

There would be, of course, specific empirical values for elasticities and regional wealth that would apply to each region or each type of good. But in general, if increases in incomes do not cover increases in necessity prices, we will not see wealth, revenue, or income effects that compensate for the increase in the prices of necessity goods, when inflation bids prices up in general. We believe that this has been the case in recent years, especially after the pandemic when the money saved during quantitative easing found its way into the productive economy.

Krugman [2022] suggested that "This era of surging inflation has also been an era of very tight labor markets." He follows by stating that the percent increase in necessity workers' incomes is greater, in inflationary conditions with tight labor markets, than the increase in luxury workers' incomes. We here point out that, while the percent increase may be greater, the actual increase may be lesser. A 5% increase on $15 per hour (= 75 cents) is less, absolutely, than a 1% increase on $200 per hour (= $2). The people gaining the 1% increase will have more dollar votes with which to bid up prices, including necessity prices in times of scarcity, than the people gaining 5%. Volatility of commodity prices, over time, would seem consistent with this suggestion that demand from higher-revenue sectors bids up commodity prices in times of scarcity.

5. DISCUSSION

5.1 Application to the real world

While marginal analysis and price signals may be very effective at understanding the distribution and re-distribution of resources in the short run, we believe they are less appropriate for models of the long run path of economic change. Below are some additional examples of how our model can offer insights that have eluded this literature.

5.2 Labor Markets

5.2.1. Job-Competition. The model offers a framework for understanding job-competition. Yotopoulos and Nugent [1976, 232-3] discuss job-competition in U.S. markets. If we have many sectors or industries, each with a different elasticity of demand, we will find that money is drawn into the industries with the more-elastic demand, in a hierarchical (most-elastic to least-elastic) way. The most-desirable factors of production, in terms of money-making ability, will be drawn into the most-elastic demand industries, and other factors will slot into the lower-ranking industries.

This represents a kind of economic social Darwinism, where the industries which draw in the most and best resources advance or expand at the expense of other industries. If the most-elastic demand industries corresponded to the most pressing human needs, we might have nothing to worry about. However, that which human beings most need – food, water, clothing, and shelter for safety, not to mention love and care – count as necessities and are likely to have inelastic demand.

In particular, some types of human services are personal and specific, such as nursing, teaching, and home-making. If the system puts downward pressure on compensation and working conditions in these professions, we may lose nurses, teachers, and home-makers to more-lucrative professions.

5.2.2. Technological Unemployment. Further, the sectoral growth model has drawn attention to the fact that many other inputs compete with workers for producers' money. Computers offering personal advice; dating apps; computerized language classes; computerized editors, etc. are only a few of many ways in which machines are reasonable alternatives to human beings in society and in business.

When the society still wants the necessity work done, it can decline more-lucrative work to the people who traditionally perform the necessity jobs. This is discrimination. We suggest that the matter requires reconsideration, in terms of what policy is likely to be effective. Perhaps we need to increase the compensation and working conditions in many types of necessity industries – specifically, those that we prefer should never go away – so that we can attract the best workers into them, including those who traditionally have done work that is no longer wanted as much as it was in the past.

We suggest that, when the economic system rewards elastic demand industries to the point where *in*elastic demand industries (and professions) start to fail, something needs to change. Not only will we see discontent at lower socioeconomic echelons, but also, we will see upper echelons start to lose good service in necessity industries. This appears to be occurring, if we believe what many people around us are saying.

The present reasoning is consistent with some undesirable attributes of real-world market economies. The sectoral approach provides a warning regarding the future role of technological progress. As knowledge increases, especially engineering and technical knowledge, it is shared and accumulates in a way that revenues and the physical work they can buy does not, as stated above. Some consequences include:

5.2.3 A growing market system may encourage loss of community identity and values; it may reward unethical behavior. As the need to earn a living, wherever work may be found even if far from home, increases, some people move away from their home communities. For example, Hunja [2011] implies that crime in Nairobi is both 'warfare' and a way to gain income. [8] Campbell and Campbell [2005, pp. 251-341] describe a network of commercial interests motivated to suppress nutritional information when it threatens profits.

5.2.4. Some industries pay better than others. It is observable that some industries pay better than others. This is consistent with the idea that some industries attract more money than others. It is not necessarily consistent with the idea that higher-paying industries represent better value to society.

According to a report from the U.S. Bureau of Labor Statistics (BLS) [2018], 9.8% of total workers in farming, forestry, and fishing were classified as working poor; the working-poor rate of people in the labor force for 27 weeks or more was 4.5 percent. Groshen [1991], summarizes several studies: "a strong link between industry [earnings] differentials and industrial concentration (or profit rates) is found in all studies that search for it [six studies], except [one study]."

The above data suggest a) that earnings may not be tied very closely to the value of the marginal product, if indeed this can be determined, and b) that workers earn more in industries where there is more money per worker. From the two-path sectoral model, we may conclude that this is more likely to be true for leading-edge industries - typically industries for which the products face elastic demand – than for necessity industries.

5.3. International Economics

5.3.1. Closed versus open economic models. As regards the likely accuracy of the closed-economy model versus the open-economy model in a world full of economies open to trade, we can point to the volatility of commodity prices as further evidence that necessity industries are subject to something like Engel's law, even when countries are open to trade.

The reason is that, while the open-economy model approximates the situation in elastic-demand industries, it does not represent the situation in inelastic-demand industries, where world prices fluctuate in response to demand conditions. We have been encouraged to see shortages as supply, or supply-chain, issues. However, the industries (and the derived demands that flow from them) with higher revenues are better able to bid up the prices of scarce goods than are the industries and derived demands that are already at low margins and squeezed to maintain revenues.

Thus, when a commodity becomes scarce, the price is likely to rise as we would expect, but the assumption that the market will distribute the scarce resource in some sense fairly is not, in our opinion, appropriate. When, in the short run, the quantity supplied equals the quantity demanded of the newly-scarce commodity, we likely have a shortage, and the price of the commodity increases.

We can argue that countries and sectors with much revenue can be flexible as regards adapting to market circumstances. If one price rises, they can change their purchasing decisions more easily than sectors where purchases of necessity goods and services already involve really low margins. When a price rises, for these latter sectors, they have few resources with which to purchase an alternative. Farmers may have to manage without commercial fertilizer; individuals may have to choose between food and decent housing. Countries may go into debt.

In particular, empirical results confirm the Prebisch-Singer hypothesis [Baffes and Etienne, 2016; Cashin and McDermott, 2002]. The Prebisch-Singer hypothesis refers to the claim that the relative price of primary commodities in terms of manufactures shows a downward trend over time. The sectoral growth model can explain why. In our model, productivity-increases flood limited necessity markets globally. This is the closed-model solution, applied globally rather than to an open-economy nation-state.

5.4. Skill-biased technological change

The sectoral approach also can explain city growth in terms of high and increasing city *revenues*. This generates preferential demand for high-skilled labor [Emerson, 1992, pp. 71-72; Ewers, 2007; Kerr et al., 2017; Fujita and Thisse, 2002]. And, the sectoral approach can explain high incomes for internet gurus. Sattinger [2001, p. lxv] observes that “the titans [of the computer industry] often lack college degrees”. He states that economic literature addressing skill-biased technological change lacks an adequate explanation for this. Computer industry innovators can earn high revenues because the market for their products are wide open and appeal to consumers with the funds to buy them. We should also note that the computer industry depends heavily on networks, and networks tend to become natural monopolies. Likewise, international trade and package delivery industries depend heavily on networks. The preferred method of dealing with network monopolies used to be regulation, to protect consumers from excessive profits, rather than using anti-trust laws against them.

5.5 Development Economics

In development economics, empirical data suggest that there is a point below which poverty persists, and above which a country can start to grow. Sachs [2005, pp. 56, 70, 73] summarizes the issues.

The present sectoral model offers a candidate for the point from which a country starts to climb out of poverty, even if not all sectors within it do. According to reasoning underlying the sectoral growth model, the point at which revenue paths start to diverge arises when approximately 50% of an economy’s income

(= MV, conceptually analogous to GDP) is spent on μ. Using μ to represent the modern sector of a developing country, it follows that the modern sector starts to grow of its own momentum, as it passes this point.

The reasoning is as follows: As wealth, revenues and incomes increase, we need to investigate the role of income elasticity of demand in our model. We address income elasticities of demand in particular, in the following discussion.

5.5.1. Income Elasticities of Demand. E_I in the discussion below, is the income elasticity of demand.

$E_I = \%\Delta Q/\%\Delta I$

We assume that the income elasticity of demand for agricultural products is less than one, and for products of the rest of the economy, is greater than one. Empirical data in support of these assumptions are presented at note 4 in the endnotes.

Given these properties of income elasticities, it follows that each consumer will spend a higher proportion of any increase in income on the rest of the economy, μ, than on agricultural goods, α. That is:

If a consumer receives $100 in extra income, she has to allocate it between α and μ.
A higher income-elasticity of demand for μ than for α implies that
$E_{I\mu} > E_{I\alpha}$, so that $\%\Delta Q_\mu/\%\Delta I_\mu > \%\Delta Q_\alpha/\%\Delta I_\alpha$
It follows that

(17) $\%\Delta Q\mu/\%\Delta Q\alpha > \%\Delta I\mu/\%\Delta I\alpha$

Since the change in the consumer's income for consideration in the spending decision on μ (i.e., the product of the μ sector), equals the change in consumers' income for consideration in the spending decision on α (i.e., the product of the α sector), which both equal the change in the consumer's income, $100, it follows that:

(18) $\%\Delta I_\mu = \%\Delta I_\alpha = \%\Delta I = \$100$, so that $\%\Delta I_\mu / \%\Delta I_\alpha = 1$

it follows that $\%\Delta Q_\mu / \%\Delta Q_\alpha > 1$ (from equation 17 above) and $\%\Delta Q_\mu > \%\Delta Q_\alpha$

That is, the percent change in the quantity of μ purchased, for a given increase in income ($100 in this example) is greater than the percent change in the quantity of α purchased. This implies a revenue bias in favor of the non-agricultural sector, or urban regions.

5.5.2. Condition for Takeoff

In order for the above conclusion to imply that consumers will spend more of any increase in income on product μ, or the rest of the economy, than on product α, or agriculture, we must further assume that the percent of agricultural products in the consumer's original budget is less than 50%. The reason this assumption is necessary is as follows.

If μ takes more than 50% of the original budget, and $\%\Delta Q_\mu > \%\Delta Q_\alpha$, it follows that the increase in μ must be greater than the increase in α, both because the original quantity was greater, and because the percent increase is greater.

We propose this as the condition for take-off. For example, according to Sachs (1991, 73) "All good things tend to move together [on the ladder of development] at each rising rung: higher capital stock, greater specialization, more advanced technology, and lower fertility. If a country is trapped below the ladder, with the first rung too high off the ground, the climb does not even get started."

5.6. Zero-sum Games

In each moment, revenues and the incomes that comprise them, are a zero-sum game. The system pushes resources from sectors facing inelastic demand and declining revenues into sectors with elastic demand and increasing revenues, because of the nature of the interactions among revenues, prices, quantities, and the quantity of money circulating. This is a property of market systems that has been variously identified as Engel's law (in agriculture) and Baumol's Cost Disease (in services).

This challenge requires a different sort of intervention from other types of market failures. A few are suggested in the discussion below.

6. POSSIBLE POLICY SOLUTIONS

While this paper is primarily theoretical, it is based on empirical observations and is fairly successful at explaining others. For example, it can explain the temporary nature of relief offered by government pandemic spending (much of it paid for items that became incomes in the advancing sector, not in necessity sectors); it can explain the persistence of inflation after the pandemic (lockdown kept many consumers from spending on luxury items during the pandemic, but this pressure was released after economies reopened); it can explain labor shortages post-pandemic (some people left their challenging jobs and re-trained for easier ones that paid at least as well).

The analysis suggests a number of policy solutions, which are summarized briefly below. Similar suggestions may be found in Emerson [2025].

6.1. Tight Money:

If money-increase causes relative prices to change at the expense of agriculture-dependent regions and other necessity industries, this suggests an unorthodox response of monetary policy – tighten it, rather than create more easy money. Arguably, there has been too little monetary correction after expansionary policies during the last fifty years or so.

To avoid manipulating interest rates explicitly, we could increase the required reserve ratio instead. Banks could also do this on their own, without Federal Reserve mandates, and employ transparency in this regard so that consumers of bank services could choose safer versus riskier banks. This, obviously, requires further debate and discussion. Numerical examples, using the assumptions of the model offered here, suggest that inequality could be mitigated by such an approach. One such is given in the appendix to this paper.

According to Krugman [2022], “And tight labor markets typically lead to wage compression — that is, bigger [percent] wage increases at the bottom than at the top.” From context, Krugman means larger percent increases at lower socioeconomic strata than at higher strata.

Monetary tightening could bring us closer to equity than redistributing income to the poor. For example, since inequity remains huge, monetary tightening could further larger percent increases at lower socioeconomic strata. Perhaps we could tighten the money supply until it brings back some semblance of wage equity. The appendix offers a numerical example in which this occurs.

6.2. Other Options:

Investment in Agriculture-Dependent Regions; Selective Application of Anti-Trust Laws, allowing price collusion (but not wage collusion) in industries with inelastic demand, or dividing up the market in those industries; Encourage the public to buy local and understand the need to pay for good service, such as product advice, as well as for products. Encourage the public to understand that government provides the kinds of social services for which making a profit is unlikely, and needs tax revenue in order to do so.

6.3. International Policy Options:

Currently favored international economic policies seem to be investment in the leading edge – that is, in IT. Under current societal rules and laws, this may maintain the U.S. as a money-magnet economy, ahead of its rivals. The question is, is this the most important economic imperative facing us today?

Protection in the form of tariffs as an international strategy implies that we believe manufacturing goods can return, and wealth can follow. If, as here suggested, the new money-magnet industry is information technology (I.T.), including software services, and not the manufacturing of goods and services unrelated to I.T., then across-the-board protection of manufacturing industry would not achieve the goal of returning wealth to U.S. manufacturers.

7. SUMMARY AND CONCLUSIONS

In a market economy over the long run, incentives (including price incentives) associated with productivity advance, especially in elastic-demand sectors, direct revenues and therefore resources, toward luxury sectors (money-magnets) at the expense of necessity sectors (resource-losers). High-revenue luxury sectors are favored by economic incentives, at the expense of low-revenue necessity sectors. Expanding the money in circulation exacerbates this effect. Not only does this circumstance misrepresent the value of necessity sectors to society, but also models based on marginal analysis may have ignored its magnitude, as this has built up over time.

That is, some two-sector teachings in economics may imply that a one-time advance in productivity has a one-time impact, without sufficient consideration given to an ongoing tendency for the same type of productivity-increase to alter prices systematically across the board over the long run.

For example, ongoing skill-biased technological change in favor of standardized luxury goods that can be widely marketed globally (such as smartphones), caused by market forces acting in accordance with Engel's Law or its equivalent in non-farm sectors, as explained in this paper, will lead to market prices being too low for the kinds of knowledge that are local and specific, such as farm knowledge and excellence in personal services.

These market prices are too low in that they do not sustain a healthy industry or sector without non-market intervention. We, here, refer to prices as they represent Smith's value in use, rather than value in exchange, which latter is what the market price gives us. Value in exchange has much to do with the number of alternative goods and services available, and less to do with their actual importance to society, or value in use.

Our thought experiment, holding the money in circulation constant, is what demonstrates that values and relative values of goods and services, or value in exchange, are related more to the quantities of goods and services than to their actual importance, or value in use. The average price level will decline as quantities increase, holding money constant. It is not hard to see that individuals whose necessity-needs are satisfied will want to see more luxuries developed, and will bid up prices for the most-desirable luxuries.

What this paper emphasizes is that there is a cost to this behavior, in terms of poorer quality in necessity goods and services, especially for workers and other inputs in necessity industries, including in personal services. We anticipate that this poorer quality in necessity sectors, systemwide, will eventually be so prevalent that even wealthy individuals and businesses, who enjoy luxury goods, will want to see it addressed.

We developed a microeconomic sectoral growth model of the macroeconomy, with money, which highlights the long-run impact of declining revenues on necessity sectors, with the specific example of the agricultural sector and, related, rural regions.

Other undesirable aspects of free market economies may also be understood in terms of market prices that reflect value in exchange rather than value in use. Solutions offered here include tightening the money supply in order to bring prices into closer alignment with societal needs; allowing price collusion among necessity businesses (but not wage collusion); encouraging the public to buy local and pay for service as well as products; or economic planning; encouraging public support for taxation and government spending in situations that are unlikely to turn a business profit.

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ENDNOTES:

1.The sectoral growth model applies worldwide. It can represent the growth path of the global economy as well as of an individual country economy or a local area. Use of the properties of a typical closed model for the sectoral growth model is explained as follows.

The reader may picture the many countries on Planet Earth experiencing similar economic changes, in parallel over time, so that the whole global system behaves like one large – albeit complex – multi-sectoral closed model, over time. Closed models deliver impoverishing agricultural growth, or Engel's law [Kelley and Williamson, 1984, 102; 125, 183].

The typical open economy model does not capture the impact of Engel's law. This is because the price elasticity of demand for traded goods, including agricultural commodities, is infinite in these models and thus ignores income elasticities of demand. This matters for necessity sectors, if not so much for leading edge sectors. Johnson [1991] explains the importance of Engel's law for understanding global agricultural economics. He says farming might decline into oblivion if food were not so important a product [Johnson 1991, 87]. Aghion and Williamson [1998, 81] say, "…if greater equality is to be a target of economic policy, it has to be tackled directly since market forces by themselves will, most likely, not do it at all." Anderson [1987] seeks a reason that agricultural industry behaves as though it is in the closed model.

2.Productivity is the ratio of what is produced to what is required to produce it. Productivity increase is an increase in this ratio (e.g. more output for the same inputs).

3.Production functions in economic models have arguments that represent physical quantities (such as Q, K, L), but real-world economic data, representing those physical quantities, are measured in monetary units. For example, GDP, a measure of the output of the economy (what would be Q in a production function), is measured in monetary units. Therefore, we combine the two effects in order to incorporate money into the technical analysis.

And, Adam Smith [1994, 36] states that, "as a measure of quantity, such as the natural foot, fathom, or handful, which is continually varying in its own quantity, can never be an accurate measure of the quantity of other things, so a commodity which is itself continually varying in its own value, can never be an accurate measure of the value of other commodities." (He is referring to changes in quantities of silver or gold, as new mines are discovered, regarding their abilities to serve as money in the sense of a measure of value.)

Smith [1994, 35] also reasons, "Hence it comes to pass, that the exchangeable value of every commodity is more frequently, estimated by the quantity of money, than by the quantity either of labour or of any other commodity which may be had in exchange for it." Smith also sometimes writes as though the price and quantity are conceptually the same thing. For example, "Whatever part of the produce, or, what is the same thing, whatever part of its price, is over and above…." (Smith, 1994, 166)

4.The USDA website: https://www.ers.usda.gov/data-products/commodity-and-food-elasticities/download-the-data/ provided the following Excel file: demandelasdata092507_1_
4/16/2019 was the download date. It had been last updated 2006. Of all the estimations in the above-mentioned USDA database, for own-price and income elasticities, respectively, a high proportion were inelastic. The results, for the empirical measures of elasticities are as follows:
For own-price elasticities of demand, of 2803 estimations of own-price elasticity for various agricultural commodities, 2203 are in the inelastic range (that is, between 0 and -1). This is 78.59% of the total, 2803.2
For income elasticities of demand, of 1064 empirical estimations of income elasticities for agricultural commodities, 1010 are in the inelastic range (between 0 and 1). This is 94.92% of the total (1064).

5. Smith also speaks of the difference between value in use and value in exchange [Smith, 1994, 31]. He is familiar with how changes in productivity can cause changes in the value in exchange, as suggested in the text. Smith [Smith in Heilbroner, 1986, 194] explains how this can happen. "[As productivity advances, with the increasing division of labor,] All things would gradually have become cheaper…. But though all things would have become cheaper in reality, in appearance many things might have become dearer than before, or have been exchanged for a greater quantity of other goods." Thus, to paraphrase Smith, all prices can decline, but some prices change relative to others and may appear to increase.

6. The system can create inputs, other than labour, even with no population increase. Many kinds of capital inputs are manufactured, and human capital can be generated with education. Such inputs can increase in absolute physical quantities, just as output can, when an increasing revenue to μ gets distributed around the sector and the system.

7. Connell et al. [1976] suggest that selectivity of migrant streams is bipolar (that is, there are two types of economically-motivated migration, represented by two different types of migrant): “For the poorer migrant, migration is increasingly a wandering search for work…The ‘push’ migration of the poor…is increasingly rural-rural and circular; the ‘pull’ migration of the middle income groups…is overwhelmingly rural-urban; and in most cases involves initially the urban acquisition of secondary schooling, and subsequently urban work based on the resulting qualification.” (pp. 197-8)

8. Anecdotal evidence (Hunja, 2011) suggests the following behavioral response to the realities of life in Kenya: “as a Kenyan who moved from rural Kenya to Nairobi, I suspect that the more interesting development question is ‘why do Kenyans not want to live in rural Kenya’? I can attest that, particularly for the unemployed youth, urban poverty and life is much more depraving than the lives they lived in their ‘villages’. And yet they keep coming to the cities! Extreme urban poverty vs. the very ‘cushy’ lives of the urban elite has provided the fodder of an ‘army’ for the low scale warfare (called car-jackings, robberies, police shooting of criminals, etc.) that's ongoing.”

8. APPENDIX – NUMERICAL EXAMPLE

Figure 6 below represents an unchanging quantity of money in circulation. Figure 7 represents an increasing quantity of money in circulation. Figure 8 shows the quantity of money declining after the tenth time period. The quantity of money (circulating) is total income, or total revenue; gray triangles; this total income (revenue), is shared by both sectors.

Figure 6: Divergent revenue paths, two sectors, α and μ, quantity of money circulating is constant. The data for this figure are presented in Table 2, columns 1-10.

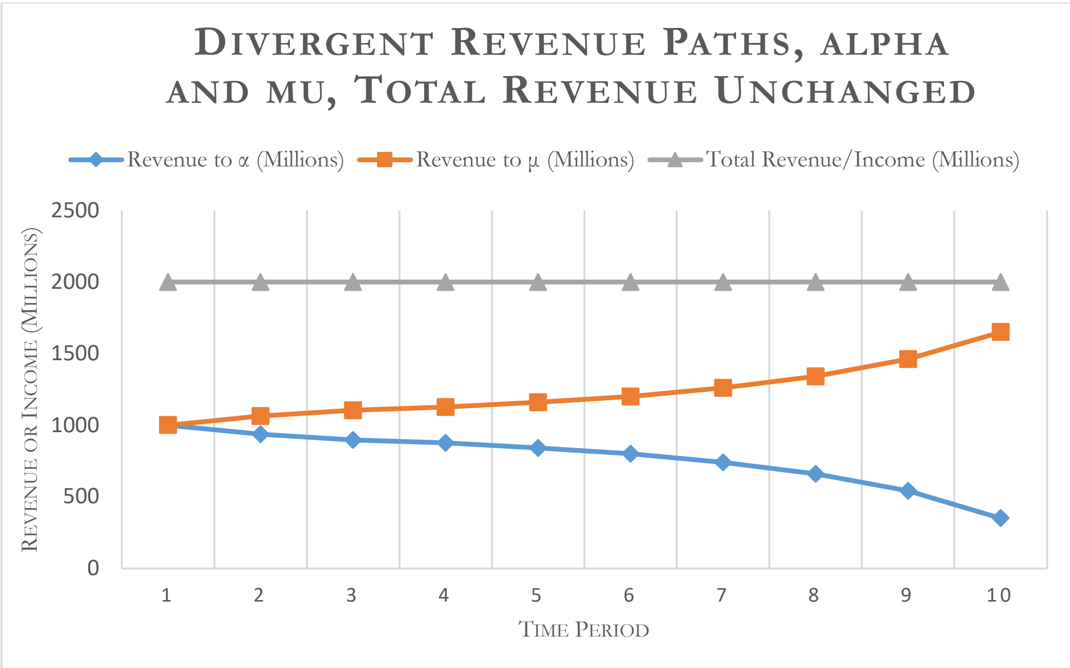


Figure 7: Divergent revenue paths, two sectors, α and μ, quantity of money in circulation increasing.

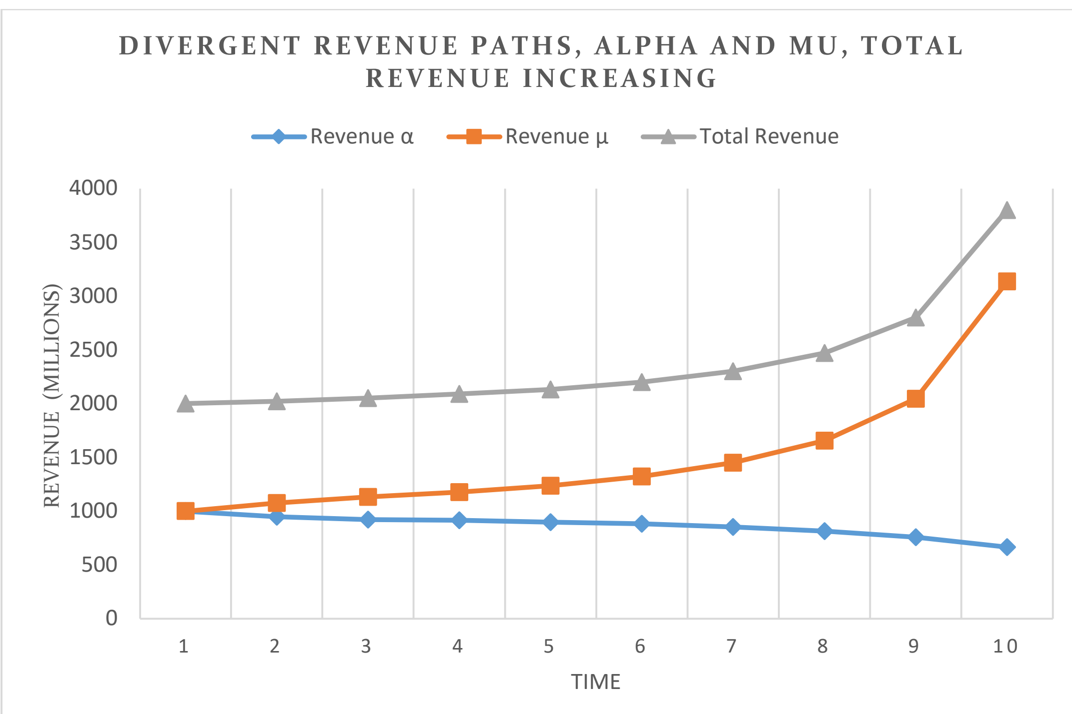


Table 1: Demand for Outputs of Both Sectors, MV increasing

	Alpha			Mu			
Period	**Quantity (Millions)**	**Price**	**Revenue (Millions)**	**Quantity (Millions)**	**Price**	**Revenue (Millions)**	**Total Revenue (Millions)**
1	100	10	1000	100	10	1000	2000
2	104	9.1	946.4	118	9.1	1073.8	2020.2
3	112	8.2	918.4	138	8.2	1131.6	2050
4	125	7.3	912.5	161	7.3	1175.3	2087.8
5	140	6.4	896	193	6.4	1235.2	2131.2
6	160	5.5	880	240	5.5	1320	2200
7	185	4.6	851	315	4.6	1449	2300
8	220	3.7	814	447	3.7	1653.9	2467.9
9	270	2.8	756	730	2.8	2044	2800
10	350	1.9	665	1650	1.9	3135	3800

Table 1: the relationships among time period, quantity demanded, price, and revenues, for both sectors as productivity increases, MV also increasing

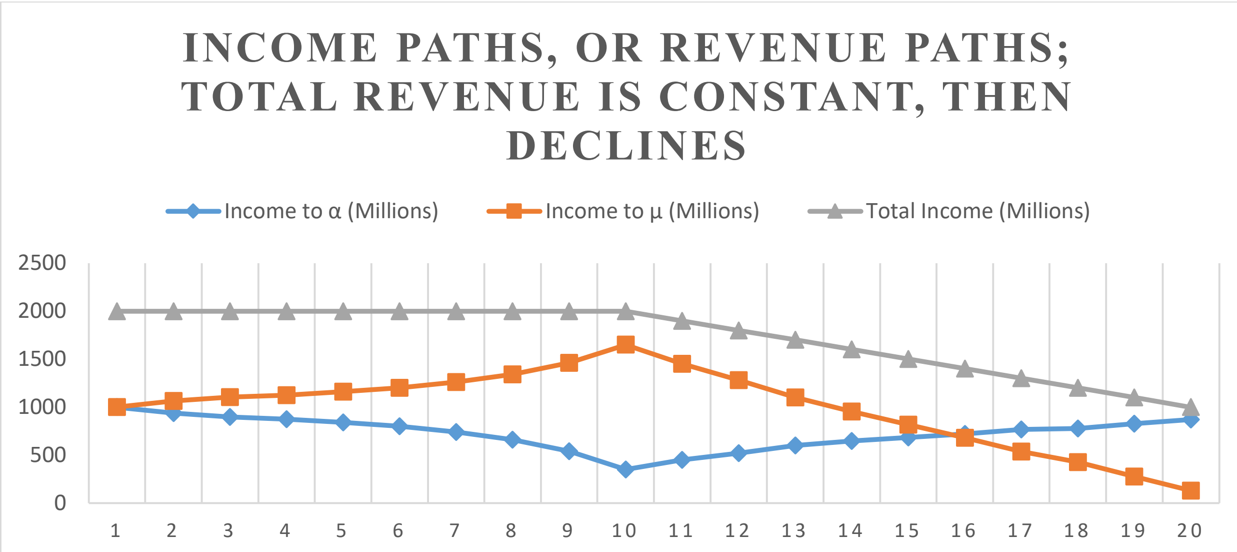
The two sectors, alpha (α) and mu (μ), are the same as in the text, with the same properties – when the price decreases for alpha (farm sector, blue diamonds), the income or revenue to the sector decreases; price increase means nominal revenue increase.

When the price decreases for mu (everything else, orange squares), the income or revenue to the sector increases; price increase means nominal revenue decrease. Table M, next page, shows the numbers, but it is not necessary to understand the details of the table in order to see what the figures suggest. For the interested reader, the table is designed such that α, the sector facing inelastic demand, has declining revenue when the money in circulation increases, and increasing revenue when the money in circulation decreases. The sector μ faces the opposite circumstance, by subtraction from the total money in circulation. Arguably, the model can explain the real-world phenomena of increasing money in circulation fairly well.

That is, we observe in the real world an expansion of luxury sectors, including leading edge industries, without much in the way of market trickle-down to the trailing edge. Since the trailing edge is necessity industries, often relying on human work rather than machine work, and since these industries are suffering from funding, staffing, and resource shortages that threaten to impede their functionality for everyone, this is a challenge we can ill afford to ignore.

Whether the real world would behave as the example implies, when the quantity of money in circulation decreases, is a topic for debate. One possible avenue for research on the data would be what happened during the pandemic, when people were not spending the large quantities of money generated by both monetary and fiscal policy in many countries, followed by what happened as economies opened up again at the end of the pandemic, when people started spending the money that had not been fully circulating during the lockdown.

Figure 8, revenue paths, two sectors, when the money circulating is first, constant, then declines.



As technological progress produces more of all goods, income (= revenue) to the sector μ (mu) increases while income (= revenue) to the sector α (alpha) decreases. After time period 10, when we reduce the money in circulation (a.k.a. total revenue, shared by both sectors; gray triangles), the relative fortunes of the two sectors reverse. As economic activity slows, α (alpha, farm sector, blue diamonds) gets a larger share of the total revenue, with the cross-over occurring at around time-period 16. At this point, people prefer spending on necessity goods, α, rather than on everything else (manufactures or luxury goods). Thus, as revenue declines, demand bids prices up for both goods, but demand is more robust in α. (Quantities of μ decline more than of α.)

Table 2 – Revenue to α, μ, and both; money circulating declines after Time Period 10

Income to α (Millions)	Income to μ (Millions)	Total Income or Revenue (Millions)	Quantity of α (Millions)	Price of α	Quantity of μ (Millions)	Price of μ	Time Period
1000	1000	2000	100	10	100	10	1
936	1064	2000	104	9	118	9	2
896	1104	2000	112	8	138	8	3
875	1125	2000	125	7	161	7	4
840	1160	2000	140	6	193	6	5
800	1200	2000	160	5	240	5	6
740	1260	2000	185	4	315	4	7
660	1340	2000	220	3	447	3	8
540	1460	2000	270	2	730	2	9
350	1650	2000	350	1	1650	1	10
450	1450	1900	300	1.5	967	1.5	11
520	1280	1800	260	2	640	2	12
600	1100	1700	240	2.5	440	2.5	13
645	955	1600	215	3	318	3	14
682.5	817.5	1500	195	3.5	234	3.5	15
720	680	1400	180	4	170	4	16
765	535	1300	170	4.5	119	4.5	17
775	425	1200	155	5	85	5	18
825	275	1100	150	5.5	50	5.5	19
870	130	1000	145	6	22	6	20

REFERENCES:

Acemoglu, Daron, Ed. (2004). Recent Developments in Growth Theory. Edward Elgar Publishing.

Aghion, Philippe and Williamson, Jeffrey. (1998). Growth, Inequality, and Globalization: Theory, History, and Policy. Cambridge University Press.

Anderson, Kym. (1987). On Why Agriculture Declines with Economic Growth. Agricultural Economics. 1, 195-207.

Archibald, Robert B. and Feldman, David H. (2006). Explaining Increases in Higher Education Costs. College of William and Mary, Department of Economics, Working Paper No. 42.

Baffes, John and Etienne, Xiaoli L. (2016). Analyzing Food Price Trends in the Context of Engel's Law and the Prebisch-Singer Hypothesis. Oxford Economic Papers. 68, 3, 688-713. Oxford University Press. https://doi.org/10,1093/oep/gpw011

Baumol, William J. and Blinder, Alan S. (2000). Economics, Principles and Policy, Eighth Edition. The Dryden Press: Harcourt College Publishers.

Bellante, Don, (1979). The North-South Differential and the Migration of Heterogeneous Labor. The American Economic Review. 69, 1, 166-175.

Berger, Sebastien, Ed. (2009). The Foundations of Non-Equilibrium Economics. Oxford and New York: Routledge.

Bowles, Samuel; Durlauf, Steven N.; and Hoff, Karla. (2006). Poverty Traps. Russell Sage Foundation.

Britannica.com. 2019: The Editors of Encyclopaedia Britannica. "Corn Law." Encyclopedia Britannica, March 20, 2019. https://www.britannica.com/event/Corn-Law-British-history.

Britannica.com: Gregersen, Erik. "History of Technology Timeline". Encyclopedia Britannica, 15 Jan. 2019, https://www.britannica.com/story/history-of-technology-timeline. Accessed 16 February 2025.

Campbell, T. Colin, and Campbell, Thomas M. II. (2005). The China Study. Ben Bella Books.

Cashin, P., and McDermott, C. (2002). The Long-Run Behavior of Commodity Prices: Small Trends and Big Variability. IMF Econ Rev. 49, 175–199. https://doi.org/10.2307/3872481

Chien, YiLi. (2015). What Drives Long-Run Economic Growth? Federal Reserve Bank of St. Louis.

Clark (2007) – A Farewell to Alms: A Brief Economic History of the World. Princeton University Press

Connell, John; Dasgupta, Biplab; Laishley, Roy; and Lipton, Michael, 1976, *Migration from Rural Areas: The Evidence from Village Studies*. Oxford University Press

Dickie, Mark, and Gerking, Shelby. (1989). Inter-Regional Wage Differentials in the United States: A Survey. SpringerLink.

Emerson, Lesley (1992). Internal Migration in Algeria, 1966-77: An Empirical Analysis. Ph.D. Dissertation, University of Maryland College Park. University Microfilms, Ann Arbor, Michigan.

Emerson, Lesley (2025). Working paper: Why U.S. Rural Residents May Have Felt Let Down by Long Run Economic Policies
https://www.anniespicsandpoems.com/_files/ugd/3472c8_4b19617d5e1d42a3a5a38bdf017762eb.pdf

Ewers, Michael C. (2007). Migrants, Markets and Multinationals: Competition Among World Cities for the Highly Skilled. Geojournal, Kluwer Academic Publishers. (Ewers, M.C. GeoJournal (2007) 68: 119. https://doi.org/10.1007/s10708-007-9077-9)

Source: Robert W. Fogel, Catching Up with the Economy, (Chicago, IL: University of Chicago Press, 1999), https://www.die-gdi.de/fileadmin/user_upload/pdfs/messner/Fogel_Catching_up_with_the_economy.pdf.

Foreign Affairs. (2020). January/February. 99, 1. The Future of Capitalism.

Fujita, Masahisa, and Thisse, Jacques-Francois. (2002). Economics of Agglomeration: Cities, Industrial Location, and Regional Growth. Cambridge University Press.

Gollin, Douglas. (2014). The Lewis Model: a 60-Year Retrospective. Journal of Economic Perspectives. 28, 3, 71-88.

Gow, Margaret M. 1960. A Course in Pure Mathematics. London: English Universities Press

Groshen, Erica L., 1991, “Five Reasons Why Wages Vary Among Employers,” Industrial Relations, 30 (3), 350-81 (In Sattinger, 2001, Vol II Ch. 22)

Harris, John R. and Sabot, Richard H. 1982. Urban Unemployment in LDCs: Towards a More General Search Model. In Sabot (1982), 65-89

Heilbroner, Robert L. 1987. *The Essential Adam Smith.* Norton and Company

Hunja, R. (2011). Conversation on World Bank blogs, in response to: Fengler, Wolfgang. (2011). Why do Kenyans Want to Live in Cities? WorldBank.org

Johnson, D. Gale. (1991). World Agriculture in Disarray. New York: St. Martin's Press.

Kelley, Allen C. and Williamson, Jeffrey G. (1984). What Drives Third World City Growth? Princeton University Press.

Kerr, Sari Pekkala; Kerr, William; Ozden, Caglar; and Parsons, Christopher. (2017). High-Skilled Migration and Agglomeration. Annual Review of Economics. 9, 201-234.

Kremer (1993) – Population growth and technological change: one million BC to 1990. In the Quarterly Journal of Economics, Vol. 108, No. 3, 681-716.

Krugman, Paul, *NYT November 29th 2022.* On inflation and low-income workers, things aren't so simple.

Krusell, Per; Ohanian, Lee E.; Rios-Rull, Jose-Victor; and Violante, Giovanni. (2000). Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis. Econometrica. 8, 5, 1029-53. (In Acemoglu, 2004, Vol II Ch. 17.)

Lal, Deepak, 2013, "Poverty and Progress: Realities and Myths About Global Poverty," Cato Institute

Lewis, W.A. (1954) Economic Development with Unlimited Supplies of Labor. The Manchester School, 22, 139-191.
https://doi.org/10.1111/j.1467-9957.1954.tb00021.x

Lipton, Michael. 1980. *Why Poor People Stay Poor.* Cambridge, Massachusetts: Harvard University Press

Lowry, Ira. (1966). Migration and Metropolitan Growth. San Francisco: Chandler Publishing Company.

Mosso, David. 2009. *Early Warning and Quick Response: Accounting in the Twenty-First Century*. JAI, Emerald Group Publishing Limited, UK.

Muckey, Erik. (2019). Kernza® in Southern Minnesota: Assessing Local Viability of Intermediate Wheatgrass. University of Minnesota Extension. Center for Urban and Regional Affairs.

Our World in Data
https://ourworldindata.org/
Our World in Data, 2025: urbanization https://ourworldindata.org/ (Uses HYDE dataset, 2023 https://landuse.sites.uu.nl/datasets/)
Urbanization: The world population is moving to cities. Why is urbanization happening and what are the consequences? Hannah Ritchie, Veronika Samborska and Max Roser "*This page was first published in September 2018. We made changes to the text in December 2024.*"

Our World in Data, 2025: "Technological Change" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/technological-change' [Online Resource] Max Roser, Hannah Ritchie and Edouard Mathieu (2023)

Our World in Data, 2025: "What is Moore's Law?" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/moores-law' [Online Resource] Max Roser, Hannah Ritchie and Edouard Mathieu (2023)

Our World in Data, 2020: food prices https://ourworldindata.org/food-prices. From: Makridakis, Spyros; Steven C. Wheelwright; Rob J Hyndman. *Forecasting: Methods and Applications.* Wiley 1997

Our World in Data: employment in agriculture, Published online at OurWorldinData.org. Retrieved 2025 from: https://ourworldindata.org/grapher/share-of-the-labor-force-employed-in-agriculture?tab=chart&time=earliest..latest [Online Resource]

Pacey, Arnold. (1990). Technology in World Civilization: A Thousand-Year History. MIT Press

Robinson, Joan. (1954). The Production Function and the Theory of Capital. Review of Economic Studies, XXI (2), 81-106 (In Sattinger, Ed. 2001. Vol III Ch. 19)

Romer, Paul M. (1990). Endogenous Technological Change. Journal of Political Economy. 98, 5, pt. 2.

Roser, Max, and Ritchie, Hannah (2020). Food Prices. Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/food-prices' [Online Resource]

Roser, Max, and Ritchie, Hannah (2023) - “How has world population growth changed over time?” Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/population-growth-over-time' [Online Resource]

Sachs, Jeffrey D. (2005). The End of Poverty. The Penguin Press.

Sattinger, Michael, Ed. (2001). Income Distribution. Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.

Schmookler, Jacob. (1976) Invention and Economic Growth. Cambridge and London: Harvard University Press.

Smith, Adam. (Erwin Cannon, Ed.) (1994). An Inquiry into the Nature and Causes of the Wealth of Nations. Random House.

Symbolab, 2025 https://www.symbolab.com/popular-calculus/calculus-246738

Trostle, Ronald, 2008, “Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices,” USDA.gov

Trostle, Ronald, Daniel Marti, Stacey Rosen, and Paul Westcott, 2011, “Why Have Food Commodity Prices Risen Again?” USDA.gov

U.S. Bureau of Labor Statistics, 2018. https://www.bls.gov/opub/reports/working-poor/2018/ (Website accessed April 7, 2025)

USDA. (2019). Economic Research Service https://www.ers.usda.gov/

USDA. (2019). last updated February 2006.
https://www.ers.usda.gov/data-products/commodity-and-food-elasticities/download-the-data/
4/16/2019 was the download date

USDA. (2018). Rural America at a Glance. 2018 Edition.

Webb, Patrick, and Block, Steven. (2012). Support for Agriculture During Economic Transformation: Impacts on Poverty and Undernutrition. Proc Natl Acad Sci U S A.; 109 (31): 12309–12314.

Wessel, David. 2021. *Only the Rich Can Play.* Hachette Book Group

Wise, Timothy A. (2014). The Paradox of Agricultural Subsidies: Measurement Issues, Agricultural Dumping, and Policy Reform. Global Development and Environment Institute, Working Paper No. 04-02.

Yotopoulos, Pan A. and Nugent, Jeffrey B. 1976. *Economics of Development, Empirical Investigations*. Harper & Row