Kaldor and the relationship between 'normal backwardation' and the theory of storage

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1. Introduction

Standard explanations of the relationship between commodity prices at different delivery dates (e.g., Clark et al. 2001) are based on the theory of storage. The theory posits that stocks of commodities have a productive value, a *convenience yield*, deriving from the possibility of meeting unexpected demand while avoiding the cost of frequent revisions in production and of manufacturing disruptions and varying inversely with the level of stocks (Geman 2005). At the same time, holding stocks entails financial and storage costs (*carrying costs*). These costs, net of convenience yield, determine the difference between futures prices at different delivery dates through arbitrage operations.

The theory of storage was developed between the 1940s and the 1960s, mainly by the US economist Holbrook Working, in alternative to the Keynes-Hicks theory of 'normal backwardation' (Telser 1958; Cootner 1960). The main difference between the two theories may be summarized as follows. Whereas the theory of normal backwardation posits that futures prices tend to systematically underestimate future expected prices (proxied by spot prices), as producers hedge against the risk of price declines by selling forward at a discount, the theory of storage assumes no such bias. As inventories decline (increase), their convenience yield increases (falls) and spot prices

tend to rise above (fall below) futures prices net of carrying costs. Having introduced the notion of convenience yield, Nicholas Kaldor (1939) is generally considered the initiator of the theory of storage (e.g., Fama and French 1987; Ng and Pirrong 1994; Geman and Ohana 2009; Jarrow 2009; Benavides Perales 2010) and as such separated from Keynes and assimilated to Working on the theory of forward markets.

This separation is puzzling for two main reasons and deserves to be investigated as such. First, Kaldor introduced the notion of convenience yield in his attempt to formulate a generalised theory of forward markets, capable of contemplating normal backwardation as a special case. Second, in elaborating his theory, Kaldor brought together two typically Keynesian elements: the risk premium paid by producers to hedge against the risk of price declines, and net carrying costs (storage costs net of convenience yield) which are the negative of 'Mr Keynes' "own rate of interest" in Ch. 17 of the *General Theory*' (Kaldor 1939: 3 fn. 4).

In exploring these issues, the paper reconstructs the link between the debate on the theory of forward markets, that took place in Britain in the 1930s and 1940s, and the theory of storage, as developed by H. Working. This link is particularly relevant for its connections with the continuing debate on the relative role of fundamentals versus speculation in determining commodity prices. As we show below, at least two competing theories of the relationship between spot prices and futures prices existed in the 1940s, one giving prominence to speculation and heterogeneous expectations, one to fundamentals and homogeneous expectations.

Interestingly, we find that that Kaldor's own theory was capable of encompassing both these theories as special cases and that Kaldor's separation from Keynes on the theory of forward markets occurred when Working grafted the notion of convenience yield onto a non-Keynesian theoretical framework, based on the observation of the US wheat market. This was meant to describe a competitive market dominated by professional dealers offering storage facilities and sharing the same (correct) price expectations rather than a market dominated by speculators and hedgers trading on the basis of heterogeneous expectations and trying to get rid of redundant stocks, which is what Kaldor had in mind. In this sense Kaldor should not be regarded as the initiator of the theory of storage but rather of a theory of voluntary stock holding and speculation much closer in spirit and substance to Keynes than to Working. This conclusion is

particularly important in view of the fact that Working's theory is one of the first applications of the efficient market hypothesis. To the best of our knowledge, Kaldor's role in the development of the theory of commodity pricing has never been investigated in a systematic way, nor have its implications for the evolution of the theory of forward markets.

Based on these considerations, the rest of the paper is organized as follows. Section 2 discusses the Keynes-Hicks theory of normal backwardation, focusing on the role of stocks, and briefly mentions Keynes's theory of the own rate of interest. Section 3 investigates the genesis of the concept of convenience yield and Kaldor's initial formulation of a 'generalised theory of the forward market'. Section 4 reconstructs how Kaldor came to reformulate his theory in the context of a Symposium that took place in 1940 and whose results were published in *The Review of Economic Studies*. Section 5 explores the theory of storage and its linkages with Kaldor. Section 6 concludes the paper.

2. The Keynes-Hicks theory of normal backwardation

Keynes's early analysis of commodity markets focused on price volatility and its bearings on short term credit and the market for hedging. In an article published in 1923[1] Keynes brought to attention the huge value of the annual flow of commodities extracted or harvested from the soil compared to the amount of fixed and floating capital in the hands of producers (1923: 255). This placed a heavy burden on the market for short term loans, and created a situation in which producers were de facto compelled to hedge their risks if they wanted to have access to bank loans, for bankers were not willing to take upon themselves the risks connected with price volatility.

The hedging technique described by Keynes in 1923 is one in which the price risk is eliminated by means of forward sales at discount price. As Keynes put it, 'The producer […] is prepared to accept a somewhat lower price in advance than what, on the balance of probability, he thinks the price is likely to be when the time comes' (1923: 261), the

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[1] 'Some Aspects of Commodity Markets' (Keynes 1923).

difference between the two prices being the risk premium. Insofar as producers hedged their production by selling it forward to merchants or other producers located at a lower stage of the process of production, the whole business could be carried out without speculators. But Keynes noticed that the time horizon of producers and that of the merchants did not usually match. This gave scope to speculators, acting as *risk-bearers*, to enter the market and earn a part of the risk premium as defined above.

Compared with a more traditional idea of speculation, based on the assumption that speculators entertain different and more accurate expectations on prices, Keynes's 1923 article introduced an element of innovation. Now, hedgers and speculators could even have the same price expectation, while the profit of the speculator would result from investments in futures contracts, each purchased at the downward biased future price tendered by the hedgers. In *Value and Capital*, Hicks would generalize the same argument as follows:

> If we are to allow for uncertainty of expectations […] we must not take the most probable price as the representative expected price, but the most probable price ± an allowance for the uncertainty of the expectation, that is to say, an allowance for risk[; while] the percentage by which the representative expected price falls short of or exceeds the most probable price, is not determined solely by the *opinion* of the planner about the degree of uncertainty. It is also influenced by his *willingness* to bear risks. (Hicks 1946: 126-7)

When applied to speculation and hedging, this entails that

> it is of the essence of speculation, as opposed to hedging, that the speculator puts himself into a more risky position as a result of his forward trading […]. He will therefore only be willing to go on buying futures so long as the futures price remains definitely below the spot price he expects; […] and it will not be worth his while to undertake the risk if the prospective return is too small. (Hicks 1946: 138)

Keynes returned to the problem of hedging by means of forward sales in the context of a wider analysis of the causes of fluctuations of investments in Chapters 27, 28, and 29 of the *Treatise on Money*, where the expression 'normal backwardation' was employed for the first time. In volume I of the *Treatise* Keynes gave a general definition of fixed, working, and liquid capital—'We shall call goods in use fixed capital, goods in process working capital, and goods in stock as liquid capital' (CWK V: 116)—referring

the reader to vol. 2, Chapter 28 for a 'more detailed definition' of working and liquid capital:

> I define working capital as being the aggregate of goods […] in course of production, manufacture, transport and retailing, including such minimum stocks, whether of raw materials or of finished products, as are required to avoid risks of interruption of process or to tide over seasonal irregularities […]. It does *not* include surplus stocks, which constitute liquid capital. (CWK VI: 103-4)

Keynes thus distinguished between that part of stocks that is *deliberately* held—and therefore included in working capital, because it is supposed to be useful in certain circumstances—and that part which is a 'surplus' over this amount and therefore *involuntarily* held. The point that Keynes was making is that '[i]f, as the result of a previous miscalculation, such stocks come into existence, the price of the goods continues to fall until either consumption increases or production falls off sufficiently to absorb them' (CWK VI: 130). The reduction of price below the normal level that producers would be willing to accept in order to get rid of their surplus stocks, depends on the costs of carrying these stocks. These costs include—along with insurance and warehouses charges, allowances for deterioration, and interest charges—the cost of hedging (risk premium), that Keynes considered particularly relevant.[2] Because of these costs, holders of liquid capital tend to get rid of it as rapidly as possible with the effect of depressing prices. As carrying costs are much higher than usually admitted—Keynes argued—price fluctuations are also much wider than they would otherwise be.

Restating the same argument in terms of the forward markets, Keynes discussed the case of producers who hedge themselves by selling forward, making a distinction between two cases: one in which 'there are not redundant liquid stocks', and one in which 'there exist redundant liquid stocks' (CWK VI: 128-9). In the former case there will be backwardation, which will only be limited 'by the unwillingness of the buyer to pay the higher spot price rather than postpone the date of his purchase' (CWK VI: 128)—and in the special case of a market in equilibrium, the one that Hicks would

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[2] On this point, Keynes took issue with Hawtrey's theory of liquid stocks, based on the idea that the amount of stocks held by producers is inversely proportional to the level of the rate of interest. See Hawtrey's *Currency and Credit* and *Trade and Credit* and CWK VI: 117-23.

consider in *Value and Capital* (1946: 138), the backwardation will be at its 'normal' level. In the latter case,

> The existence of surplus stocks must cause the forward price to rise above the spot price […] ; and this contango must be equal to the cost of the warehouse, depreciation and interest charges of carrying the stocks. But the existence of a contango does not mean that the producer can hedge himself without paying the usual insurance against price changes. On the contrary, the additional element of uncertainty introduced by the existence of stocks and the additional supply of risk bearing which they require mean that he must pay more than usual. In other words, the quoted forward price, though above the present spot price, must fall below the anticipated future spot price by at least the amount of the normal backwardation; and the present spot price, since it is lower than the quoted forward price, must be much lower than the anticipated future spot price. (CWK VI: 129)

Indicating current price by *CP*, forward price by *FP*, expected price by *EP*, warehouse, depreciation and interest costs by *c* and the risk premium by *r*, when liquid capital exists, prices stand in the following relation

$$CP < FP < EP$$

$$CP + c = FP = EP - r$$

This explanation of the spread between current and future prices already included, along with the risk premium, the cost of carrying stocks. The importance of this latter element was downplayed, if not altogether overlooked, in Hicks's *Value and Capital*.[3] By contrast, Kaldor would consider carrying costs an essential component of his theory of forward markets, a theory based on the development of the Keynes's ideas in the *Treatise* and in Chapter 17 of the *General Theory*. In that chapter, discussing the concept of own rate of own interest (the return of an asset in terms of itself) Keynes isolated three attributes which different types of assets possess in different degrees:

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[3] For Hicks 'Stocks may indeed be left in the shops unsold; but they are unsold because people prefer to take the chance of being able to sell them at a future date rather than cut prices in order to sell them now' (1946: 131). While this is not inconsistent with Keynes's argument, Hicks did not enter into the practical problems connected with the variations of prices that might become necessary in order 'to sell them [the stocks] now'. Moreover, Hicks did not follow Keynes on the definition of carrying costs, and held fast to the notion that the level of stocks of intermediate products is 'determined through the rate of interest' (1946: 118).

i) Some assets produce a yield or output q, measured in terms of themselves, by assisting some processes of production or supplying services to a consumer.

ii) Most assets, except money, suffer some wastage or involve some cost through the mere passage of time (apart from any change in their relative value), irrespective of their being used to produce a yield; i.e. they involve a carrying cost c measured in terms of themselves. […].

iii) Finally, the power of disposal over an asset during a period may offer a potential convenience or security, […] there is, so to speak, nothing to show for this at the end of the period in the shape of output; yet it is something for which people are ready to pay something. […] We shall call it liquidity premium l. (CWK VII: 225-226)

Based on these concepts, Keynes argued that the own rate of interest of any commodity is $q - c + l$. As shown in Section 3 below, Kaldor's convenience yield corresponds to the element q in Keynes's formulation, while the 'net carrying costs' in Kaldor's theory speculation and forward markets derives from the Keynesian definition of the own rate of interest of any commodity.

3. Kaldor on speculation, risk and convenience yield

Kaldor re-elaborated the Keynesian concepts of fixed, working and liquid capital, normal backwardation and own rate of own-interest in the first part of his 1939 essay on *Speculation and Economic Stability* (Kaldor 1939). In the context of this re-elaboration, he formulated a generalized version of Keynes's theory of the forward market which consists of three main elements: 1) the notion of speculative stocks, 2) the introduction of the concepts of convenience yield and net carrying costs, 3) the establishment of the idea that hedgers can be both forward sellers and forward buyers.

Kaldor defined speculative stocks of assets as 'the difference between the amount actually held and the amount that would be held, if other things being the same, the price of that thing were expected to remain unchanged' (Kaldor 1939: 1) and discussed the two conditions for an asset to be the object of speculation: 1) perfect or semi-perfect marketability, and 2) low carrying costs. Perfect marketability requires that the asset be an article of general demand, fully standardised or capable of full standardisation. Low

carrying costs require that the asset be durable and valuable in proportion to bulk. Carrying cost *proper* consists of wastage and storage cost.

> But *net* carrying cost also depends on a third factor: the yield of goods. In normal circumstances, stocks of all goods possess a yield, measured in terms of themselves, and this yield which is a compensation to the holder of stocks, must be deducted from carrying costs proper in calculating net carrying costs. The latter can, therefore, be negative or positive. (Kaldor 1939: 3)

While Kaldor recognized that his definition of net carrying cost is 'the negative of Mr Keynes' "own rate of own-interest" in ch. 17 of the *General Theory*—except that no allowance is made here for the factor termed "liquidity premium"[4]' (Kaldor 1939: 3 fn. 4)—the relationship between the notion of speculative stocks and Keynes's taxonomy of capital assets in the *Treatise* is more complex. Kaldor distinguished between goods which are used in production and goods which are used up in production. Fixed capital, in the sense of the *Treatise*, belongs to the first category and cannot be used for speculative purposes as it lacks standardization. Working and liquid capital, instead, belong to the second category and, being standardized, can be used for speculation. Like working capital, speculative stocks are held voluntarily and 'have a yield , *qua* stocks, by enabling the producer to lay hands on them the moment they are wanted and thus saving the cost and trouble of ordering frequent deliveries, or of waiting for deliveries' (Kaldor 1939: 4). Unlike working capital, however,

> the amount of stocks which can thus be 'useful' is, in given circumstances strictly limited; their marginal yield falls sharply with an increase in stocks above 'requirements' and may raise very sharply with a reduction of stocks below 'requirements' […] Hence as we defined 'speculative stocks' as the *excess* of stocks over normal requirements […] we may say that with working-capital-goods carrying costs are likely to be positive when speculative stocks are positive, and negative when they are negative. (Kaldor 1939: 4)

Having related his own notions of speculative stocks and convenience yield to Keynesian categories, Kaldor went on to discuss the relationship among current, future

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[4] A possible explanation for this omission may be that Kaldor developed his theory of speculation focusing on perfectly marketable (i.e. very liquid) goods. The relationship between liquidity and risk premia, however, is a complex one. On this see Kaldor (1939: 4 fn. 5) and Kaldor (1960).

and expected price, under the assumption of a *single expectation for the market as a whole*. Kaldor recognized that

> The expectations of different individuals composing the market are normally different of course. But it is permissible to speak of a single expectation for the market as a whole, since *cet. par.* there is always a definite amount of any good that would be held, at any particular expectation, if all individuals' expectations were the same. (Kaldor 1939: 1 fn. 1)[5]

> If expectations were quite certain, speculative activity would so adjust the current price that the difference between expected price and current price would be equal to the sum of interest and carrying costs […] minus the yield […] If expectations are uncertain, the difference […] must cover, in addition, a certain risk premium. (Kaldor 1939: 5)

In algebraic terms, this reads as follows:

$$EP - CP = i + c + r = i + c' - q + r$$

Where, EP is the expected price, CP is the current price, r is the risk premium (related to price fluctuations and increasing with the dispersion of expectations around the mean and the size of commitments), i is the interest cost, c net carrying cost, c' carrying cost proper (wastage and storage) and q the convenience yield.[6] The presence of risk creates the incentive for market participants to develop facilities, in the form of forward contracts, to transfer risk from risk-adverse to risk neutral (or less adverse) agents in return for the payment of a premium. As to this, Kaldor distinguished among three different cases.

> If speculative stocks are zero, i.e. $EP = CP$, then $-c = i + r$, i.e. the negative of carrying cost must be equal to the sum of interest cost and risk premium, and since i and r are always positive, the carrying cost must be negative, i.e. the yield must exceed the sum of storage cost and primary depreciation by the required amount. In this case $FP = CP - r$, the forward price must fall short of the current price by an amount which Mr. Keynes calls normal backwardation'. (Kaldor 1939: 6)

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[5] It should be noted that differences in individual risk premia make transactions possible even if all individual price expectations are equal. It should also be noted that, while Kaldor made explicit assumptions about expectations this was not the case with Keynes.

[6] In Keynes's formulation i was included in c.

In algebraic terms,

$$FP - CP = i + c' - q, \text{ hence } FP = EP - r$$

> The proposition that the forward price must fall short of the expected price by the amount of the marginal risk premium, […] is probably true in the majority of markets; in the case of certain industrial raw materials, however, where the outside buyers are contractors with given orders for the period ahead, the 'hedgers' may be predominantly forward buyers, and the 'speculators' spot buyers and forward sellers. Now the 'carrying costs' for these speculators may be higher than the carrying costs for the market generally. This is because the yield of stocks of raw materials (which in our definition is included in net carrying costs) consists of convenience, […] and this convenience is largely lost if the stock held is already sold forward. (Kaldor 1939: 6)[7]

$$FP - CP = i + c', \text{ hence } FP = EP - r + q$$

As in the first case, $EP = CP$ (normal conditions, balanced markets), speculative stocks are zero and what stocks are traded have a positive convenience yield. In this case, however, contrary to the previous one, the yield accrues to forward buyers (hedgers) rather than speculators. This implies: 1) that the forward price will be higher than the expected prices (reflecting the hedgers' eagerness to buy) and 2) that contango will be observed. Contango will also be observed when speculative stocks are positive, their yield is zero ($q = 0$), the current price falls below the forward price by an amount equivalent to (positive) carrying costs, and the forward price falls below the expected price irrespective of whether hedgers are forward buyers or forward sellers.

$$FP - CP = i + c', \text{ and } FP = EP - r$$

At this stage, Kaldor's theory of the forward market is already a generalisation of Keynes's own, built on a less selective definition of stocks and a more complex vision of hedging practices. As to the similarities, both theories focus on hedgers and speculators, trading risks on financial markets, rather than on dealers, earning revenues

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[7] Kaldor specifically related the possibility of transferring q to stocks of raw materials, which assist production and whose usefulness comes from being readily available, rather than to of financial assets, where the yield always stays with stock holders.

for providing storage facilities, and both theories relate speculation to the business cycle, through its impacts on price and output.

4. The Symposium

Kaldor's 1939 essay became the object of intense debate and of a Symposium on the *Review of Economic Studies*. J.C.R. Dow's contribution to the Symposium deserves particular attention (Dow 1940) for the arguments used to criticize Kaldor's theory and, in particular, the idea that for some industrial raw materials, *where the outside buyers are contractors with given orders for some period ahead*, stock-holders (speculators selling forward) loose the convenience yield to hedgers (forward buyers) and forward prices exceed expected prices.

Dow acknowledged that forward sales would transfer the yield of stocks from stock-holders to hedgers, but claimed that futures rather than forward contracts, a difference ignored by Kaldor (Dow 1940: 186-7), were the standard instruments to hedge stocks. Selling futures rather than forward, stock holders retained control of their stocks and of the convenience yield, while 'there is *always* the possibility that the forward price will be above the expected price; and *always*, with the normal sort of risk, the futures price will be below both' (Dow 1940: 187). By ignoring the difference between futures and forward contracts, Kaldor had therefore treated as general a very specific case.

Dow's second line of criticism was based on the notion of *negative* risk, the risk that prices rise rather than fall (positive risk). Negative risks affect two categories of agents: 1) manufacturers using the commodity as input, and 2) speculators sell futures contracts without owning the stocks. Symmetrically, positive risks, affect producers and buyers of futures contracts. Assuming identical price expectations (as Kaldor had done) and different degrees of risk aversion, Dow showed that when positive and negative risks were equivalent futures prices would fluctuate between $EP - r$ and $EP + r$, whereas in case positive risks prevailed (the normal case for Dow) futures prices would be lower than expected prices (as in the case of normal backwardation). Only in very specific circumstances, much more specific than what Kaldor had envisaged, would negative risks prevail.

Kaldor's curt response to Dow[8] and to 'some further discussions on the subject with Mr. R. G. Hawtrey' (Kaldor 1940: 196) gave him a chance to refine his theory of the forward market.

> The main defect in my previous account was the insufficient allowance made for the *difference in expectations* of different individuals. […] I still believe that for certain problems in the theory of speculation, this concept of the 'representative expectation' is perfectly legitimate. […] From the point of view of the theory of the forward market, however, it is not legitimate; for the determination of the forward price, and in particular, the relation of the forward price to the expected price will not be the same in the case where everybody's expectations are equal as in the case where the 'representative expectation' is an average of different individual expectation […] In both cases individuals participating in the forward market can be divided into two groups: 'speculators' and 'hedgers'.[9] (Kaldor 1940: 196)

When all individuals have the same expectations 'forward transactions can only arise between hedgers and speculators owing to differences in the "marginal risk premium"' (Kaldor 1940: 197). 'Insofar as hedgers are both sellers and buyers of futures, their opposite risks mutually cancel each other out, hence the futures price in transactions between hedgers and hedgers can vary anywhere between' (Kaldor 1940: 198) $EP - r$ (the lowest price hedgers accept when selling forward) and $EP + r$ (the highest price hedgers accept to pay when buying forward). As to which of the two cases is likely to prevail, Kaldor stated

> In my earlier paper I have said that in the majority of markets, the hedgers will be forward sellers; and only in the case of certain raw materials […] can it be the other way round. I should now like to modify this statement. The hedgers are likely to be predominantly buyers, rather than sellers. (Kaldor 1940: 197)[10]

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[8] On this see Kaldor (1940: 197 fn. 4, 198 fn. 2, 199 fn. 2).

[9] Kaldor defined *hedgers* as 'those who have certain commitments, independent of any transactions in the forward market, either because they hold stocks of the commodity, or are committed to produce the commodity, or are committed to produce, in the future, something else for which the commodity is required as a raw material... *Speculators*, on the other hand, have no commitments apart from those entered into in connection with forward transactions' (Kaldor 1940: 196).

[10] Kaldor provided two main motivations for this change of mind: (1) 'technical uncertainties connected with production are much greater in the stages of production prior to the stage where the futures market is situated than in subsequent stages' (Kaldor 1940: 197), (2) producers, especially producers of agricultural crops, may compensate price fluctuations with output fluctuations, moreover, if output risk prevails the 'risks borne by producers are enlarged, and not reduced, by hedging' (Kaldor 1940: 197).

If hedging influences the position of the futures price *FP* relative to *EP*, a second factor hitherto not discussed by Kaldor—arbitrage—determines the level of *FP* relative to current prices *CP*. Arbitrageurs buy spot and sell futures simultaneously, holding stocks until the date of delivery. They run no risks of the sort hedgers and speculators trade among themselves and their presence limits the extent to which futures prices may rise above current prices when stocks are relatively abundant. 'While there is no limit, apart from expectations to the extent to which the futures price may *fall short* of the current price, it cannot *exceed* the current price by more than the sum of interest plus carrying costs'.[11] If the arbitrageur, by holding stocks, obtains the advantages, as well as the disadvantages, which other holders of stock obtain from their holding, his 'carrying cost' will consist of the cost of storage and wastage *minus the yield*, so that

$$FP - CP = i + c' - q$$

but since, in all cases

$$EP - CP = i + c' - q + r$$

$$FP = EP - r$$

In this case, which applies to securities in particular, the futures price falls short of the expected price by an amount equivalent to the marginal risk premium irrespective of whether hedgers are predominantly buyers or sellers. But 'where the yield consists simply of "convenience," the arbitrageurs would enjoy no such convenience, on stock bought solely for arbitrage purposes' (Kaldor 1940: 199). This implies the possibility that the futures price rises above the expected price. Expressing this possibility in algebraic terms

$$FP - CP = i + c'$$

$$EP - CP = i + c' - q + r$$

$$FP = EP - r + q$$

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[11] If *FP* exceeded $CP + i + c'$, riskless profits could be earned by buying spot, selling forwards and holding stocks to maturity.

In this re-stating the two cases, Kaldor moved forward with respect to his 1939 formulation.

> I still maintain, therefore, that in the case *everybody's expectation are assumed to be the same*, the conclusions stated in my earlier paper were correct. […] In markets were hedgers are predominantly sellers, or even when they are predominantly buyers but the yield is a money return which automatically accrues to all holders, the futures price must fall short of the expected price by the marginal risk premium. In markets where hedgers are predominantly buyers *and* the yield of stocks consists of convenience, the future price can exceed the expected price. […] In the latter case, […] FP will be either *EP + r*, or *EP – r + q,* whichever is less. (Kaldor 1940: 200)

In the more realistic case of heterogeneous expectations, multiple types of transactions are possible 'not only between hedgers and hedgers, and hedgers and speculators, and hedgers and arbitrageurs, …, but also between speculators and speculators; and transactions of the latter type may swamp all others' (Kaldor 1940: 200). In this case, which we may surmise Kaldor had come to consider as the most relevant one, *FP* will fluctuate between *EP – r* (the average demand price of *bull* speculators, the counterpart of *bear* speculators and hedger sellers) and *EP + r* (the average supply price of *bear* speculators, the counterpart of *bull* speculators and of hedger buyers).

$$EP - r \leq FP \leq EP + r$$

With speculation and heterogeneous expectations being given a prominent position and the introduction of arbitrageurs , Kaldor's final formulation of the theory of forward markets significantly downplays the role of the convenience yield. On the specific issue of normal backwardation Kaldor concluded

> The doctrine first propounded in Mr. Keynes' *Treatise on Money*, and taken over by Professor Hicks […] has only a limited application. It is not valid if there is a marked divergence in individual expectations; and even if unanimity of expectations is assumed it will only necessarily hold if markets where hedging is predominantly on the selling side or where the yield of stocks enters automatically in arbitrage costs. (Kaldor 1940: 201)

Hawtrey (1940) acknowledges Kaldor's effort in modifying his theory of the 'expected price' but retains his perplexities about the assumption of uniform price

expectations. Hawtrey objects to this hypothesis on the basis of a series of arguments which may be summarized as follows:

> Not only are there sure to be some people who have formed no expectations at all in regard to the economic quantity concerned, but those who have will have formed very incomplete expectations. […] The most complete expectations will take the form of estimates of the respective probabilities of a series of results. But different people's estimates will not relate to the same series of results. Nor will they relate to the same future dates […] In the particular case of dealers in a forward market, the trader who hedges does so for the express purpose of being relieved from estimating future price movements. […] And the expectations formed by the professional dealers and the speculators themselves do not take the form of an estimate of what the price will be at some future dates. The speculative buyer merely anticipates a rise and the speculative seller a fall. (Hawtrey 1940: 203)

Hawtrey's contribution concludes the 1940 Symposium with what appears as a further generalization of Kaldor's own theory, based on the identification of two limiting cases, reflecting very different degrees of uncertainty regarding commodity prices, in the context of the same theory. 'When the future movement of prices becomes very uncertain, there are wide differences of opinion among dealers, and both bulls and bears hope for big gains. … When there is very little difference of opinion among dealers as to price movements, there may practically be no speculation' (Hawtrey 1940: 204). In the first case, speculators dominate the market, prices fluctuate a lot and price margins may be regarded as risk premiums. In the second case, transactions involve hedger buyers (manufacturers) trading with hedger sellers.[12] Dealers, who carry the stocks and sell them forward, relieve manufacturers of the cost of holding the stocks and receive their compensation through the premium of the forward price over the spot price. It is only when the 'shortage of spot supplies becomes severe enough to outweigh the entire carrying cost that a "backwardation" or excess of the spot price over the forward price appears. The scarcity must be temporary.' (Hawtrey 1940: 205).

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[12] As to hedger sellers, Hawtrey writes: 'the hedging sellers are almost entirely the *holders* rather than the producers (of stocks)' (Hawtrey 1940: 204) and justifies this significant departure from Keynes's main focus on producers as hedgers on the basis of a series of arguments presented on page 204 of his essay. Kaldor had reached analogous conclusions focusing on agricultural producers.

Hawtrey's two cases are particularly interesting as they indicate the two directions along which the theory of forward markets evolved in the 1940s and 50s. On one side, Working's works on the wheat markets (see Section 5 below), focusing on: 1) storage cost and convenience yield as the main determinants of the difference between commodity prices at different delivery dates, 2) efficient markets dominated by dealers offering storage facilities, sharing the same (correct) expectations about prices and market fundamentals. On the other side, the British literature putting emphasis on: 1) speculation and volatility as the main determinants of commodity prices, 2) relatively efficient markets populated by distinct categories of traders (hedgers vs. speculators), operating on the basis of heterogeneous expectations.

An application of the British approach to the theory of commodity prices can be found in an article by Gerda Blau that was published, once again in the *Review of Economic Studies*, four years after the Symposium (Blau 1944). From a theoretical point of view, this article did not add new ideas to the debate. To a large extent, Blau's paper built on the Kaldorian framework as it has been described above. Only, it downplayed the importance of convenience yield and placed more emphasis on expectations, as well as on the relative weight of hedgers, speculators, arbitrageurs, in determining futures prices.

The downplaying of convenience yield was the result of focusing on futures instead of forward markets. Provided that, in futures markets, standardized commodities are dealt with, and that the difficulty of obtaining new supplies of these standardized commodities at arm's length is supposed to be very low in these markets, the convenience of holding stocks turns out to be very low. On the other hand, the great emphasis on the role of expectations, and especially on the possible existence of different expectations among the agents operating in the same market, somehow reinforced Kaldor's conclusion that the Keynesian theory represented a special case.

More specifically, situations in which the opposing forces of bull and bear speculation dominate, thus placing *FP* somewhere between *EP − r* and *EP + r*, were very plausible. At the same time, however, Blau came to the conclusion that commodity markets could not easily become the sort of 'casino' markets described in chapter 12 of Keynes's *General Theory*. Rather than that, Blau came back to some of the seminal ideas of Keynes's 1923 article, where speculation could not act effectively in limiting

price instability but could nonetheless reduce the producers' risks connected with it (Blau 1944: 23-6).

As Keynes also had argued, price instability is a necessary condition for speculation, so there is a (plausibly quite high) minimum level of volatility that has to be accepted if speculation has to exist. On the other hand, the 'danger' that speculation could augment market instability instead of reducing it

> […] is likely to be more severe in an organised market of railway shares than in an organised market for an agricultural crop because the railway shares' value for the community as a whole is likely to depend on expectations over a period of 10-20 years or more while the agricultural crop's value […] is likely to depend on expectations over the crop year and hardly more than one year after. (Blau 1940: 25)

Blau was here probably referring to the Keynesian idea of radical uncertainty over longer periods (CWK VII: 147-64; Keynes 1937). Especially in the case of crops, the life of a commodity traded in futures exchange is much shorter, and this increases the probability that the individuals operating in the markets will rely on their knowledge of fundamentals instead of falling into the beauty contest situation described by Keynes in the *General Theory*. This conjecture finds supports in Blau's subsequent observation when she writes: '[…] despite all limitations, hedging can, on the whole, be regarded as an effective insurance against major price fluctuations, and because of the lowered risk the hedger can do a larger amount of transactions with the same amount of capital' (1944: 26). Once again developing an idea that was put forth by Keynes in 1923, Blau observed that 'A further reason for the lowering of costs' is that 'the hedge is generally accepted […] as a collateral by crediting banks', and went further to say that 'the security derived from hedging may diminish the cautious trader's natural disinclination to carry stocks which has been characterised by Keynes as one of the faults of the competitive system' (Blau 1944: 26; see also Keynes 1938).

It is not at all clear whether Keynes or Kaldor would have endorsed Blau's opinions about the relative efficiency of commodity markets,[13] and it is not our object to answer

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[13] Keynes became convinced that commodity markets were characterized by endemic excess volatility, due to the reluctance of traders to hold stocks, and proposed to correct what he saw as a market failure by means of government-sponsored buffer stocks (Keynes 1938). Blau was aware of Keynes's opinion when she wrote: 'the security derived from hedging may diminish the cautious trader's natural disinclination to carry stocks which has been characterised by Keynes as one of the faults of the

this question. On the other hand, these conclusions are interesting enough, from the standpoint of the present reconstruction, because they base a reappraisal of the economic function of commodity markets on a view of their functioning that, as it will be shown presently, is very different to the one that Working was developing in the same years.

5. The theory of the price of storage

As the debate on commodities and futures markets was going on in Britain, parallel research on this issue was being conducted in the USA, notably by Holbrook Working. Based on his knowledge of the US wheat market, Working (1948, 1949a) formulated the theory of the price of storage to explain the difference between spot and futures prices. This theory consists of three elements: 1) the idea that all prices, spot prices included, react to market expectations in approximately the same way, irrespective of the time of delivery, 2) that their difference depends on carrying costs net of convenience yield, and 3) that net carrying costs can be positive or negative.

The origin of this theory can be traced back to Working (1942) where the author, building on previous research (Working 1934, Hoos and Working 1940), refuted the prevailing idea (that Working attributed to Hawtrey 1938, among others) that 'spot prices are not generally supposed to reflect anticipations of the future in the same degree as futures prices' and concluded that 'the difference between prices of successive wheat futures at any given time seems to reflect the existing market appraisal of the prospective marginal cost of carrying wheat from one delivery month to the next' (Working 1942: 47).

In the context of this analysis, Working observed cases of negative carrying costs in connection with low stock levels that were in blatant contradiction with the cost of carrying theory, and related this to the need of maintaining a minimum amount of stocks to ensure regular production (Working 1942: 42-3). This argument was akin to that put forth by Kaldor to introduce the notion of convenience yield but a post-script to the

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competitive system' (Blau 1944: 26). Kaldor came to the endorse Keynes's vision in the 1970s (on this, see Spraos 1989).

1942 article, the Appendix note on pp. 51-52, bore witness to the fact that Working had written that paper before coming into contact with Kaldor (1939) and the Symposium. In this note Working subscribed to Hawtrey's criticism of Kaldor's treatment of market expectations and downplayed the importance of risk as a factor determining futures prices. The note made no mention of the notion of convenience yield.

Building on these results, Working (1948: 2) compared four different theories to explain the case of negative carrying costs, which he defined *inverse carrying charges*,[14] in the market for wheat, listing them as follows:

(1) 'Cash and futures prices, though related, are not equivalents aside from the time element, at least in the United States wheat market.'

(2) 'The future, as against the present, is discounted.'

(3) Expectations regarding future demand and supply conditions tend to have more effect on prices of deferred futures than on cash prices or on near futures.

(4) An inverse carrying charge is a true negative price of storage, arising from the fact that stocks may have a high marginal 'convenience yield'.

Working refuted the first explanation on the basis of technical considerations and of his knowledge of hedging practices on the US wheat market. In particular, he found that futures were commonly sold (bought) in connection with a purchase (sale) on the cash market only when the discount (premium) of the spot price on (over) the futures prices was expected to fall (increase). Working saw this form of discretionary hedging as arbitrage 'in fact as well in form because its occurrence depends on a judgement regarding the relation between two prices' (Working 1948: 5). As shown below, this was the first step of a general redefinition and generalization of the concept of hedging that continued at least until Working (1962).

As to the second explanation, traced back to Vance (1946) and Keynes (CWK VI), based on futures prices being downward biased, Working concluded that this could not 'explain more than a very small inverse carrying charge' (Working 1948: 13). Working

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[14] As Working states 'In the technical language of American futures markets, *carrying charge* refers to a difference at a given time between prices of a commodity for two different dates of delivery. […] In British usage, 'contango' and 'backwardation' refer to positive and inverse carrying charges respectively' (Working 1948: 1).

refuted the third explanation, *that expectations should affect prices for different forward dates differently*, on the basis of the same arguments, as he had used in 1942 and recognized that 'heavy surplus stocks may force spot and futures prices into a pattern of relationship determined by the costs of carrying stocks' (Working 1948: 13). Generalizing this argument, Working introduced a theory in which inter-temporal price relations depend *exclusively* on the price of storage (carrying costs). Finally, he explained the possibility of inverse carrying charges by explicitly referring to Kaldor and to his notion of convenience yield (Working 1948: 20-1).[15]

Indicating by P_1 a spot or forward price, by P_2 a forward price for a date later than that to which P_1 applies and by P_s carrying charges (price of storage), Working summarizes his framework with the following formula

$$P_1 + P_s - P_2 = 0$$

As Working put it, the previous equation

> gives no information by itself regarding the economic influences which determine any one of the variables included, but it affords a basis for explaining any one of them in terms of known explanations of the other two […] Treatment of the carrying charge as a price of storage involves providing a direct explanation of P_s instead of relying on explanations in terms of differences between the explanations of P_1 and P_2. Direct explanation … is simpler and more reliable than indirect explanation and it opens the possibility of explaining either P_1 or P_2 in terms of the other and of P_s These advantages prove substantial in practice. (Working 1948: 22-3)

Working saw P_s as a function of outstanding stocks and as the main independent factor determining the difference between spot and futures prices.

Working (1949a) clarified the relationship between P_s, P_1 and P_2 in the context of an analysis of hedging by professional dealers supplying storage services. Based on practical examples, Working showed how futures prices at different delivery dates could guide a dealer in his decisions by providing 'a basis for anticipating his return for storage which is far superior to any estimate which could be made in the absence of a

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[15] When stocks are low, and their convenience yield positive and very high, net carrying costs (storage cost minus convenience yield) will be negative (backwardation).

good hedge in a futures market or of an outright forward sale […] and a means through hedging, of *assuring* receipt of that return' (Working 1949a: 1257-8).[16]

Working (1953) noted three relevant facts about hedging in commodity futures markets:

> First, […] hedging of the sort here considered is not properly comparable with insurance. It is a sort of arbitrage. […] Secondly, hedging does not eliminate risks arising from price variability. Risk is less than on stocks held unhedged but it still exists. […] Thirdly, hedging is not necessarily done for the sake of reducing risk. (Working 1953: 325)

Based on these observations, Working defined hedging as 'the purchase or sale of futures in conjunction with another commitment, usually in the expectation of a favourable change in the relation between spot and futures prices' (Working 1953: 326).

In his 1962 synthesis of the 'New Concepts Concerning Futures Markets and Prices' developed over the previous thirty years, Working clarified that he saw hedging as a 'multipurpose' activity done to seek profit from stock holding and speculation, to avoid loss, and to reduce risk, and 'defined as the use of futures contracts as a temporary substitute for a merchandising contract' (Working 1962: 432). In the same context, he noted that 'futures prices tend to be highly reliable estimates of what should be expected on the basis of *contemporarily available information* concerning present and probable future demand and supply' (Working 1962: 432). This definition is relevant as it connects Working's investigation of commodity futures markets with a parallel strand of his research activity concerning the time-series properties of financial prices. As part of this investigation, Working came to the conclusion that prices forming on *perfectly functioning markets* move as random walks and that price changes are completely unpredictable (Working 1949b), findings that would be at the core of the 'efficient market hypothesis'.[17]

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[16] In particular, Working discussed the problem of a dealer, holding stocks at the end of November and deciding whether to sell in December or to hold on until May, and showed how this decision depended on whether the difference between futures prices for delivery in May and December was sufficient to cover carrying costs, under the assumption that spot prices at the end of April stood in the same relationship to future prices in May as spot prices in November stand to future prices in December.

[17] For a recognition of the role of Working in the development of the efficient market hypothesis see Samuelson (1982).

6. Conclusions

The main conclusions of our paper may be summarized as follows. In 1939, Kaldor proposed a generalization of the Keynes-Hicks theory of normal backwardation relating differences between spot and futures prices to the type of hedgers prevailing in the market. In particular, where hedger sellers prevailed Kaldor thought futures prices would fall below spot prices, taken as proxy of future expected price (normal backwardation). Where hedger buyers prevailed, however, futures prices would tend to rise above spot prices. This generalization was based on three main assumptions: 1) homogeneous expectations, 2) risk averse hedgers, 3) speculators insuring hedgers in return for a premium. In response to several lines of criticism to his 1939 contribution, Kaldor reconsidered his views, introducing the possibility of heterogeneous expectations. This led him, and other British authors, to admit the possibility of speculators trading among themselves rather than with hedgers and to downplay the role of fundamentals in determining commodity emphasizing that of speculation and the role of a third category of operators, arbitrageurs.

Meanwhile, in the US, Working developed a model of wheat prices at different delivery dates based on the assumption of homogeneous expectations and of trading taking place among professional dealers, offering storage facilities in competition against each other, producers and consumers. Working observed that spot and futures prices moved in step and that, normally, spot prices fell below futures prices due to storage cost (contango). The fact that sometimes this was not the case confronted Working with a puzzle which he named reverse carrying charge. Working's discovery of the notion of convenience yield allowed him to solve this puzzle, without abandoning his preferred theoretical framework and the idea that fundamentals rather than speculation are the main determinants of wheat price.

Kaldor's separation from Keynes on the theory of forward markets therefore occurred when Working introduced the concept of convenience yield onto a non Keynesian theoretical framework. This model, one of the first applications of the efficient market hypothesis, differed from Kaldor's final formulation in not assigning any specific role to professional speculators in the price formation process. Moreover, whereas Kaldor and other British economists working on the theory of forward markets

formulated a complex taxonomy of different cases, classified on the basis of the identity of market participants, on the prevalence of one type of trader over the other (e.g. hedgers versus speculators), on the type of hedging technique and on the type of commodity, Working's theory was based on a specific market structure (dealers selling, manufacturers buying), on a specific hedging technique (discretionary hedging) and on a specific commodity (wheat).

Explaining how Working's theory of storage, including the notion of convenience yield, came to prevail on Kaldor's more general approach is not the object of this paper. However, our reconstruction seems to indicate two possible (and possibly concomitant) explanations. First, the theory of the price of storage is based on observable and measurable factors rather than on expectations and individual risk premiums. Second, the theory of the price of storage is consistent with the efficient markets hypothesis.

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