

Historical Roots of Commodity Markets: From Mercantilism to the Theory of Storage^a

Raízes históricas dos mercados de commodities: do mercantilismo à teoria da estocagem

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Abstract: Commodity markets today are shaped by financialization and price volatility, yet the categories through which they are analyzed were formed considerably earlier. This paper traces the development of commodity market theory from the seventeenth to the mid-twentieth century, identifying two parallel trajectories. The first examines the evolving conception of commodities: from precious metals, through land as a gift of nature, to standardized outputs of finite natural resources traded as financial assets. The second follows the transformation of income from mere ownership: from classical land rent, through scarcity rent, to convenience yield, a return retaining the structure of rent while no longer requiring non-reproducibility. Integrating traditions often studied separately, from mercantilist bullionism to the theory of storage, the study reveals both conceptual continuities and major breaks in the successive redefinition of these categories. In this redefinition lie the historical roots of contemporary approaches to commodity pricing, risk transfer, and the intertemporal allocation of exhaustible resources.

Keywords: Commodity. Resource rent. Convenience yield.

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Resumo: Os mercados de commodities são atualmente moldados pela financeirização e pela volatilidade dos preços, mas as categorias por meio das quais são analisados formaram-se há muito tempo. Este artigo traça o desenvolvimento da teoria dos mercados de commodities do século XVII a meados do século XX, identificando duas trajetórias paralelas. A primeira examina a evolução da concepção de commodities: dos metais preciosos, passando pela terra como dádiva da natureza, até produtos padronizados de recursos naturais finitos negociados como ativos financeiros. A segunda acompanha a transformação da renda associada à mera propriedade: da renda fundiária clássica, passando pela renda de escassez, até o rendimento de conveniência, retorno que conserva a estrutura da renda mesmo prescindindo do caráter não reprodutível do ativo. Ao integrar tradições frequentemente estudadas de forma separada, do bullionismo mercantilista à teoria da estocagem, o estudo revela continuidades conceituais e rupturas importantes na redefinição sucessiva dessas categorias. Nessa redefinição estão as raízes históricas das abordagens contemporâneas acerca da formação de preços de commodities, da transferência de risco e da alocação intertemporal de recursos exauríveis.

Palavras-chave: Commodity. Renda de recursos naturais. Rendimento de conveniência.

JEL: B12. G13. Q32.

Introduction

Commodity markets lie at the intersection of real economic activity, financial markets, and resource constraints. Although these markets now operate in an era marked by commodity financialization¹ and extreme price volatility, the analytical categories through which these markets are understood were established much earlier, between the seventeenth century and the middle of the twentieth.

The existing literature covers the main areas of commodity market analysis, while generally treating them within specific periods, schools, or theoretical problems. Studies on early modern economic thought examine the formation of mercantilism as a distinct political economy and the changing treatment of specie, trade, and the sources of wealth (Charbit, 2002; Magnusson, 2015). Hubacek and van den Bergh (2006) provide a broad account of changing concepts of land in economic theory, tracing its transformation from a productive factor to a multidisciplinary analytical category and, in the context of this study, its relation to natural resources and rent. The development of resource economics has been examined through conservationism and the problem of exhaustible resource depletion (Crabbé, 1983; Ramos Gorostiza, 2002; Spash, 1999), as well as through the interpretation of Hotelling's resource model (Ferreira da Cunha; Missemmer, 2020; Gaudet, 2007). Carter (1999) provides a comprehensive literature survey on the formation of commodity futures markets and the theoretical development of futures pricing, including the theory of storage and the informational efficiency problem. Research has also examined the relationship between the Keynesian normal backwardation and the theory of storage (Cristiano; Paesani, 2012). The subsequent development of the theory of storage has been studied through the work of Working, including his contribution to early financial economics (Delcey, 2025).

This body of literature is organized around a single identity of the commodity: as an instrument of wealth, as a product of nature, or as an asset. Each account is bounded by the period, school, or problem it addresses, leaving the transitions between these identities unexamined.

¹ Following Cheng and Xiong (2014), financialization refers to the increasing involvement of financial investors in commodity markets and the growing integration of commodity futures with financial markets.

Income arising from mere ownership is divided in the same way: classical rent theory, resource rent, and convenience yield are treated in separate literatures, without being related to the changing identity of the object.

The objective of this paper is to reconstruct two trajectories together. The first is the successive redefinition of the commodity as an object of analysis: from precious metals regarded primarily as instruments of state power, through land treated as a gift of nature, to commodities understood as outputs of finite natural resources and, eventually, as financial assets. The second is the transformation of income from mere ownership: from classical land rent, through Hotelling's scarcity rent, to Kaldor's convenience yield. Considered together, these trajectories show one object passing through three identities, and a category of income persisting as its dependence on non-reproducibility diminishes. The categories now used to analyze financialized commodity markets were formed in the course of these redefinitions.

To achieve this objective, this study adopts a Schumpeterian approach to the history of economic analysis (Schumpeter, 1954). This approach operates at two levels: while individual concepts are recovered from primary sources in their original historical terms, the trajectories traced across them are this study's synthesis of how these ideas were reformulated across analytical traditions. The analysis also considers historical context where it helps explain changes in the object of analysis or the emergence of new theoretical problems, as in the transition from mercantilist concepts of bullion and trade to physiocratic notions of land and productivity, and in the rise of conservationist concerns with the depletion of non-renewable resources. The selection of authors and works follows their relevance and contribution to the two central trajectories identified in the study, while secondary literature is used to situate these contributions within broader historical and historiographical scholarship, clarify particular interpretations, and incorporate archival evidence where relevant.

This study covers the period from the seventeenth century to the mid-twentieth century. The seventeenth century marks the beginning of the sequence traced in the study, when economic thought increasingly addressed trade and wealth systematically, with precious metals emerging as an object of economic inquiry. Over the following centuries, other

natural resources contained in the earth's crust, as well as land itself, emerged as autonomous objects of analysis. By the late 1950s, the main theoretical concepts developed through this process were in place, and they set the terms of the subsequent research.

The paper is organized as follows. Sections 1–4 review foundational contributions from mercantilism, physiocracy, classical political economy and its Marxian critique, and neoclassical economics. Sections 5–8 examine twentieth-century developments, including theoretical contributions arising from the conservationist movement, Hotelling's model, Keynes's analysis of forward markets, and the theory of storage. Section 9 concludes.

1. Foundations of Commodity Thought: Mercantilism and Physiocracy

The development of economic science was shaped by the historical evolution of its object of study, economic reality itself. Over time, economic activity came to be seen as an autonomous domain, distinct from politics, philosophy, or theology, governed by its own regularities rather than merely moral or political concerns. Observations were gradually systematized into coherent theoretical structures, allowing the identification of causal relationships and the formulation of specific concepts and categories. Simultaneously, economic thinking acquired an analytical orientation, shifting from normative judgments about how economic life should be conducted to careful examination of how it actually operates, what Joseph Schumpeter later described as “tooled knowledge” (Schumpeter, 1954, p. 7). This evolution reflects the transition from descriptive commentary to a structured, theory-driven, and empirically grounded economic science. The fundamental determinants of this transformation in the sixteenth and seventeenth centuries were profound structural changes in European society, which included the gradual transition from feudal fragmentation to centralized states and markets, the expansion of colonial empires and rapid growth of international trade following the Age of Discovery, and the institutionalization of the state as an active economic actor.

Mercantilism illustrates this transitional stage in the evolution of

economic thought. Although not yet a fully developed economic doctrine, it comprised a collection of scattered views focused on state wealth and power, emphasizing export promotion, protectionist policies, the development of manufactures and merchant fleets, and the accumulation of bullion and specie². Its central principle was the pursuit of a favorable balance of trade: exports should exceed imports, ensuring the inflow of precious metals and strengthening the state's fiscal and political authority. As William Petty writes in *Political Arithmetick*:

[...] the great and ultimate effect of trade is not wealth at large, but particularly abundance of silver, gold, and jewels, which are not perishable nor so mutable as other commodities, but are wealth at all times, and all places; Whereas abundance of wine, corn, fowls, flesh, etc. are riches but hic et nunc [...] (Petty, 1690, p. 18–19)

Thomas Mun similarly emphasizes that “[...] all nations (who have no mines of their own) are enriched with gold and silver by one and the same means,” namely, through international trade (Mun, [1664] 1895, p. 34). Although mercantilists regarded precious metals as wealth, they treated their capacity to embody value as fundamentally distinct from that of other goods. Their analysis therefore focused primarily on the monetary functions of gold and silver in trade, reflecting the widespread prevalence of bimetallic monetary systems in Europe from the fifteenth to the nineteenth centuries³.

For the study of commodity markets, mercantilism is significant because it approached precious metals differently from later economic thought. These metals were viewed mainly as embodiments of national wealth, while their relative scarcity as economic resources, alternative (non-monetary) uses⁴, or treatment as ordinary tradable commodities received comparatively little attention. Gold and silver served as money because they are naturally rare, durable, resistant to corrosion, homoge-

² An overview of mercantilism, presented as a fragmented set of propositions later consolidated into a more coherent stream of thought, is provided by Blaug (1985, p. 10–24).

³ For a taxonomy of commodity-based monetary regimes and an analysis of specific deviations from bimetallism across Europe, see Esteves and Nogues-Marco (2021, section 1).

⁴ The role of silver as a commodity rather than as specie is discussed in Flynn and Giráldez (2002), who examine its arbitrage from Europe to China.

neous, divisible into units of varying size and weight, compact in value storage, and relatively easy to transport. Many of these characteristics, such as homogeneity, high substitutability, low differentiation, and minimal value added, are shared with what we now define as commodities. This helps explain why such goods later became institutionalized as assets, as discussed further below.

Goods other than precious metals received little attention from mercantilists. As Lewis H. Haney observed in *History of Economic Thought*: “As to natural resources, it was pointed out that by a better utilization of waste lands things then imported might be produced at home” (Haney, 1915, p. 96). Although production was regarded as the second most important sphere of economic activity—after trade, with agriculture ranking third—the limited scope of largely non-industrial production did not create conditions for the commodification of raw materials or the emergence of independent commodity markets. Consequently, commodities were incorporated into political economy rather than treated as autonomous economic objects. Mercantilism thus constituted an early attempt to conceptualize economic life at the level of the nation-state, helping establish the foundations of political economy as a distinct scholarly discipline (see Magnusson, 2015).

The physiocratic reaction against the mercantilist doctrine in the eighteenth century reflected both changes in economic reality and evolving approaches to identifying the sources of the wealth of the realm. While mercantilists focused on trade and the accumulation of specie, they largely overlooked the internal productive base of the economy. In predominantly agrarian societies such as France, the material prosperity of the state depended on the productivity of the land, which generated real surpluses sustaining both population and commerce (Charbit, 2002, p. 858–859). Gold and silver, though measures of wealth, did not themselves create new goods; in contrast, the yield of cultivated land constituted a tangible, reproducible source of value. Accordingly, the physiocrats regarded agriculture as the only truly productive sector of the economy. This constituted a fundamental analytical reorientation, moving from a normative focus on specie toward a systematic, “strictly scientific” study of productive processes (Oncken *apud* Neill, 1949, p. 532).

The systematic study of land as the productive basis of agriculture,

pursued in the search for natural economic laws, provided a starting point for later theorization of the economic role of natural resources contained in the earth's crust. Representatives of physiocracy classified natural resources, including forests, bodies of water, and mineral deposits, under the general category of "land," without distinguishing them analytically from agricultural use⁵. In their view, the economy was a closed, stationary cyclical system, and the productivity of land was treated as constant. This approach effectively precluded consideration of the finiteness and exhaustibility of natural resources: scarcity was understood as a purely physical constraint rather than as the result of intertemporal trade-offs or of finite geological deposits (Hubacek; van den Bergh, 2006, p. 7). Consequently, physiocrats treated land as a generative and self-renewing source of surplus, embedded within a stationary circular flow.

A central concept of physiocracy was that of the *produit net* (net product), defined as the surplus of the value generated in agriculture over the value consumed in production—that is, over production costs. With respect to mining and fishing, however, physiocratic views were not entirely uniform⁶. Turgot, for instance, observed that "the land produces fruit annually, but a mine produces no fruit. The mine itself is the garnered fruit" (Turgot *apud* Gide; Rist, [1909] 1915, p. 14). He concluded that mining and industrial enterprises did not generate a net product, since any surplus obtained would ultimately accrue to the landowner on whose property the mine was located⁷; yet in practice, such a surplus was typically negligible. The functioning of enterprises, including those engaged in the extraction of mineral resources, was considered in terms of the productivity of the land on which they were situated. Thus, the values of goods were reducible to the quantities of land required for producing them (Hubacek; van den Bergh, 2006, p. 7). The physiocrats' contribution lies in their focused study of land; nevertheless, this approach precluded the conceptualization as commodities of either mineral resources,

⁵ A review of the evolution of conceptualizations of land as an economic category in the history of economic thought is provided by Hubacek and van den Bergh (2006).

⁶ On the exclusive productivity of agriculture in physiocracy, see Weulersse (1910), vol. 1, p. 243–315. For the discussion of the productivity or unproductivity of mines, quarries, and fisheries, see esp. p. 277–280.

⁷ The justification for ownership of natural resources located beneath landholdings is articulated in Turgot's *Brief on Mines and Quarries*, which is analyzed in Crabbé (1985).

given the absence of industrial-scale utilization, or agricultural products, for which there were no centralized markets trading standardized goods. The commodity exchanges that did exist in Europe at the time were exceptional rather than representative of general commercial practice⁸.

In both mercantilist and physiocratic thought, commodities remained embedded within broader notions of wealth accumulation or natural productivity. In our view, neither school reconciled the commodity as an instrument of wealth with the commodity as a product of nature, and, as a result, the analysis of commodity markets remained fragmented. Only with the classical school were these perspectives brought together through the concepts of rent and labor, allowing commodities to be studied as distinct market entities shaped by both physical constraints and conditions of production.

2. Classical Political Economy and the Emergence of Rent Theory

Classical political economy, which dominated economic discourse from the second half of the eighteenth to the first half of the nineteenth century, developed and refined the theory of rent. Adam Smith was the first to employ the concept of land rent in explaining the formation of value in both agriculture and industry, thereby laying the groundwork for subsequent rent theories (see Ghosh, 1985, p. 69). In Chapter XI of Book I of *An Inquiry into the Nature and Causes of the Wealth of Nations*, Smith defines rent as the income accruing to the landowner by virtue of ownership and the use of land in production. Rent, in his account, arises from the surplus product generated either by nature or by the labor of the tenant and depends on the fertility of the land, its location, and the demand for its output. Smith characterizes rent as a monopoly price that emerges under conditions of control over scarce resources, such as land or access to the seashore. As he writes, “the rent of the land, therefore, considered as the price paid for the use of the land, is naturally a monopoly price. It is not at all proportioned to what the landlord may have laid out upon the

⁸ Commodity exchange trading was already present in several European commercial centers, notably Amsterdam and Antwerp. See Stringham (2003) and Poitras (2009), respectively.

improvement of the land, or to what he can afford to take; but to what the farmer can afford to give” (Smith, [1776] 1976, p. 161)⁹.

Smith’s innovation lies in recognizing that the price of a commodity contains a rent component derived from ownership of a scarce natural resource. In the context of commodity production, an important contribution of Smith also lies in his analysis of rent derived from coal mines and from mines producing precious metals. By treating income from a coal mine and income from farmland under a single category, Smith places a depleting stock within an analysis developed for a renewable flow. The distinction becomes analytically consequential only when exhaustibility is addressed directly, as in the work of Gray and Hotelling discussed below. He observes that rent from a coal mine depends on the mine’s “richness” and location: poor or remote mines may yield no rent at all, while some may be unable to bring their product to market even when extraction costs are covered. Mining rent is also less stable and constitutes a smaller share of gross product than agricultural rent, owing to greater variability in output (Smith, [1776] 1976, vol. I, ch. XI).

Furthermore, Smith analyzes how local conditions of extraction shape the international dimension of price formation. He explains that the influence of a particular mine on prices depends on both the nature of the commodity and the geographical scope of its market. Smith distinguishes in particular between precious metals and coal. Gold and silver possess high value per unit of weight and are easily transportable, so their market is global in scope: even relatively small changes in output at a single mine may affect world supply and, consequently, prices. By contrast, coal is typically traded within more localized markets, since long-distance transportation is costly. Its price therefore depends on local supply and demand; even a substantial increase in output would likely alter conditions only within the consuming region (Smith, [1776] 1976, vol. I, ch. XI). Smith’s analysis of rent through the prism of land constitutes one of the first sustained investigations of commodity markets, particularly coal. He also examines how territorial factors and transportation costs shape the interaction between local and global markets, thereby incorporating spatial and logistical constraints into economic analysis.

⁹ On monopoly rent as an economic category, see Evans (1991), esp. p. 2–4 on the classical economists.

In “The Third Sort” of the “Different Effects of the Progress of Improvement upon three different Sorts of rude Produce,” Smith considers those goods whose quantity is either limited or uncertain with respect to the possibility of expansion through human labor (Smith, [1776] 1976, p. 246–255). He includes in this category commodities such as wool, raw hides, and other products directly dependent on agricultural conditions. Smith observes that the supply of such goods is determined by livestock populations, which in turn reflect the level of agricultural development. In this sense, the real price of these resources tends to rise alongside economic progress, although this tendency is neither linear nor inevitable, since it depends on the effectiveness of efforts to expand supply. Smith also emphasizes that demand conditions and technological improvements influence the potential growth of output, introducing an additional source of price instability. This offers an early recognition both of supply inelasticity and of the interdependence between resource availability and the stage of economic development, concerns that later theories of commodity markets would place at the center of their analysis. Two things follow from the developments traced here. The commodity has come to be understood as a produced or extracted good whose price decomposes into wages, profit, and rent; rent, in turn, has become a distinct category of income, accruing to the owner of a scarce resource by virtue of ownership rather than production.

The concept of land rent, as analyzed by Smith, was further developed in the works of James Anderson and David Ricardo. In Smith’s discussion, one can already find an argument that would later be regarded as Ricardian: “Rent, it is to be observed, therefore, enters into the composition of the price of commodities in a different way from wages and profit. High or low wages and profit are the causes of high or low price; high or low rent is the effect of it” (Smith, [1776] 1976, p. 162). While Smith acknowledged that lands of differing fertility yielded different levels of rent, a more formal treatment of differential rent appears already in Anderson’s *An Enquiry into the Nature of the Corn-Laws* (1777), a work that would subsequently be associated with the Ricardian interpretation of rent.

According to Ricardo’s theory, heterogeneity of land and differences in soil fertility constitute the fundamental source of (differential)

rent. As he argued, “if all land had the same properties, if it were unlimited in quantity, and uniform in quality, no charge could be made for its use, unless where it possessed peculiar advantages of situation” (Ricardo, [1817] 1821, ch. 2). Rent thus arises because cultivation must extend to progressively less fertile or less favorably located land, while the price of agricultural produce is determined by the cost of production on the marginal (no-rent) land. Moreover, the inherent scarcity of land suitable for highly productive agriculture yields another source of rent, independent of fertility and location differences, later formalized as *scarcity rent* (Hubacek; van den Bergh, 2006, p. 9).

We can conclude that, by the end of the classical period, commodities had become established objects of economic analysis, examined in terms of production, supply and demand, price formation, transportation, trade, and the geographical and economic constraints affecting their distribution. Extractive natural resources, particularly precious metals and coal, were treated explicitly as commodities intended for industrial use, while agricultural products were analyzed in similar terms. A central category in the analysis of such resources was rent. The classical school bridged the conceptual divide between money and “gifts of nature” by integrating both within the category of the commodity. While its approach remained largely static and descriptive, the object of the study had been unified. Rent, understood as income arising from the ownership of land or mines and reflected in the price structure of the goods produced from them, would later be developed in economic theory as resource rent, a concept discussed further below.

3. Marx: Commodity Form and the Boundary of Rent

Karl Marx’s engagement with the classical tradition redefined its categories in ways that had direct consequences for how commodity markets could be conceptualized. In the first volume of *Capital: A Critique of Political Economy* (Marx, [1867] 1976), Marx defines a commodity as a use-value produced for exchange rather than for the producer’s own consumption, and its exchange-value is regulated by the socially necessary labor time required to produce it. Unlike Smith and Ricardo, however, Marx does not treat the commodity as a mere empirical starting point;

he makes the category itself the object of analysis, arguing that classical political economy correctly identified labor as the source of value but never asked *why* the products of labor take the value-form at all, that is, why they confront one another on the market as commensurable, exchangeable things rather than simply as useful objects (Marx, [1867] 1976, ch. 1, sec. 4). The commodity is therefore not an object at all in Marx's account, but the value-form itself: the shape products of labor assume where production is generally organized for exchange, and a shape belonging to that mode of production rather than to production as such. Generalized exchange through the commodity form is thus a feature of a particular form of social production rather than a permanent one, regardless of whether this condition is understood as a historical stage or as an analytical starting point (Arthur, 2002). The category cannot be detached from the relations of production in which it is embedded: the commodity form makes labor power purchasable and thereby makes surplus value and accumulation possible.

The same shift, from taking economic categories as given to deriving them from historically specific social relations, extends to Marx's rent theory, as Ricardian rent, whether from differential fertility or from the scarcity of land as such, requires no institutional barrier to arise. In the analysis of ground-rent published in the third volume of *Capital*, Marx disputed this conclusion, arguing that exclusive private ownership of land functions as a monopoly capable of extracting *absolute rent* even from marginal land yielding no productivity surplus, purely by virtue of title rather than any productive contribution (Marx, [1894] 1981, ch. 45). For Marx, the class monopoly of landed property is the premise of ground rent as such, differential no less than absolute (Marx, [1894] 1981, ch. 37), whereas in Ricardo, ownership is not part of the mechanism, which turns instead on differences in quality and the margin of cultivation. Absolute rent was not, however, unconstrained monopoly extraction: Marx bounded its magnitude by the gap between agricultural value and price of production generated by the below-average organic composition of capital in agriculture. The grounding of that limit has been questioned, and its adequacy for distinguishing absolute rent from rent arising from monopoly pricing remains debated (Fratini, 2018).

The Marxian rent category nevertheless stops at the threshold of the

commodity itself. In Marx's treatment of the costs of circulation, storage is unproductive where the stock exists because the commodity has stagnated in circulation: the labor of maintaining it then creates neither value nor surplus-value (Marx, [1885] 1978, ch. 6, sec. 2(b)). Nor can holding a commodity generate rent, since rent in all its forms presupposes a monopolizable natural condition of production whose supply capital cannot augment, whereas commodities, as products of labor, are in principle reproducible. This holds even for monopoly rent, where a unique natural condition sustains a price above the price of production and the excess accrues to the owner: here the monopoly price generates the rent, but what is monopolized remains the condition of production, not the stock (Marx, [1894] 1981, ch. 46, p. 910–911). A return to mere possession of a commodity stock therefore has no place in the account. It arises only in the twentieth century, with Kaldor's convenience yield, and on terms that dissolve rather than extend the classical precondition (see Section 8).

In our view, these two departures, namely the reconceptualization of the commodity as a form belonging to a specific form of production rather than an unexamined object of exchange, and the identification of ownership as a source of income distinct from productivity or scarcity, bring both trajectories traced in this study to their sharpest formulation. Asking why products of labor assume the value-form makes the identity of the commodity a question rather than a premise. Where the classical economists treat the commodity as given and derive rent from a price-theoretic mechanism requiring no account of ownership as such, Marx makes the social form of the commodity itself the analytical starting point and grounds a distinct category of income in ownership alone, while foreclosing its extension to commodity stocks.

4. Neoclassical Economics and the Marginalist Approach to Commodities

The neoclassical school, which emerged in the second half of the nineteenth century, explained value by subjective utility rather than by the conditions of production. Its central elements, such as resource scarcity, rational economic agents, marginal analysis, equilibrium price for-

mation, efficiency, and utility maximization, became the theoretical and methodological basis for the conceptualization of commodity markets. One of the precursors of the neoclassical paradigm was the marginalist revolution, a rapid transformation in economic theory in the early 1870s characterized by the systematic introduction and application of marginal magnitudes in economic analysis. This development is associated with the independent contributions of Carl Menger, William Stanley Jevons, and Léon Walras.

Menger, founder of the Austrian school, introduced in *Principles of Economics* a conceptual distinction between a “good” and a “commodity,” analyzing the functional transformation by which an object becomes an economic good and, under conditions of exchange, a commodity (Menger, [1871] 2007, ch. VII). Where Marx located the identity of the commodity in the relations of production, Menger located it in the valuations of individuals. Both responded, within four years of one another, to the same difficulty in classical value theory, but resolved it in incompatible directions: the one made the social form of the commodity the object of analysis, while the other dissolved the question into subjective valuation and removed production from the explanation altogether.

Jevons advanced the formalization of political economy through the systematic use of mathematical methods, particularly in *The Theory of Political Economy* (Jevons, 1871). He regarded certain concepts, such as the theory of rent, as inherently scientific and mathematical, laying groundwork that Irving Fisher credited with the beginning of the mathematical method in economics (Fisher, [1892] 2007, p. 109). Beyond his contributions to the formalization of marginal utility theory, developed contemporaneously with Menger and Walras, Jevons’s systematic economic analysis of the exhaustibility of natural resources is of particular relevance here. In *The Coal Question* (Jevons, 1865), he offered an empirical investigation of the finite character of coal as a fossil resource, examining the limits of extraction, the dynamics of growth driven by mineral exploitation, the (exponential) increase in demand for coal, and the implications of resource depletion for the long-term prosperity of the United Kingdom. The work (Jevons, 1865, ch. VII) also identified the effect now known as the Jevons paradox, whereby greater efficiency in the use of a resource can increase rather than reduce its total consumption.

By formalizing scarcity as the defining economic problem, the neo-classical school supplied the microeconomic apparatus on which the later analysis of exhaustible resources would be built. Both trajectories therefore pass through this transformation, but in opposite directions. The object of analysis is redefined once more: with Menger, a commodity is identified neither by its substance nor by its origin but by its position in exchange, while Jevons's investigation of coal establishes exhaustibility as an economic rather than merely physical property. Income derived from ownership, by contrast, loses its distinct standing: where returns to all factors are determined at the margin, rent ceases to be a separate category of income and becomes one marginal return among others. The question of what accrues to ownership as such would resurface only when exhaustibility restored non-reproducibility to the center of analysis, in the work of Gray and Hotelling.

5. Conservation Movement and Resource Depletion Theory

Recognition of the scarcity of natural resources led to detailed study of their depletion, including the intertemporal effects of extraction, the formation of commodity prices in this context, and the evaluation of the trade-offs between exploiting resources and retaining them *in situ*. The marked increase in attention to the issue of natural resource depletion in economic science is associated with the spread of conservationist ideas in the United States at the turn of the twentieth century¹⁰, influenced by the German historical school of economic thought¹¹.

Lewis Cecil Gray was among the first to address limited natural resources in the context of conservation. In two works (Gray, 1913, 1914), he proposed a model of non-renewable resource extraction under idealized conditions, applying the law of diminishing returns to a coal mine for the first time. The resulting cost curve created intertemporal trade-offs: extraction could be delayed when costs exceeded the period's minimum

¹⁰ On the development of environmental thinking in economic theory, see Spash (1999); on the American conservation movement in the late nineteenth and early twentieth centuries, see Ramos Gorostiza (2002).

¹¹ On the influence of the German historical school on the development of economics in the United States, see Filip (2022).

average cost, yet the interest rate incentivized earlier extraction, reflecting the opportunity cost of leaving the resource unextracted. Overall, he argued that an increase in price or a reduction in the interest rate slowed extraction, since the primary costs were incurred immediately while the benefits were distributed over time (for further discussion, see Crabbé, 1983). Gray's model thus represented an early formalization of scarcity rent in non-renewable resources, anticipating the dynamic pricing mechanisms later refined by Hotelling (1931) and establishing a key bridge from conservationist concerns to later resource rent theory in commodity market analysis.

Of particular note is Gray's contribution to the concept of "aggregate depletion of natural resources" (Gray, 1913) in the context of intergenerational equity. From a modern economic perspective, his analysis can be regarded as fully macroeconomic (Crabbé, 1983, p. 208). Gray examined the tension between present and future resource use, seeking to determine the optimal rate of conservation, and was the first to classify natural resources by scarcity. Related theoretical issues were explored by Richard T. Ely (Ely, 1917, p. 10–21; Ely; Hess; Carver, 1918) and John Ise (1925), who, like Gray, addressed questions of social justice in distributing the benefits and costs of non-renewable resource extraction across generations, and considered mechanisms for pricing resources.

Both trajectories take a new form here. The object of analysis ceases to be a flow of output from land and becomes a finite stock whose extraction is distributed over time, the step that makes possible Hotelling's later treatment of a hypothetical asset defined solely by exhaustibility. Income from ownership, dissolved into marginal returns by the marginalist turn, is reconstituted on a different basis: what accrues to the owner of a deposit depends not on fertility or location but on the timing of extraction, so that non-reproducibility returns in the form of exhaustibility and rent returns as an intertemporal magnitude. Gray's concern with aggregate depletion and intergenerational equity also anticipated questions that would become central to modern debates on sustainability.

6. Hotelling and the Economics of Exhaustible Resources

The issue of depletion of fossil resources was further developed within the neoclassical school by Harold Hotelling¹². In his foundational work *The Economics of Exhaustible Resources* (1931), Hotelling proposes a dynamic approach to pricing fossil resources, providing the first analytical formalization of the problem of optimal depletion of natural resources over the long term.

Gaudet notes that Hotelling had two main motivations for writing this paper. First, it responded to the conservationist view, which held that unregulated markets would inevitably lead to overexploitation of non-renewable resources. Second, he sought to develop a theory of exhaustible resources that addressed the limitations of static equilibrium models in dynamic contexts, building on his earlier model of asset depreciation as a reduction in the discounted value of future returns (Gaudet, 2007, p. 1034). However, later research based on his archives suggests that the influence of conservationist arguments on the original model is likely overstated (Ferreira da Cunha; Missemmer, 2020, p. 6). Instead, he appears to have been primarily motivated by the rapid growth of oil extraction in the United States in the early 1920s and the corruption scandals surrounding it (see, e.g., Yergin, 1991, p. 211–217).

Following the principle of scarcity rent, Hotelling formalized the concept of *resource rent* as the difference between a resource's market price and its marginal extraction cost (now also known as the *Hotelling rent*), and concluded that, under competitive market conditions, this rent would increase at the rate of interest. According to this approach, a resource owner compares the profitability of selling the resource and investing the resulting income with the potential increase in price if the resource is left in the ground. This conclusion follows from the principle of maximizing the present value of resource rent, which implies an optimal rate of extraction that ensures efficient depletion of the resource over time while maximizing the total discounted profits from its sale. Thanks to Robert Solow, this principle became known as the *Hotelling rule* (Solow, 1974, p. 12).

¹² On the role of Hotelling in the development of neoclassical economics, see Egbert, Sedlarski, and Todorov (2021).

Hotelling argued that the socially optimal use of a non-renewable resource over time can be achieved under competitive equilibrium, provided the social discount rate equals the interest rate and there are no market failures, such as externalities or incomplete property rights (Livernois, 2009, p. 23). The Hotelling rule links price dynamics with interest rates, guiding a resource owner's intertemporal extraction decisions to maintain *ceteris paribus* indifference between current and future use. Its core mechanism is an arbitrage condition: the rate of price increase must equal the return on alternative investments to preserve equilibrium, so that extraction is delayed when expected price growth exceeds the interest rate and accelerated when it falls below.

Hotelling's legacy in the study of commodity markets is characterized by a shift toward formal, dynamic modeling, with a focus on intertemporal aspects of analysis. Nevertheless, empirical tests have generally failed to confirm the rule for most commodity markets. The divergence has become known as the *Hotelling puzzle*¹³. The inconsistency between the theoretically predicted steadily rising prices and the observed volatility indicates that factors such as technological progress, discovery of new deposits, information asymmetry, and changes in market structure play a significant role in market functioning (see, e.g., Livernois, 2009, p. 27–29). Despite these limitations, the model remains a foundational element in the economic analysis of commodity markets.

Hotelling's archival materials at Columbia University clarify the theoretical foundations and empirical limits of his model (Ferreira da Cunha; Missemmer, 2020). His drafts reveal that Hotelling deliberately abstracted from geological constraints, modeling a hypothetical asset defined solely by "exhaustibility" rather than real fossil resources. Describing actual markets requires accounting for cumulative extraction, as costs rise with depth, and the rate at which output changes, since abrupt adjustments increase costs more sharply than gradual ones (Ferreira da Cunha; Missemmer, 2020, p. 7–11). Although Hotelling did not further develop this approach, his theory marked a shift from practical economic concerns to treating commodities as assets subject to explicit assumptions and pricing constraints.

¹³ For discussion of the Hotelling puzzle and related empirical findings, see, e.g., Chari and Christiano (2014, p. 1).

Both trajectories reach a decisive point here. The object of analysis is no longer a resource but an *asset*, the form in which commodities are analyzed in financialized markets today. Income from ownership, correspondingly, is fully reconstituted as an intertemporal magnitude: scarcity rent grows at the rate of interest, so what accrues to the owner is determined by the arbitrage between extracting now and holding *in situ*. Non-reproducibility remains the underlying condition, as it was for Ricardo; what has changed, in our view, is that it is now expressed as exhaustibility and priced across time.

7. From Spot to Futures: Keynesian Views on Commodity Prices

Following the First World War, commodity futures markets experienced a pronounced surge in trading activity, most notably at the Chicago Board of Trade. Exceptional price volatility in the early 1920s stimulated speculative interest in grain futures, driving trading volumes to levels not equaled again until the commodity boom of the 1970s (Iorgulescu; Pütz; Siklos, 2022). This heightened market activity provided the context for John Maynard Keynes's intensive study and personal participation in commodity futures trading. In *Some Aspects of Commodity Markets* (Keynes, [1923] 1978), Keynes lays the foundations for the theory of normal backwardation, which he later formalizes in *A Treatise on Money* (Keynes, 1930). He argues that, in physical markets, particularly agricultural commodity markets, producers play a leading role as they seek to hedge against price risk. To do so, they are willing to pay a premium to speculators who open long positions in the futures market, while speculators, in turn, provide "insurance" to hedgers. In such a situation, the futures price of a contract must be lower than the expected future spot price of the underlying commodity, allowing speculators to be compensated for bearing risk. Keynes locates the source of income in risk-bearing rather than ownership: the premium is payment for a service and accrues to whoever performs it, regardless of who holds the commodity. Forward-market analysis thus arrives at commodity pricing without assigning any return to ownership.

In the classification proposed by Keynes in *A Treatise on Money*

(Keynes, 1930, vol. 2, ch. 27), where he distinguishes between fixed, working, and liquid capital, he further differentiates two categories of commodity stocks, whether raw materials or finished goods: stocks consciously held by producers as part of working capital, and excess stocks accumulated involuntarily, which he assigns to liquid capital (Keynes, 1930, vol. 2, ch. 29). Keynes classifies commodity stocks by their function within the firm's capital rather than by their physical character or natural origin. The identity of a commodity now depends on the role it plays in the holder's operations, just as for Hotelling it depended on the intertemporal allocation of an exhaustible stock. Keynes argues that the emergence of such unwanted surpluses leads to further price declines until they are absorbed either through increased consumption or reduced production (Keynes, 1930, vol. 2, ch. 29, p. 145). Keynes extends this logic to forward markets, analyzing the behavior of producers who hedge price risk by selling output forward (taking short positions). He distinguishes between two cases: one in which excess stocks are absent, and one in which such surpluses exist. In the first case, Keynes argues that backwardation occurs—that is, the futures price is lower than the spot price. Under market equilibrium, the level of backwardation is “normal,” corresponding to the standard risk premium demanded by speculators for assuming price risk (Keynes, 1930, vol. 2, ch. 29, p. 143). In the second case, when excess stocks exist, the futures price rises above the spot price, resulting in contango. The extent of this contango equals the costs of holding stocks (storage, interest, depreciation, insurance) together with the risk premiums paid for hedging (Keynes, 1930, vol. 2, ch. 29, p. 135–136). Holding stock is, in his view, pure cost. However, Keynes emphasizes that the existence of contango does not imply that producers can hedge without cost. On the contrary, the presence of excess stocks increases market uncertainty and the overall need to transfer risk, forcing producers to pay even higher-than-usual hedging premiums. As a result, while the forward price exceeds the current spot price, it remains below the expected future spot price by at least the “normal backwardation” (Keynes, 1930, vol. 2, ch. 29, p. 144; Cristiano; Paesani, 2012, p. 146).

Nevertheless, the theory of normal backwardation was debated for decades. Kamara (1982) and Carter (1999, p. 223–226) review the attempts either to confirm or refute Keynes's conclusions. Fantacci, Mar-

cuzzo, and Sanfilippo (2010, p. 416) demonstrate that Keynes did not follow his own theory in practice as a futures market speculator, and that there is no evidence that his practical actions confirmed the theoretical positions he proposed. Rockwell (1967, p. 110) found that speculators' profits are determined by forecasting ability rather than by risk-bearing, and concluded that normal backwardation is not adequate as a general explanation of price dynamics in commodity markets.

John R. Hicks generalized the argument. Where Keynes derived the risk premium from the position of agricultural producers, Hicks derived it from the structure of forward markets as such: hedgers are more willing to dispose of risk than speculators are to assume it, so the forward price must stand below the expected spot price by a margin sufficient to induce speculators to take the opposite side. The same reasoning carries to the loan market, where the reluctance of lenders and borrowers to commit long term, its "constitutional weakness," makes the long rate exceed the average of expected short rates by a risk premium (Hicks, [1939] 1946, p. 146). Together the two accounts came to be known as the Keynes–Hicks approach to forward pricing¹⁴.

In *The General Theory of Employment, Interest and Money*, Keynes builds on his earlier analysis of commodity markets, particularly the wheat market, arguing that the difference between spot and futures prices reflects the "own rate of interest" of a commodity, which depends on yield, storage costs, and liquidity premiums (Keynes, 1936, ch. 17; see also Oka, 2021). The inclusion of a yield term is notable: in the *Treatise*, holding a commodity generated only cost, whereas the own-rate formulation admits that possession may itself yield a return. However, the point is left underdeveloped, and it is Kaldor who pursues it (Kaldor, 1939, p. 3, n. 4).

8. Commodity Prices and the Theory of Storage: The Kaldor–Working Perspective

Nicholas Kaldor's *Speculation and Economic Stability* (Kaldor, 1939) restated the forward-market theory of the *Treatise* formally before qualifying it, a qualification he credits to Hawtrey (Kaldor, 1939, p. 6). Speculators, he argued, do not always assume risk passively; in every

¹⁴ For further discussion, see Cristiano and Paesani (2012, p. 143–147) and Brillant (2014).

market there is a range of price oscillation within which speculation destabilizes and outside which it stabilizes, so its effect depends on the elasticity of expectations rather than being uniformly beneficial (Kaldor, 1939, p. 10).

Examining the underlying conditions for speculation, Kaldor showed that in many markets, particularly industrial commodity markets, the roles of participants may be reversed compared with the Keynesian model: hedgers are often forward buyers (outside buyers who are contractors with orders placed for some period ahead), whereas speculators are the stock holders selling forward. Moreover, he argued that all commodity stocks generate a certain “yield” simply by existing (Kaldor, 1939, p. 3). This benefit of holding a physical stock manifests as the *convenience* of being able to use it immediately. Accordingly, stock holders possess this benefit, while speculators who have already sold the commodity forward are deprived of it and effectively face higher carrying costs (Kaldor, 1939, p. 6).

In our view, convenience yield occupies, structurally rather than by descent, a role similar to that of rent in classical and Marxian analysis, representing a return derived from possession rather than production. This similarity, however, should not obscure an important difference. While rent arises from ownership of an asset that cannot be reproduced, which explains its persistence, convenience yield arises from holding a stock of a reproducible good and exists only as long as this stock remains scarce: when stocks are redundant, the marginal yield falls to zero and the Keynesian result holds (Kaldor, 1939, p. 4). Income derived from mere ownership thus survives the transition into commodity markets, but its character changes: it becomes contingent on scarcity and determined by market conditions. The passage of income from ownership into this contingent, market-priced form helps make the later financialization of commodity markets conceptually possible: once the return to holding a commodity is priced by the market, the stock can be treated as a position to be valued rather than merely as a good to be held. From this perspective, pricing in forward markets is determined not only by the risk premium but also by the differing *carrying cost* faced by market participants: if the convenience yield from physical ownership exceeds the risk premium, the forward price can exceed the expected spot price, reversing the sign of the deviation Keynes had treated as normal.

Kaldor assumed that hedging could, in some cases, eliminate the convenience yield. J. C. R. Dow refined Kaldor's pricing mechanism, showing that the convenience yield is not lost when hedging via futures contracts, since such contracts do not require physical delivery of the commodity (Dow, 1940). Therefore, the loss of yield predicted by Kaldor occurs only in the case of forward sales, and Kaldor clarified his position accordingly (see Kaldor, 1940). An overview of Kaldor's approach and an attempt to synthesize it with the Keynesian account are offered by Gerda Blau (1944), who argued that backwardation is a situational phenomenon rather than a universal one.

Holbrook Working had reached related conclusions about the role of commodity stocks empirically several years earlier. Analyzing wheat futures quotations on the Chicago Board of Trade from 1885 to 1933 (Working, 1933), he demonstrated that the spread between July and September futures prices is primarily determined by the current level of wheat stocks in the United States. In 1948, Working further developed these ideas, laying the foundation for *the theory of storage*. Analyzing data on wheat and corn markets in the United States and the United Kingdom over more than fifty years (1884–1938), he sought to explain the occurrence of backwardation (Working, 1948).

Working criticized prevailing explanations for backwardation, which included the assumed independence between spot and futures markets (more precisely, current and forward quotation markets) (Vance, 1946); the notion that futures prices are systematically “biased downwards,” i.e., discounted relative to expected future spot prices as compensation for risk (Keynes, 1930; Vance, 1946); and the assumption that expectations about future market conditions (supply–demand balance) influence distant prices more than near-term prices (Federal Trade Commission, 1924). Against these, Working proposed that the spread—*the carrying charge*—behaves like the price of holding stocks. When the carrying charge is large and positive (contango), transactions involving purchase of the physical commodity and hedging through short futures occur in high volumes, as holding stocks is profitable; when it is large and negative (backwardation), such transactions decline (Working, 1948, p. 19–20). The carrying charge thus functions as the price of storage, with the quantity of stocks as the quantity of storage supplied, producing the graphical *Working curve*.

Summarizing the theory of the storage price, Working emphasized that when stocks are scarce, a negative storage price exerts pressure on hedgers and prevents excessive accumulation, directing part of the commodity toward consumption during shortages (Working, 1949). In the formalized presentation of his theory, he explained that the negative storage price reflects the existence of a convenience yield, a decade after Kaldor had named it, that exceeds the direct costs of holding the commodity. Working's model makes the primary function of commodity futures markets the provision of a return on storage rather than the transfer of risk from hedgers to speculators (Carter, 1999, p. 211, 226).

Working's method, which relied on empirical observation and careful data analysis as the foundation for building and testing economic models (Berdell; Choi, 2018; Delcey, 2025), aligns with the American institutional school and its inductive study of economic realities in their concrete historical and institutional contexts¹⁵. His statistical investigations also had an impact on the development of financial economics. First, his shift from absolute price levels to price differences focused attention on relative price changes. Second, his concept of futures prices as random, unbiased market expectations contributed to the methodological foundations for the efficient market hypothesis (see, e.g., Delcey, 2019). The convenience yield has since been reinterpreted: Pindyck (2001), for instance, treats commodity holdings as real options, linking storage and extraction decisions to market prices.

The theory of storage linked the relationship between spot and futures prices to the level of stocks, storage costs, and the convenience yield. Later work formalized the supply of storage and questioned whether the convenience yield is an artifact of how spreads are measured (Carter, 1999, p. 227). The object of analysis is no longer the commodity itself but the relation between its spot and futures prices: storage becomes a service with its own price and its own supply. The return to ownership, which Kaldor had derived from the behavior of holders, becomes observable. We can conclude that what began with Ricardo as a structural claim about land ends as a magnitude estimated from the spread between quoted prices.

¹⁵ On institutionalist and neoclassical economics in early twentieth-century America, see Yonay (1998).

9. Conclusion

This study has traced the formation of commodity market theory from the emergence of systematic economic thought in the early modern period through to the middle of the twentieth century, following two trajectories: the successive redefinition of the commodity as an object of analysis, and the transformation of income from mere ownership.

The object passed through three identities: an instrument of wealth, a product of nature, and an asset. With each redefinition, its identity became less dependent on the material properties that had previously determined it, until the commodity could be specified by its position in exchange and by the relation between its spot and futures prices. These redefinitions were rival answers to questions arising under changing conditions of production and trade.

Income from mere ownership followed a less continuous path. It first emerged as a distinct category under conditions in which non-reproducibility was taken for granted and was then grounded in ownership itself, though without extending to commodity stocks. It lost that standing when returns to all factors came to be determined at the margin, and reappeared when exhaustibility brought non-reproducibility back into the analysis, only to be displaced again when forward-market analysis located income in risk-bearing rather than ownership. In its final form, the convenience yield no longer required non-reproducibility at all. What recurs across these breaks, in our view, is a structure: a return accruing to possession rather than production, expressed differently in successive theories. A structural return grounded in non-reproducibility had become a contingent yield on a reproducible stock.

Reconstructed together, the two trajectories appear as aspects of the same movement. The studies discussed above focus on one identity of the commodity and capture these stages individually, but do not follow the development from one to another. The long-run reconstruction makes that transition visible.

It also bears on the interpretation of later developments. By the middle of the twentieth century, the commodity was already being analyzed as an asset, and the return to holding it had become a quantity determined by market conditions. The financialization of commodity

markets is a later phenomenon (see, e.g., Basu; Bauthéac, 2025), but the categories through which it is understood (such as the pricing of forward positions, the return to holding a stock, and the treatment of a stock as an asset) had been established beforehand. Built to explain markets of the past in which the participants held the commodity, they now organize the analysis of markets in which participation extends well beyond storage and production. That those categories do so is not incidental: financialized trading relies on the very categories reconstructed here, so tracing their formation also helps explain how these markets came to be understood from within. The questions those markets raise are posed in terms with a longer history than the markets themselves.

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