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Assessing Multi-factor Productivity of the Agro-Industries in Trinidad and Tobago: A Research Agenda

Kit Fai Pun [aΨ], Clement K. Sankat[b] and Cavelle B. Motilal[c]

[a, c] Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies; E-mail: KitFai.Pun@sta.uwi.edu; cmotilal@hotmail.com

[b] Office of Principal, The University of the West Indies, St. Augustine Campus, Trinidad and Tobago, West Indies; E-mail: Principal@sta.uwi.edu

[Ψ] *Corresponding Author*

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Abstract: *Nowadays, processed and semi-processed food and agricultural products account for about two-thirds of total agricultural trade globally. Hence, the deployment of resources in agriculture has become increasingly responsive to market forces and increasingly integrated in the network of industrial interdependencies. This paper discusses the forward and backward linkages, and identifies leverage points in the agro-industry sector with reference to Trinidad and Tobago (T&T). A research agenda has been initiated to investigate into these linkages in the context of agro-production functions, and use the Törnqvist index to determine the agro-contributions towards the nation's gross domestic product. This exploratory work would contribute to develop a conceptual multi-factor productivity model that facilitates the analysis of the forward and backward linkages of the agro-industry sector in T&T.*

Keywords: *Agro-industry, linkages, productivity, model, Trinidad and Tobago*

1. Introduction

In the context of a rapidly evolving global food and agriculture system, rising incomes and changing food consumption patterns around the globe would influence the growth in the processed food industry. It has also been recognised that the developmental progress of a country has a direct correlation with the expansion in the privately driven agro-industry sector. Attendant upon growth in the latter is a sharp increase in output and labour productivity as a result of deeper backward and forward linkages (ISNAR, 2003). An industry may encourage investment in both subsequent stages of production by "forward linkage" and in earlier stages through "backward linkage". The development of agro-industries has many beneficial feedback effects on agriculture itself. The most direct one is the stimulus it provides for increased agricultural production through market expansion (ISNAR, 2001, 2003).

Agriculture and industry have traditionally been viewed as two separate sectors both in terms of their characteristics and their role in economic growth (Dilip, 2009). Agriculture has been considered the hallmark of the first stage of development, while the degree of industrialisation has been taken to be the most relevant indicator of a country's progress along the development path. Moreover, the proper strategy for growth has often been conceived as one of a more or less gradual shift from agriculture to industry, with the onus on agriculture to finance the shift in the first stage.

This view, however, no longer appears to be appropriate. On the one hand, the role of agriculture in the process of development has been reappraised and revalued from the point of view of its contribution to industrialisation and its importance for harmonious development and political and economic stability. On the other hand, agriculture itself has become a form of industry, as technology, vertical integration, marketing and consumer preferences have evolved along lines that closely follow the profile of comparable industrial sectors, often of notable complexity and richness of variety and scope. This has meant that the deployment of resources in agriculture has become increasingly responsive to market forces and increasingly integrated in the network of industrial interdependencies.

Agro-processing industry can be classified in both the upstream and downstream industries. Upstream industries are engaged in the initial processing of agricultural commodities. Examples are rice and flour milling, oil pressing, and fish canning. Downstream industries undertake further manufacturing operations on intermediate products made from agricultural materials such as bread, biscuit and noodle making. From the point of view of development strategy, one of the most important features of any industry is the degree to which it is able to generate demand for the products of other industries. This phenomenon is known as linkage. An

industry may encourage investment both in subsequent stages of production by "forward linkage" and in earlier stages through "backward linkage". The establishment of certain primary processing industries can lead, through forward linkage, to a number of more advanced industries.

Backward linkages from agriculture to rural input suppliers refer to the supply of production inputs by rural enterprises to agricultural producers. It involves non-farm activities that supply inputs to farming activities such as, metalworking and repair and fertilizer production. The type and magnitude of these linkages depend on the prevalent agricultural technology available (Haggblade et al., 1989). Forward linkages from agriculture to processors and distributors refer to the connection of agriculture with non-farm activities that demand crop production for direct marketing or processing proposes. These linkages are said to be about ten times more important than backward linkages (Haggblade et al., 1989). Among forward linkages are those links with food processing that have been identified as the most important, followed by distribution of agricultural products.

In Trinidad and Tobago (T&T), agro-production has been changing from an industry dominated by individual or family-based, small-scale, relatively independent firms to larger firms that are more tightly aligned across the production and distribution chain (Chairatana, 2000). The agro-industry in T&T is characterised of high degree of interdependence on the forward and backward linkages and its productivity is affected by a host of inputs and outputs.

As productivity growth is the main determinant of economic growth in the long run, structural change away from primary production towards manufacturing is assumed to be a precondition for sustained economic growth (Martin and Mitra, 2001). Advances in a nation's productivity, measured as the rate of output growth in excess of growth due to increases in factor inputs, are a significant source of increase in national income and improvements in the standard of living and global competitiveness (Reardon and Barrett, 2000). The Törnqvist index has been advocated for examining the inputs and outputs and determining the multi-factor productivity of a nation (US Bureau of Labour Statistics, 2005).

This paper reviews the productivity problems and identifies the linkages and core leverage points of the agro-industry sector in T&T. The use of gross- versus net-output productivity analyses is discussed along with a research agenda initiated to develop a multi-factor productivity model for the agro-industry and related sector.

2. Productivity Problems of the Agro-Industry Sector in T&T

Over the past fifty years, agriculture in the T&T has lost its position as the dominant economic activity (World's Scientific Academics, 2000). Nowadays, most of T&T exports are concentrated in petroleum and chemical upstream-sectors and in the food and beverages' final consumption goods. In T&T, the food processing industry has been declining in terms of both output and export with productivity remaining relatively low. The past 30 years has been witness to considerable change in the agriculture sector - export agriculture has declined significantly; domestic agriculture has surpassed export agriculture in employing productive resources and in value of output; and the sector has further diminished in relative importance within the economy. Events over the years have emphasised the need for increased productivity and competitiveness if the agricultural sector is to increase profitability and attract investment (MFPMR, 2001).

The food import expenditure of T&T has increased from 14.9% in 1999 to 18.9% in 2004 (Kendall, 2006). According to GORTT (2009), the T&T's economy has contracted in real terms by 0.9%. The non-petroleum sector declined by an overall 5.0% and its contribution to total gross domestic product (GDP) fell from 59.0% in 2008 to 56.6% in 2009. This further reflects the decline in economic activity in the agricultural sector by 1.0% in 2009 which is a result of the continuing weakening of domestic agriculture which was forecasted to contract by 4.1% following a 1.3% contraction in 2008. The report further elaborates that the food and beverage industry contributed to the deceleration of the sub-sector due to the anticipated decline in production activities. Increasing food prices further exacerbated the issue in domestic inflation, thus contributing to the slow-down in the economy. Productivity in the manufacturing industry decreased by 2.2% during the fiscal year 2008/2009. This can be attributed to the current issue of rising food prices which appears to be a reflection of the neglect of the agriculture and rural sectors over the years.

In recent times, the developments in the global trade environment, shifting economic policies, energy crisis, consumer preferences, environmental sustainability and other technological, social and economic issues have served to exacerbate the problem. The demise of the local agricultural sector over the past decades is mirrored in the declining contribution of the sector to GDP and the recent agricultural census (CSO, 2004) which shows a 37% decline in the number of farms when compared with 1995. Among the many reasons for this state of affairs are the general lack of an overall enabling environment for agriculture, the poor integration between the primary agriculture and agro-processing sub-sectors, low levels of capital investment and high risk exposure in the primary agriculture sub-sector that is traditionally plagued by low levels of productivity (IICA, 2007).

Agro-processing activities based on non-traditional domestic raw material are generally small-scaled and at low levels, except in the case of broiler and meat

preparations. Condiments, juices and spices are the major products which are being processed for both the domestic and export markets (Harrynanan, 1999). Hence, more pressure has been concentrated on product safety, quality, trust and environmental-friendliness. The sector is becoming more industrialised, more specialised, more politicised and more managerially intense. Also, significant market-based responses to the pressures for change are occurring simultaneously (Chairatana, 2000).

According to Singh et al. (2005), there is a strong and expanding intra- and extra-regional trade for agro-based value-added activities in T&T. The drive towards making agriculture more competitive can be achieved by having an expanded value-added sector whereby the use of surpluses from the oil and gas sector can be used to fund this thrust. This strategy would provide not only for the emergence of new agro-based industries and products, but will certainly provide the necessary production stimulus at the farm level and the advantages of vertical integration with new commodities.

Agricultural products are shaped by technologies of growing complexity, and they incorporate the results of major research and development efforts as well as increasingly sophisticated individual and collective preferences regarding nutrition, health and the environment. While one can still distinguish the phase of production of raw materials from the processing and transformation phase, often this distinction is blurred by the complexity of technology and the extent of vertical integration: the industrialisation of agriculture and development of agro-processing industries is thus a joint process which is generating an entirely new type of industrial sector.

Because of agriculture's high degree of interdependence with forward and backward activities, agro-industry can play a very important role in accelerating economic activity. Processing is only one link in a continuous chain between raw material production and final consumption. The specificity of agro-industry vis-à-vis other industrial sub-sectors lies largely in the biological nature of the raw material which are generally characterised by the seasonal nature and the variability of their production as well as by their perishability. These aspects put particular demands both on the organisation of agro-industrial activities and on the agricultural base producing the inputs, thereby adding to the need for a close integration of raw material production and processing. The concept of linkages has evolved from Hirschman (1958)'s theory of "unbalanced growth" which has been recognised as playing a crucial role and providing substantial contributions towards guiding the appropriate strategies for future economic development.

Both agriculture and industry have contributed to the economy. They have become an integral component of development process in almost all the developing countries with the degree of interdependence varying and also changing over time (Dilip, 2009). In the theory and empirical literature, the inter-relationship between agriculture and industry has been discussed from different channels (Ahluwalia and Rangarajan, 1986).

Whereas some of these channels emphasise the "agriculture-industry" linkage on the supply side or production side, others stress the linkages through the demand side. The production linkages basically arise from the interdependence of the sectors for meeting the needs of their productive inputs, whereas the demand linkage arises from the interdependence of the sectors for meeting final consumption. Further, the linkages between the two sectors can also be categorised into two groups based on the direction of interdependence. One is the backward linkage, which identifies how a sector depends on others for their input supplies and the other is the forward linkage, which identifies how the sector distributes its outputs to the remaining economy. More importantly, these two linkages can indicate a sector's economic pull and push, because the direction and level of such linkages present the potential capacity of each sector to stimulate other sectors and then reflect the role of this sector accordingly.

In T&T, the introduction of new agro-products or services has normally been done through a process of importing existing technology, or copying existing ideas. This is a process of experimentation and 'discovery', since conditions in each country are very different, and each firm, in fact, develops a unique method of production (i.e. an 'idiosyncratic production function') in the process of implementing an existing technology. Even though the technology is not new, the process of experimentation, adaptation and optimisation for local conditions can be costly (ISNAR, 2001; World Bank, 2005). Many domestic agro-firms have consequently shifted from manufacturing to distribution. For instance, agro-processing is at present playing an important role in the food system, stretching from farms and ranches to retail food markets.

Having the financial means of buying food is no longer synonymous with guaranteeing the food security of a nation. The Government of T&T had recognised the need to sustain the productivity growth in its agriculture and agro-industry sectors and to examine the linkage effects for the development of the nation. Various efforts at diversification into non-traditional commodities have led to the growth of fresh produce exports, and to the mushrooming of an agro-processing sector, largely comprised of a range of small and medium-sized enterprises (SMEs). These enterprises make a significant contribution to the economy through foreign exchange earnings, employment, backward linkages to the productive sector, forward linkages into the distributive and tourism sectors, and overall social and economic stability, particularly in rural areas (Harrynanan, 1999; Pun et al., 2006). Nevertheless, if without effective linkages, the relevance of backward-forward linkages becomes uncertain, and the anticipated productivity gain would not be met.

There is a need to integrate agriculture into economic development by the reinforcement of the backward and forward linkages: Backward linkages at the farmer level, or initial processing levels; and to the providers of services; Forward linkages with the other sectors, such as SMEs through agro-industries, tourism through provision of fresh fruits and vegetables, eco-tourism through agro-forestry, the financial services through banks and credit agencies, and other services, especially marketing and export.

The future of agriculture needs to be modern and competitive to ensure competitiveness, and by extension, economic sustainability (KPMG, 2009). In many ways the existing agriculture lags behind in sustainable productivity from what science can propose. It involves therefore catching up, having modern production methods and desirable product quality and, in the case of animals, of better breeds, balanced nutrition, and desirable product quality. It means using knowledge developed by the sciences to anchor agriculture into ecology in order to ensure sustainability. This would entail integrating production with consumer and market requirements. Consequently, primary production must be integrated with the other elements of the commodity supply chain (such as processing, branding, marketing and export). Hence, there is a pressing need to reinforce the links between commercial producers and the other operators through clustering.

3. Productivity Analyses in Agro-industries

Based on literature, two approaches are commonly applied to measure both the multi-factor and labour productivity indexes in agro-industries and related operations. The gross-output approach specifies gross output as a function of capital, labour, energy, and the intermediate material inputs. Alternatively, the net-output approach specifies net output as a function of labour and capital inputs only (Huang, 2003). Agro-industries are fundamentally different from other manufacturing industries in the sense that food processing is quite materials-intensive.

The rate of technological development reflecting changes in an industrial output for a given input bundle may be measured by using a production function. Measurement of productivity indexes utilises two production indicators, namely, the value of shipments and the value added. According to the US Bureau of Labour Statistics (2005), the multi-factor productivity can be expressed by applying the Törnqvist index as a discrete approximation of the Divisia index as follows:

$$ln(A_t / A_{t-1}) = ln(Q_t/Q_{t-1}) - \sum_i [1/2(S_{it}+S_{it-1})\, ln(X_{it}/X_{it-1})] \quad \text{.....Eq.1}$$

This expression shows that the rate of change on multi-factor productivity $ln(A_t / A_{t-1})$ is the difference between the rate of change on output $ln(Q_t / Q_{t-1})$ and a weighted average of the rates of change on all factor inputs in the bracket.

Similarly, using the Törnqvist index approximation of labour productivity can be expressed as follows:

$$ln(Q_t / Q_{t-1}) - ln(X_{jt} / X_{jt-1}) = ln(A_t / A_{t-1}) + \Sigma_{i,\, i \neq j}\, 1/2(S_{it} + S_{it-1})\, [ln(X_{it} / X_{it-1}) - ln(X_{jt} / X_{jt-1})] \quad \text{.....Eq.2}$$

This expression in natural logarithmic form shows that the rate of change on labour productivity is equal to the sum of the rate of change on multi-factor productivity and the contribution of the changes on all other inputs per unit of labour to output.

Two approaches namely the gross-output and the net-output approach can be used to specify a production function for measuring the multi-factor and labour productivity indices. Firstly, the gross-output approach suggests that the adjusted value of shipments is a function of capital, labour, energy, and material inputs as follows:

$$Q_t = A_t\, f(K_t, La_t, Lb_t, E_t, M_t) \quad \text{....Eq.3}$$

where,

- Q_t is the gross output defined as the value of shipments adjusted by the net change in inventories.
- A_t is the index of multifactor productivity for the value of shipments. This gross-output production function represents a production structure that includes the contribution of all factor inputs that are available from data sources.
- K_t represents capital services charges with the producer price index of capital equipment as a deflator. Capital services charges are approximated as the sum of depreciation charges for fixed assets and interest costs on the average value of fixed assets at the beginning and ending of that year. The labour inputs are divided into two components: production and non-production workers.
- La_t represents production worker-hours.
- Lb_t is the number of non-production employees.
- E_t represents purchased fuels and electricity with the producer price index for intermediate energy goods as a deflator.
- M_t is the cost of materials, with the producer price index of crude foodstuffs and feedstuffs as a deflator.

Secondly, the net-output approach uses net output or the net value added as an output in a production function. Net output is calculated by subtracting the cost of materials, supplies, containers, fuel, electricity, and purchased services from the value of shipments and then deflated by the producer price index of processed foods and feeds. The net output represents the value that is added, by the application of capital and labour, to intermediate inputs in converting those inputs to finished products. Therefore, capital and labour are the relevant inputs in generating the net output of an industry, and a production function for the net output is specified as follows:

$$Q_t^* = A_t^*\, f(K_t, La_t, Lb_t) \quad \text{.....Eq.4}$$

where,

- Q_t^* is the quantity of net output or net value added, and K_t, La_t, and Lb_t are defined the same as in Eq.3.
- A_t^* is the index of multi-factor productivity for the net

value added.

Emphasised by Huang (2003), the existence of the net-output production function requires that the production of gross output (as shown in Equation 3) be characterised by value-added separability, in which intermediate inputs cannot be the source of productivity growth. In other words, intermediate inputs are excluded from consideration in the net-output model on the assumption that they are insignificant to the analysis of productivity growth. With this restrictive assumption, the purpose of measuring net-output productivity from Equation 4 is to calculate an industry's contribution to the nation's GDP in a simple and straightforward way. For interpreting industry productivity, however, the gross-output model specification is generally preferred.

The gross-output productivity and net-output productivity approaches are desirable for analysing the productivity of the agro-industry sector. The gross-output approach is more effective for interpreting agro-food trends, since it measures the ability to produce higher gross output from the same level of all inputs because of the technological change. The net-output approach at the same time evaluates the contribution of the food manufacturing industry to the growth of the nation's GDP.

4. A Proposed Research Agenda

Many agricultural productivity studies (e.g., Colins (1999), ISNAR (2003) and World Bank (2005)) have focused on productivity changes and the relationship between inputs and outputs at the farm level. Considerably, less attention has been devoted to research on productivity beyond the farm gate such as food manufacturing. In fact, the food manufacturing industries in recent years have undergone substantial structural changes because of a high profile of mergers and acquisitions (Ball and Chambers, 1982). Only a few studies (e.g. Harrynanan (1999) and Huang (2003)) addressed the productivity in the agro-industry and related sectors. Besides, existing literature lacks an integrated model or framework that conceptualises multifaceted antecedents pertaining to the forward and backward linkages of the agro-Industry sector in emerging economy.

In productivity studies, the gross-output approach by using the real value of sales as output in a production function was popularly used. Few studies, however, have addressed the issue of potential difference in productivity measurements from the gross output approach as compared with the net-output approach by using the real value-added as output in a production function. The use of value-added in measuring productivity provides a measure whereby the linkage of an industry's contribution to GDP is determined. By measuring the agro-industry sector's productivity aids in understanding the effects of its evolution on the performance of the industries while at the same time their competitive strength is evaluated (Huang, 2002). Further, by focusing exclusively on micro, small and medium scale enterprises, the study to be undertaken in the region would identify the linkages with processing firms that take place.

In this context, the Department of Mechanical and Manufacturing Engineering of The University of the West Indies has initiated a research project with the aims to 1) analyse the forward and backward linkages of the agro-sectors, and 2) develop a multi-factor productivity model to determine the production functions and calculate the agro-contributions towards the nation's GDP in T&T. Execution of this agenda combines the results of extensive literature review, acquisition of empirical data, and the development and testing of the proposed model. There are three distinct stages of the research which would last for a period of two years based in T&T. The methods and processes of respective stages are depicted in Table 1.

Table 1. A three-stage approach of the research

Stage I: Literature Review	
1	Conduct a desk research focusing on literature published in referred journals in areas of agricultural productivity studies with particularly reference to those for the Caribbean region.
2	Elicit documents and materials from agro-industries, universities, research institutes and other sources based in T&T and other nations of the Caribbean region.
Stage II: Familiarisation and Data Acquisition	
3	Investigate the agro-industry practices relating to the approaches of productivity analysis, and the forward and backward linkages in the agro-industry sector of T&T.
4	Identify the factors and attributes that contribute to the development of a productivity model based on the Törnqvist index.
5	Design of study instruments that would be employed in acquiring empirical data via the conduct of industry survey and case studies in the targeted agro-firms and interviews of industry practitioners, experts and academics.
Stage III: Model Development and Testing	
6	Use the literature and empirical data acquired from the first two stages to identify input, control and output elements for the productivity model.
7	Re-visit the participating agro-firms and interview their senior management and representatives to evaluate the model and the accompanied attributes and process.
8	Document the process and identify the specifications, changes or refinements for facilitating the implementation of the model.

The research would incorporate the conduct of industry survey and interviews with invited industry practitioners and experts (including academics). There are two series of agro-firm visits, the first being in Stage II (i.e., Familiarisation and Data Acquisition) and the second being in Stage III (i.e., Model Development and Testing) during the study period. It is intended to investigate into the current productivity analysis and practices of the participating agro-firms in T&T. A productivity model and the accompanied attributes and process would be derived. Important input, control and output elements of the model would be consolidated in these agro-firms. More information regarding the forward and backward linkages, the leverage points and the dominating factors in the agro- and related sector would be acquired and collated.

5. Conclusions

The agro-industry has the capacity to generate demand and employment in other industries. Traditional economic models (such as gross- versus net-output productivity approaches) stress that productivity growth is integral in sustaining economic growth because of population growth and resource scarcity. Multi-factor productivity growth is the preferential indicator of overall economic performance; it measures the efficiency with which capital, labour and research and research and development (R&D) are used together in production. Therefore, important forward and backward linkages must be formed and maintained between the agro-industry and other industries, for instance, by providing food and beverages for tourist industry while at the same time providing attractions to assist in the developmental strategy. Improvements on knowledge on multi-factor productivity are an important source to determine the agro-production functions and calculate the agro-contributions towards the nation's GDP.

This research aims to identify the forward/backward linkages and leverage points in the agro-industry sector with reference to T&T. It is anticipated that the findings would be contributing to:

1) Help governments and/or policy makers to determine the forward and backward linkages and identify leverage points in the agro-industry; and
2) Provide some basis for future research in accelerating productivity growth and agro-economic activities in T&T.

The development of the multi-factor productivity model would be a supplement to the literature on the agricultural productivity studies in T&T and the Caribbean region. Future work would further evaluate the applicability and efficacy of the model in both SMEs and larger agro-firms. Comparative evaluations and case studies are suggested to examine the parameters of the model and impact of its adoption in firms across the agro- and related sectors.

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Authors' Biographical Notes:

Kit Fai Pun *is a Professor of Industrial Engineering in the Department of Mechanical and Manufacturing Engineering at The University of the West Indies. He is presently the Chairperson of the Technology Management Council (formerly, the Engineering Management Society Chapter) of the IEEE Trinidad and Tobago Section. Professor Pun is a Chartered Engineer in the UK and a Registered Professional Engineer. His research interests are in the areas of industrial engineering, engineering management and innovation.*

Clement K. Sankat *is the Pro Vice Chancellor and the Principal of the St Augustine Campus of The University of the West Indies, Trinidad and Tobago. Professor Sankat is a Chartered Engineer in the UK. His research interests are in the areas of post-harvest and food process engineering, engineering design, and science, technology and innovation management and policy.*

Cavelle B. Motilal *is a PhD student at The University of the West Indies where she obtained her BSc (Hons) and MPhil in Agricultural Engineering in 1997 and 2000, respectively. Presently, she is working as an Agricultural Engineer at the Ministry of Agriculture Land and Marine Resources in Trinidad and Tobago. She is a member of the Association of Professional Engineers of Trinidad and Tobago and a registered Project Management Professional. Research interests are innovation, agricultural engineering, health and safety.*

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