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Report on Productivity and Productivity Improvement Tools

Prepared for Community Futures and the RDI

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## Report on Productivity and Productivity Improvement Tools

*“You cannot manage what you cannot measure”*

*Anonymous*

Productivity improvements have long been identified as the principle source of economic growth, improvements in standard of living and increased wages (Diewert, Porter, Nelson). There has been considerable disagreement concerning the measurement of productivity and sources of productivity growth. These disagreements stem both from technical difficulties in measurement and in interpreting the strength of results (Diewert etc.). However, the source of productivity growth is generally accepted to be technological improvements.

Post-war North America saw an unprecedented economic boom. The WWII industrial efforts translated to a position of economic dominance as most nations rebuilt shattered infrastructure and capital stocks. As the rest of the world rebuilt its capital stock and infrastructure around a new technology driven industrial paradigm, the dominance of the western economic performance has steadily eroded (Monroy 2000). Lagging North American productivity is often attributed to under-investment in our capital stock and insufficient innovation.

Canadian productivity has been found to lag behind many of our Organization for Economic Cooperation and Development (OECD) counterparts. From 2001 to 2009, Canadian productivity grew at 0.7% compared to 1.9% in the US and over 4% in Korea (OECD 2010, OECD StatExtracts, Labour Productivity Growth). Within Canada, British Columbia lags behind the Canadian average (Deloitte 2010). In fact, British Columbia ranks 7<sup>th</sup> of the 10 Canadian provinces.

One goal of the REDI project is assisting Kootenay based businesses to improve their competitive position through increased productivity. A key step in this assistance is to foster a strong commitment to improved competitiveness and thus to innovation. Part 1 of this report offers a summary of the research on productivity drivers and of the most successful operational improvement philosophies developed in the field of business and administration. Part 2 offers an overview of selected online productivity improvement tools that could be used as models for the current project. Part 3 offers some recommendations for successful application of these concepts in the REDI Project. A treatment of technical productivity measurement is offered as an appendix to the paper.

## Part 1 Productivity Backgrounder

### Introduction to Productivity

Productivity is a measure of how well a production unit uses its resources. We measure productivity as units of output per unit of input. Productivity is typically represented by some version of the following equation:

$$(1) \quad \text{Productivity} = \frac{Q}{X}$$

where Q is output and X is input. Output includes all of the goods and services produced and sold. Input includes all of the materials, services, machinery usage, and efforts expended in the production of the outputs.

A production unit can be defined at any level of aggregation desired: a single facility within a multi-facility organization, an entire firm, a whole industry, a sector of the economy, a country, or a region. There are both challenges and advantages that are unique to each level of aggregation.

In practice, there are many different ways to measure productivity. Each measure has its benefits and drawbacks. Some measures are well suited to analyzing an entire country's performance compared to the rest of the world. Country-level productivity is strongly associated with improving the welfare of the nation. This may be useful for national policy-makers trying to enhance the well being of an entire population through the development of the national economy. These macro-level measures of productivity will not give any sense of how a particular firm's practices can improve their profitability.

Other measures of productivity are well suited to analyzing the performance of a firm or a branch of a company. Measurement at this level of detail will tend to be inadequate in recognizing the value of interactions between firms or discovering patterns at a regional level.

This report focuses on firm level productivity and productivity improvement tools. Engaging in a process of examining firm productivity drivers is an important step to improving the competitive position of the firm and, by virtue of the firm's position within the community, the entire region. Productivity improvement tools focus on improving the drivers of productivity and removing obstacles to productivity improvements.

### Productivity Drivers

Understanding the factors that drive some firms to increase productivity while others stagnate is a more difficult question to answer. Researchers generally agree that productivity is driven by: quantity and quality of built capital, quantity and quality of human resources, and technology. Specifically, productivity will be improved by: improving the quality of human resources through education and workplace environment, improving the quantity and quality of capital through

investment, and improving technology through the commitment to R&D, quality management and a strong pursuit for innovation (Nelson 1981, more sources).

According to Nelson (1981), improving any one of capital, labour or technological innovation will feed back to improving the others. However, technology and innovation are the strongest driver of productivity improvement because of the strength of the feedback on capital and human resources.

Canadian investment has lagged behind most of our competing trade partners. Generally speaking, Canadian executives take a more risk averse approach to R&D decisions and toward investment in new technologies. Despite having a very advanced and heavily subsidized post-secondary education system, the proportion of our population attaining post-secondary education is lower than that in the USA (Deloitte 2010).

### **Human Resource**

Since we are discussing the performance of a human driven system, it should be no surprise that the quality of our human resources is a principle driver of productivity (Lucas 1988). The quality of our human resources is driven both by innate ability and by training. A more subtle influence, but equally important (Nelson 1981), over the performance of labour is the work environment. The work environment is affected by the system of management and by the social network of employees.

#### *Education*

Education is critical to developing a highly competent workforce. An educated workforce is capable of working with current advanced technologies and with complex capital. An educated workforce is also more likely to become engaged in the improvement of the production system.

Today's information and communications technology (ICT) and production technologies, in general, are complex. Across all sectors and all regions of the developed world, our ICT and production systems are becoming so complex that people require increasing levels of skills training to offer competent help. If we consider all employees to have a role in advancing the efficient usage of technology, and perhaps innovating improvements to the production process, training and human resource skills development is paramount.

#### *Work Environment*

Researchers have found interesting linkages between the social work environment and the performance of the labour pool. Where the strength of social networks outside of the workplace negatively impacts labour productivity growth (Sabatini 2006), the social network within the firm has a positive relationship with productivity. This linkage can be both a strength and a source of concern. If the workplace environment does not breed a commitment to the goals of the firm, the

social work conditions can poison the potential productivity of the entire firm. Fortunately, management can influence this condition.

## Capital

The role of capital in productivity has been long discussed. The quantity of capital accumulation (Krugman 1994) is important for improvements to the capital to worker ratio and TFP (Gundlach 2005). And, as evidenced by the modern asian experience (where productivity has skyrocketed with the build up of capital and partly because of very high savings rates), capital deepening or capital intensity plays a very important role (Otsuka 2001).

### *Quantity of Capital*

A single worker can dig far more holes with a backhoe than with a shovel. Useful machinery and equipment allows a production system to use labour far more efficiently. Investment in new capital is required to continue a trend of capital deepening and to keep the capital stock in its prime vintage. Investment increases the capital:labour ratio and allows labour to be more productive.

### *Quality of Capital*

The quality of capital is not a constant. Similar capital from different manufacturers may have different quality attributes. And, capital becomes worn over time and may not be as efficient as it was at the start of its lifespan. As anyone who has worked with old computer equipment or cheap handyman tools can attest, the quality of our equipment greatly impacts what we can accomplish with it.

There is also a tendency to embed technological improvements in newer vintage capital. Not only is the effectiveness higher in newer equipment. Both incremental and revolutionary changes in the embedded technology are included in the purchase of new capital.

## Technology and Innovation

Technology is a general description of the way resources are combined in the production process. This may include: the choice of capital to labour ratio, the management style, the types of capital employed, the types of labour employed or the types of production processes employed. While improvements in the quality of capital or the skills of labour contribute to capital and labour productivity, technological progress accounts for the remaining unexplained productivity gains. Innovation drives the process of technological improvement.

### *R&D*

The role of innovation in improving productivity is the most difficult to understand. Research and development (R&D) is undertaken to develop new products, new capital, new processes and new techniques. In a rural context, innovation may also be focused on gaining economies of scale. While there is widespread agreement that

R&D is critical to technological improvement (Solow 1957, Grilliches 1979), attributing a direct result or quantifying the impacts on productivity is difficult to accomplish for a number of reasons.

Returns from R&D are uncertain. There is no acknowledged guarantee that engaging in R&D will create financial returns for the firm. The options that are open to a researcher are vague by nature. Knowing, or feeling remotely certain, that the choices made will turn out to be the correct one is virtually impossible. Coupled with the risk that a competitor will make “the discovery” first, R&D is highly uncertain.

Innovation and R&D contributes spillover effects to other stakeholders, as well. New processes and new products become publicly observable once developed. So, the profits, while accruing principally to the innovators, are quickly sought by imitators. The extent of spillover effects will depend on the concentration of competitors and the publicity generated around the innovation. Because these spillover effects originate outside of the control of the affected firm, it is virtually impossible to quantify the relationship.

There is a time lag between the R&D spending and reaping the returns from innovation. While this is irrelevant to the contribution of R&D to productivity, it is very relevant to the decision to undertake R&D. R&D is an exploration of the unknown with no guarantees of a financial return. If the lag-time between R&D investment and financial is long enough, it makes the linkage between R&D and profit unclear to those paying for it. Coupled with the uncertainty of returns on R&D, lag-times can lower R&D investment levels. These time lags also make it very difficult to establish a causal link between R&D and profits.

#### *Process Improvement and Commitment to Quality*

Technology, remember, refers to the way resources are combined. As mentioned innovation can be applied to any of the internal processes, management or production, used by the firm. Innovative firms tend to pay close attention to their production processes and tweak them for maximum performance. While not a necessary condition, firms with a high level of commitment to quality tend to be more proactive in innovating productive processes.

Some firms are more concerned with quality than others. A firm’s orientation toward quality is related to all three of the productivity drivers, principally through the orientation toward innovation. Firms that are concerned with the quality of their product will tend to provide greater training for their workforce and include the labour pool in the pursuit for higher quality. This may mean contributions to process re-engineering, suggestions for capital upgrades or simply becoming invested in the end product. There is an implicit devotion to innovation and improvement that is created through the pursuit of quality.

#### *Competition and Innovation*

The competitiveness of the marketplace is capable of driving firms to innovation. The more competitive the marketplace, the greater the gains to be made from innovating: technological progress, new products or leaning<sup>1</sup> existing processes. With little competition, there is little motivation to improve upon the status quo. Competition forces firms to perform at the top of their game. Lack of competition allows firms to rest on their laurels.

#### *Management Skills and Innovation*

The abilities or quality of management is likewise an important contributor to productivity. Management fosters innovation within the organization, influences the work environment for the labour force, makes decisions regarding investment in new capital and training programs. The quality of management is seldom discussed in productivity literature but it is an essential factor all the same.

#### **Productivity Improvement: Best Practices**

The research on productivity clearly indicates that human capital, built capital and innovation are the drivers of productivity improvement. The business community has been well aware of this for decades. With these drivers in mind, researchers have examined the business practices of some of the worlds most successful firms. A number of operational best-practices have risen to the top of the field, inspired by phenomenal success. The following is a survey of the most cited systematic approaches to improvement.

#### **Kobayashi    20 Steps**

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<sup>1</sup> The concept of lean manufacturing is discussed in the next section of the paper.



# Kobayashi's 20 Keys to Workplace Improvement



## *Defining Features*

Kobayashi's 20 Keys offer businesses a step-by-step guide to improving a business. This should not, however, be confused with some mechanical process. At any level of commitment to the process, the 20 Keys will benefit an organization. However, the 20 Keys are most effective when embraced as a continual process of self-evaluation, improvement and philosophical evolution. This requires the commitment on the part of the entire organization. It likewise entails a continual process of education.

The 20 Keys are built on four pillars: cleaning and organizing, rationalizing the system, improving team activities, and leading technology. These four pillars support the three central goals: improved quality, lowered cost, faster lead time. The following 20 Keys build and support attaining these goals.

Organizations fully embracing the 20 Keys will embark on retraining the entire staff, from the top to the bottom, in the pursuit of innovative and efficient

operations. The three central goals (improved quality, lowered cost and faster lead time) embody productivity improvement. Improved quality typically yields higher prices,  $p$ , in the marketplace (or at the very least, fewer refunds). Lower costs will lower input price,  $w$ . Improving lead time will increase the amount of output,  $q$ . Decreasing waste (an implicit goal in the 20 Keys) will reduce the inputs,  $x$ , required. If we take the measure of price weighted productivity,  $pq/wx$  (see Appendix 1), each of these four impacts will improve productivity.

Benchmarking the performance of the organization is an important component of the 20 Keys process. Members of the firm/organization are given a questionnaire that evaluates their operations, relationships and philosophy from a number of perspectives (details below). This allows the organization to establish performance targets and starts the internal dialogue regarding improvement strategies that can be undertaken. This is an invaluable process both internally and for comparing with peer organizations.

To give the clearest picture, this questionnaire should be given to each team or group within the organization. The scores are then averaged out to give an overall grade for the organization. The 20 Keys approach is very driven toward team performance and divesting responsibility to individuals within the organization. Given this philosophy, it seems appropriate to involve the entire staff in the process from the beginning.

The 20 Keys process forces businesses to take an outward focus. That is to say, to consider their operations from the perspective of clients. Much like the Lean Manufacturing philosophy, the 20 Keys embrace the elimination of activities that do not create value for the client (there is a more detailed discussion of wasteful activities in the Lean Manufacturing section).

When successfully implemented, the 20 Keys approach leads to improved productivity, greater attention to detail and quality, better workplace environment, and improves the businesses ability to respond to changing market conditions.

### *The Keys*

1 Cleaning and Organizing: This is the start and the finish. Housekeeping, so to speak, but not from the top down. It is to be a team process, ingrained into the employees with the understanding that cleaning and organizing at EVERY stage in EVERY process makes the work more efficient and easier. This is the foundation for success in every other key.

2 Rationalizing the system: This is essentially business planning at finer and finer detail as the process carries on. Detailing exactly the activities that need to be accomplished, expectations and goals of each team so that everyone knows what their contribution is and how it will be measured

3 Kaizan Groups (Team Activities): Giving ownership over activities to the teams that will actually be performing the work. The job of management is to guide and support. Give easy jobs at first to gain experience and confidence.

4 Reducing Inventory: All the inventory between arrival of raw materials and finished produce (work in progress inventory). In line with Lean Manufacturing, you want to eliminate any process, or steps that a customer wouldn't want to pay for (space for mid-process inventory).

5 Quick Changeover: The ability of a business to switch its production line to produce a different product is akin to the businesses' ability to respond to customer needs. This requires very precise business process engineering.

6 Method Improvement / Value Analysis: Examining every step, activity and the flow of production to eliminate anything that doesn't add value. This is definitely a process that teams should be involved with. And, it needn't be restricted to production processes. This process applies to: product development, order systems, distribution etc.

7 Zero Monitoring: Eliminating any processes requiring human oversight. The goal is for full automation. Where this doesn't make sense (due to scale or type of business) there may be improvements to be made where staff do monitor equipment of each other!

8 Coupled Processing: Coupling points are those stages of the production process where one team hands off product to a client team. In line with JIT processing, the teams want to ensure they only hand over enough to meet the needs of the client team.

9 Maintaining Equipment & Machines: Establishment of scheduled maintenance to ensure no downtime.

10 Time Control & Commitment: Building work schedules for staff that allow them to work productively and efficiently the entire time that they are present.

11 Quality Assurance: Must be an indoctrination of staff so that quality is maintained throughout the process ALWAYS. Consistent delivery of produce meeting pre-determined specs that meet (exceed) customer expectations. Appropriate standardized processes and plans should be established. This may include ISO 9000 or TQM

12 Developing Suppliers: Treating suppliers as an extension of the process, to be improved and to engage in a process of continual improvement will benefit both businesses.

13 Eliminate Waste: Overproduction (wasted effort in service industry), waiting, transportation, extra processing, inventory (materials, intermediate product and finished goods all cost money to store), motion, defects. Most waste can be eliminated through efficient planning

14 Empowering staff: Giving power and responsibility to staff requires commensurate investment in the development of their human resources, and adequate support from management. This builds the capacity to innovate.

15 Cross Training: The goal is to have staff trained in as many facets of the business as possible so that production doesn't hinge on any single person and each team member can contribute to each process.

16 Production Scheduling: Putting in place systems of managing schedules requires enormous communications with all teams and clients.

17 Efficiency Control: Developed with staff, efficiency control involves setting benchmarks and measurement tools to monitor efficiency. It is a group effort designed to improve throughput times.

18 Using Information Systems: Use the modern computer technology to develop sophisticated business information and to share it with the whole team.

19 Conserving Energy and Materials: The triple bottom line (Financial, Environmental, Social) provides a solid basis for ensuring there is as little waste as possible. Adherence to these principles is desirable as it develops new markets, is marketable and contributes to that sense of organizational integrity.

20 Leading Technology: Making sure that the organization has a comprehensive system of managing the internal knowledge both for documentation purposes and for fostering innovation.

The Kobayashi 20 Keys system is the strongest because it encompasses ALL of the productivity drivers. Both skills development and workplace environment play a prominent role in the 20 Keys. Capital investment is required to eliminate as many steps as possible. Innovation and technology are inherent in virtually all 20 Keys: it's a philosophy, after all, with the aim of re-engineering the entire production process.

### **Lean Manufacturing - Just In Time – Six Sigma**

Another manufacturing philosophy to emerge from Japan is the Lean Manufacturing philosophy, which includes the Just in Time system of production management. Lean Manufacturing is a philosophy not far out of touch with, but pre-dating, Kobayashi's 20 Keys. Lean Manufacturing is devoted to considering every part of the production process through the lens of value creation. If an action, a process, a

simple repeated movement, does not create value for the customer, it should be eliminated (Chang 1995).

The philosophy of Lean Manufacturing revolves around a system of process re-engineering where nothing is produced unless it is demanded. Tailoring a production system to this type of philosophy requires considerable flexibility. The production process must be capable of producing small batches and changing output on short notice. This philosophy can be applied, with some creativity, to non manufacturing contexts.

The “Lean” in Lean Manufacturing can be thought of as trimming the fat, or the waste. Lean Manufacturing defines seven types of waste: overproduction, inventory, transportation (handling), defects, processes (unnecessary ones), operations (if they fail to add value for customer), inactivities (machines and operators). The first two types of waste (overproduction and inventory) are related to the Just In Time concept of production rationalization. Transportation, defects, processes and operations are wastes that fail to deliver value to the customer. Inactivities leaning refers to eliminating down time, or speeding up the changeover time to the next product. One can easily see the parallels with Kobayashi’s 20 Keys.

#### *Philosophy*

The Lean Manufacturing philosophy centres on the customer. It could even be extended to be more broadly about people, from the customer to the lowliest employee. This philosophy is intended to infuse the entire organization, focusing all activities to creating value for the customer.

#### *Management*

Lean Manufacturing has implications for management ranging from strategy to employee relations. Management must transform itself from a command and control role to a guidance and coaching role. This requires an empowerment of the employees that fosters teamwork, responsibility and ownership of processes and workmanship. Once the power is divested to the workforce, management may take on a more strategic role and focus on long-term goals.

#### *Tools and Techniques*

The tools and techniques used in implementing a Lean philosophy are just that: tools. It should be emphasized that the incorporation of philosophy and re-jigged management role are equally important to the successful implementation. The tools include the Just-In-Time system of input delivery and output delivery, with no wasteful accumulation of inventories. The other pillar of the Lean philosophy is autonomation. Autonomation builds a system of defect detection that stops production immediately if defects are detected. It is a system of automation with human guidance. Other tools support these pillars, but these are the primary supports of the Lean Manufacturing philosophy (Ahrens 2006).

#### *Six Sigma*

Six Sigma is an approach to Lean Manufacturing that measures and codifies the way organizations seek progress. “Sigma” refers to the greek notation for standard deviation, a measure of statistical dispersion from the mean. “Six” refers to the number of standards of deviation that will be accepted for measures of quality and production accuracy. Organizations, by measuring their performance in a rigorous statistical way, will use this tool to continually improve.

The Lean Manufacturing / Six Sigma system is a rigorous (thanks to the statistical nature of Six Sigma) way to eliminate waste and streamline a productive operation. These philosophical streams, and they are philosophical systems to be embraced, are aimed principally at a devotion to innovation and technological improvement. The elimination of waste is a trimming of the existing technology.

### **Porter’s Diamond**

Legendary economist Michael Porter developed the business cluster development framework known as Porter’s Diamond (Porter 1990). Porter posits that the sophistication of an organization is comprised of two components: operational effectiveness and strategy (Porter 2000). However, the ability to excel in a given location, to a certain extent, rests on the microeconomic conditions of the physical location.

The four sources of competitive advantage, in the Diamond, are: factor input conditions, related and supporting industries, context for firm strategy and rivalry, and the demand conditions. All of these conditions are location specific. Considering these features offers insights on a different aspect of the bigger picture than what is normally considered.

#### *Factor Input Conditions*

Factor inputs refer to: natural resources, human resources, capital resources, physical infrastructure, administrative infrastructure, information infrastructure, scientific and technological infrastructure. Improvements in the quality of inputs can lead to productivity gains. In the modern context, these improvements in quality often come in the form of highly specialized attributes. Despite the high degree of labour and capital mobility today, in reality highly specialized inputs may not be readily available in every location. This is particularly true in labour markets, which are strongly linked to education infrastructure.

#### *Related & Supporting Industries*

No businesses act in isolation. The presence of capable, locally based suppliers, and of competitive related industries is of enormous importance to the health of a business. This is a critical component of cost suppression. Without the availability of supporting industries, search time and doing-it-yourself will add tremendously to costs.

#### *Context for Firm Strategy & Rivalry*

The level of competition a firm faces greatly influences the firm's productivity. Firms facing little local competition tend to compete using price (which leads to wage suppression). Greater competition pushes businesses to improve efficiency and to innovate, both with technology and with product differentiation. In this context, competition encourages appropriate forms of investment and sustained upgrading.

#### *Demand Conditions*

Conditions in a firm's local product market likewise influence their drive to innovate. Sophisticated and demanding local customers, those customers whose needs can be used to anticipate customer needs elsewhere, can provide an invaluable incentive to get ahead of the curve. The limit of this condition sees unusual local demand in specialized segments of the market that can be translated to global market trends.

#### **Balanced Scorecard**

Art Schneiderman designed the Balanced Scorecard approach to performance measurement in 1987. This was made popular by Robert Kaplan and David Norton in the early 1990s (Kaplan and Norton, 1992). This represented a broadening of the benchmarking and measurement process but is not a philosophical approach in the vein of the 20 Keys. The balanced scorecard combines financial progress with operational, and innovative progress.

The Balanced Scorecard includes examination of four areas: the customer's perspective of the organization, areas where the organization must excel, ways the organization can continue to improve, and the financial standards. Organizations engage in the process of defining goals, systems of measurement, targets, and initiatives to meet the goals – for each of the four scorecard areas.

While this tool is not a productivity-promoting tool specifically, it has proven an effective management tool. The Balanced Scorecard has become a widely used and well-recognized management tool around the world. A number of its foci are shared with the productivity promoting tools under examination by this study. The success of the Balanced Scorecard provides additional support for the importance of some critical productivity drivers.

The Balanced Scorecard contains important elements of Kobayashi's 20 Keys, Porter's Diamond and the Lean Manufacturing philosophies.

- taking the customer perspective and examining quality, timeliness and level service
- improving internal processes, lowering cycle-time, boosting HR skills
- innovating new products, creating additional value for customers, boosting efficiency
- ensuring healthy cashflow, and the financial health of the organization

The critical elements of the productivity improvement tools considered in this paper are common to most business improvement strategies. What differs between tools is the focus and method of delivery.

## Part 2 Survey of Productivity Improvement Tools

### Productivity Alberta

The Productivity Alberta (PA) system of productivity analysis is a subjective self-assessment benchmarking tool. Organizations that use this tool, and follow up with a sincere effort to improve, can use the results to analyse their organization and compare against their industry peers. The questionnaire draws on: the scientific axiology research of Dr. Robert Hartman (a neuro-axiology researcher), Kobayashi's 20 Keys, Lean Manufacturing, and Innovation work by the Warren Company (Innovation and Strategic Consultants).

The PA tool elicits a representation of a firm's approach to: Leadership & Management, Innovation, and Operations. While the questionnaire and tool are designed for medium sized industrial producers, most of the tool applies to smaller users and to a service industry setting. Drawing heavily on the philosophical approaches of Lean Manufacturing and the 20 Keys ensures a tool that, in many instances, transcends sectors and firm size.

PA employs questions that draw heavily on the neuro-axiology research of Dr. Richard Hartman. The neuro-axiology approach is based on ordinal ranking of values. Using questions rooted in such a field pushes the users to approach their answers from a value-laden mindset. This sets the tone for what is a widely accepted position that the most significant productivity gains come from the adoption of a philosophical shift (Chang 1995, Ahrens 2006). Many successful firms incorporate a value system akin to that promoted through this system.

The other principle influence that is evident through the PA questionnaire is the Kobayashi 20 Keys philosophy. Again, the 20 Keys are a philosophy-based approach to organizational transformations. The 20 Keys philosophy, like the neuro-axiology of Dr. Hartman, considers ordered improvements in the way an organization creates value and recognizes improvements that create more value.

### *Methodology*

The Productivity Alberta system is a self-administered questionnaire that explores an organization's approach to: innovation, management and operations. This online tool is designed to be followed by consultation, additional analysis and follow-up measurement to track progress. Productivity Alberta offers a wide-range of services and courses to assist organizations in their pursuit of progress.

### *Questionnaire*



The questionnaire given through the Productivity Alberta survey is given with a high degree of attention to detail, objectivity and rigour. The questionnaire is subjective and self-administered. Questions are of a multiple choice ranking variety. Most questions include contextual references to help businesses accurate self-asses.

The wording of the PA questionnaire is exceptional. Questions both lead the user to consider their organization from an objective position and guide users to consider all facets of their organization from a value creation perspective. This questionnaire is the most exhaustive, well written and potentially effective tool encountered during the research.

### *Results*

Results are given in a “spider-web” graph based on the Kobayashi method of analysis. The results are given and compared to sectoral competitors and provincial standards. This gives a graphical representation, empirical reference point and comes with an accompanying set of recommendations

### *Strengths*

The questionnaire attacks all three primary drivers and important sub-components  
There is excellent context and guidance given to users within each question  
The online comparability to peers provides an excellent benchmark.  
This questionnaire is comprehensive and VERY well written.

### *Weaknesses*

An objective measurement of actual productivity would provide another important benchmark if included.  
The reports generated do not include the entire questionnaire.

### **Workplace Productivity Snapshot (New Zealand)**

The New Zealand Department of Labour has sponsored considerable work in the field of productivity improvement. This work comprises the development of a long-term strategy that facilitates innovation through their Skills-Productivity Nexus (New Zealand Department of Labour). Their work examines ways to foster technological improvement, motivations for increased skill development, and the innovation of new products, services and production systems.

The Workplace Productivity Snapshot is the tool that was developed by the New Zealand Department of Labour and its partners. This tool focuses on seven categories affecting productivity: Leadership and Management Capability, Productive Workplace Culture, Innovation and Technology, Human Capital, Production Systems, Networking and Collaboration, and Measurement.

These topics are well directed to analyse an organization’s attitudes and approaches toward the principle drivers of productivity. Workplace culture and human capital

development have been signaled in this report as critical components of labour productivity. The remainder of their categories approach different aspects of the firm's attitude toward innovation and the pursuit of technological advance.

It is worth noting that this survey fails to directly question the firm's commitment to maintaining its built capital or investing in new built capital. This would seem a rather distressing omission given the importance of capital in the mixture of productivity. The specific inclusion of questions concerning the firm's ability and willingness to internally benchmark is good.

### *Methodology*

The New Zealand system is not nearly as sophisticated as the Productivity Alberta system. The Workplace Productivity Snapshot borrows from the Lean Manufacturing philosophy and contains questions that hint at some of the sophisticated analysis included in the 20 Keys. The tool is intended only as an indicator as to where firms should concentrate further investigation. Firms that use this tool are encouraged to follow up with more sophisticated tools and consultation in the private sector.

### *Questionnaire*

The questionnaire offers five questions for every one of the categories given above. The questions are designed to focus the firms attention on how rigorously both staff and management address the seven categories. The questions are in multiple choice ranking format and force users to consider to what degree they push their firm to improve.

While there is a range specified within the questionnaire (1 being "Don't know", 5 being "Always"), there is little flavour infused in the wording. One of the strengths of the big productivity consultancies, or the Productivity Alberta questionnaire is the detailed description of what each rank looks like that is offered for each question.

### *Results*

Users of the tool record their answers in a spreadsheet. The questionnaire provider does not compile the results. The results are not compared to peer organizations. Users will, however, have a spreadsheet where they can begin tracking their improvement if they choose to continue using this tool.

### *Strengths*

This is a simple tool that anyone could understand and use.

The survey takes very little time to take.

Answering the survey opens the door for SME managers to start examining productivity in a structured and meaningful way.

### *Weaknesses*

The tool is over simplified. With the information available and methodologies available on this topic, the questions could have been more elegantly crafted with a richer level of detail.

A purely subjective questionnaire with no reference to peer organizations may not give managers the critical “outside perspective”.

### **Small Business Checkup**

The Small Business Checkup is sponsored by the Leadership and Management Development Council of British Columbia (LMDCBC), the Canada / British Columbia Business Services Society, and Western Economic Diversification Canada. The checkup is a questionnaire focused on thirteen categories: Specific Business Environment, Competitive Environment, Business Objectives, Management Activities, Internal Policies, Operating Practices, Business Practices, Strengths and Weaknesses, Management Skills, HR Practices, Leadership Skills, Technical Skills, and some Financial Measures.

These categories are not as exclusively focused on productivity. Rather they are designed to be a more general tool to indicate areas of general business practice improvement. However, an examination of the questions reveals that many of the productivity drivers are addressed through the questionnaire. All thirteen of the categories, taken together, provide a picture of the organization’s approach to human capital management and development, management skills and attitude toward technological advance.

It is worth noting that this questionnaire targets small businesses. Small businesses tend to be on the lowest end of the sophistication scale, where keeping accurate books cannot be taken as a given. This questionnaire is well suited to unsophisticated users interested in improving their general practices. This tool is **not** designed for moderately sophisticated firms that are ready to commence the process of scalar growth, development and expansion.

### *Methodology*

The Small Business Checkup is the least sophisticated tool of those reviewed. The questions tease out important aspects of business management, from skills training opportunities for staff to the level of management attitudes toward innovation. These questions are not focused specifically on productivity, so they do not follow one of the predominant productivity focused methodologies.

### *Questionnaire*

The questionnaire is made up of roughly 150 questions spread across all thirteen categories. The questionnaire follows a multiple-choice format, many of which are rank questions. As expected of the least sophisticated tool reviewed, there is little context or guidance offered regarding how to answer the questions. Users are left to their own devices and experience to guide them through the answers.

### *Results*

Users answer the questions on-line. The results are instantly compiled and compared to peer organizations for the province of British Columbia. The results are given with a number of useful pieces of information and suggestions. The system generates potential implications based on the answers, and it also offers links to information sheets that could be useful to small business owners. Finally, the check-up offers users advice concerning the incorporation of any lessons learned into their business plan.

### *Strengths*

This is a simple tool that anyone could understand and use.

The survey takes very little time to take.

This tool is focused on small business.

Comparisons with peer firms is offered to users

Simple advice is given based on results of the survey.

### *Weaknesses*

The tool is a generalist tool.

There is inadequate context given in the questions to let small business owners understand what behaviours are on the weak and strong sides of the ranking scale.

## **Malaysian Productivity Corporation**

The Malaysian Productivity Corporation (MPC) is a standout in their approach to assisting businesses improve productivity. The MPC productivity calculator is just that – a (very) rough calculator of productivity. MPC uses the online productivity analysis as an introduction or a conversation starter, with the ultimate goal of engaging businesses in a more formal discussion of business best practices and productivity improvement.

The public website offered by MPC provides potential clients with a succinct introduction to formalized business practice improvement. MPC promotes the use of standardized benchmarking and productivity analysis. However, there is very little useful interactive material to be had through the website. At the time of writing, the author had not received any reply to written requests for MPC publications. If and when those publications are received, this report will be updated accordingly.

### *Methodology*

The MPC productivity calculator takes top level data on revenues, costs, assets, employees and intermediate goods and services and provides estimates of: Labour Productivity, Capital Intensity, Capital Productivity, Unit Labour Cost, and Labour Cost per Employee. The methodology employed ignores composition changes or price changes (inputs or outputs). This renders the product useless in terms of long-term usage as a business improvement tool. However, it may well be a useful

tool to get the conversation started with businesses that are intrigued by the process.

#### *Questionnaire*

N/A

#### *Results*

Results from this process will be invalid if there are any significant price changes in either inputs or in outputs. Likewise, they will be invalidated if there is any technology change which alters the mix of labour types, or if there is a change in the outputs.

Any results from this calculation will not make valid comparisons between firms, nor be comparable to national productivity figures (as they are based on mathematically defensible data and procedures).

#### *Strengths*

The MPC productivity figure gives businesses something they can relate to. A number is given. This can be useful to get managers in the door to start discussing business process improvements.

#### *Weaknesses*

The MPC tool does not give any context to the figure.

This productivity measurement is invalid for any but the most basic non-comparative uses.

This tool offers no ability to compare with peers, or even as a long-term benchmark.

### **Part 3 Recommendations**

The productivity improvement tools reviewed as part of this report all draw the attention of stakeholders to the important factors that drive firm productivity. Surveying productivity and productivity improvement delivers a number of contextual lessons that do not perfectly fit with the project design, but are worth including because of their general effects on the competitive environment and contributions toward a productive culture.

The following are a number of recommendations, for both the business sector and the public sector that may help create an economically productive momentum if applied. These recommendations are directed toward the creation of a more competitive economic environment that benefits all regional citizens.

## Business Sector

Competition is a private sector environment. While the best practices regarding operational activity will help a firm's internal productivity, there are other strategic considerations that may enhance any productivity work the firm engages in.

### *Cluster Development*

In rural communities, business clusters can be a powerful way to mitigate high costs associated with relative isolation (Porter 2004). The development of clusters is the ultimate expression of Porter's Diamond Model (Porter 2000). Porter's Diamond is comprised of four points: factor input conditions, context for firm strategy and rivalry, demand conditions, and related and supporting industries.

Firms play the feature role in developing clusters. Local firms can encourage the development of high-quality, highly-specialized input markets. This can be played out by working with post-secondary institutions (to build skills development), with municipal and regional governments (to leverage efficient local infrastructure) and directly with their suppliers.

Business owners may be able to work with their clients to develop more advanced customers. Many customers are open to developing new ideas or different ways to work with their inputs. Innovative proprietors can play a creative role in shaping the demand conditions in which they operate.

While there is little a firm can do to influence the location of their existing suppliers, they can be supportive of new providers in the region. There may be growing pains, but developing competent local suppliers of inputs and services could easily pay off many times over. And, businesses could help develop ties between their suppliers and other regional competitors. This may help build the regional importance to their suppliers.

Cluster development opens the doors to complementary economies. Buying power is greater in numbers. There are opportunities for shared marketing campaigns. And, customers enjoy a wider range of complementary products that enhance their experience. There has been a strong correlation found between the strength of clusters and regional growth and development (Porter 2000). Clusters reduce the costs of finding specialized built capital and human capital. Clusters facilitate collaborative enterprise and innovation. Anything the business community can do to foster cluster development will be well worth the efforts.

### *Social Work Environment*

Researchers have examined the nature of the social work environment and found significant effects on labour productivity. Feeling like a team is important to the staff of an organization. Strong linkages between workers allows information to spread faster, information to be trusted by those receiving and decreases the time needed for workers to fall into appropriate roles and executing orders.

Furthermore, a devoted workplace is less likely to tolerate shirking within the team and more likely to innovate.

The effectiveness of any team depends on the ability to communicate quickly. People who are familiar with one another understand each other's body language, tone and verbal communication style without having to discuss it. This allows effective teams to get working far more quickly than team members who have to engage in lengthy communication dances.

Likewise, a level of trust between team members greatly improves the speed to action when orders are received. Knowing that team members understand their role and will perform without being monitored gives confidence to the other team members. In total, each team member can work without doubts regarding the remaining tasks.

The collective work ethic developed within an organization carries a lot of inertia. It can be either a positive or a negative force with which to contend. An overarching strong work ethic will be reinforced from within the workforce. An environment where labour feels that it is "us against them" can render an organization ineffective. Since this factor is so subject to inertia, managers should do whatever they can realistically do to ensure that a positive work ethic is developed by their teams.

#### *On the Job Training*

Employers have an opportunity to shape their workers. The provision of on the job training demonstrates a commitment to the workforce and develops skills specifically suited to the organization. Skills development is another form of investment that can lead to process improvement, efficiency gains and an environment of innovation.

#### **Public Sector**

It is also important to consider the role of the public sector in improving productivity. Rural areas are characterized by low population density. This feature handicaps businesses in the pursuit for economies of scale (Porter 2004). The pool of qualified labour tends to be smaller, the momentum of regional dominance in a market fails to develop, the costs of physical infrastructure is shared by fewer stakeholders and there tends to be lower levels of support services (this list is not exhaustive). The public sector is capable of shaping the business environment to create the conditions for improved performance.

Some rural traits are inherited while others are created. It is the public service's job to perform enough analysis of natural endowments and to play these against strategic directions. While the inherited characteristics are formative, a strategic development plan should be guided by a vision of the desired economic trajectory.

The rural business environment is largely created by the following four factors: context for firm strategy and rivalry, demand conditions, input market conditions,

and related/supporting industries (Porter 2004). It is recommended that an analysis of these regional conditions becomes a part of future research work.

#### *Promotion of business clusters*

High tech tends to cluster in cities. Resource, food processing and tourism tend to cluster in rural areas. Local governments can help the development of clusters first by analysing what clusters could potentially develop. The seed of cluster development should already be evident. New clusters develop from sectors that are established.

The role of the local government is to remove barriers from the formation and development of the cluster. This is not limited to regulatory barriers, but include the encouragement of education and skill development specific to the growing cluster, and facilitation through infrastructure improvement. Regulatory barriers should be eliminated except where they provide a long-term positive benefit to society.

Any policies enacted by local government should be focused at the cluster rather than a particular firm or industrial sector. Focusing too tightly will distort markets and create inefficiencies. Focusing on the cluster widens the scope and will tend toward improvement of public or quasi-public (those that anyone can access) goods and services. These may include: facilitation of investment capital, hosting trade meetings, sponsorship of certification or rating, establishment or sponsorship of focused education programs.

#### *Education support*

There is an important role played by post-secondary institutes. Selkirk College plays an important role, both in supporting the existing business environment and in playing a strategic development role. A labour pool with skill-sets appropriate to the business environment is incredibly important. Accessibility of education opportunities will generally increase the quality of the available labour pool.

However, the College also plays a pivotal strategic role. Post-secondary institutes have the opportunity to coordinate education opportunities with economic development goals. Courses and programs can create a concentrated pool of talented labour. Lowering search times for high-quality, qualified personnel will help propel sectors of strategic importance.

Educational institutes can also coordinate with strategic industrial groups to tailor programs or courses to the needs of the economy. With adequate economic momentum, a sector may be able to partner with educational institutes. These partnerships would be directed and filling skills shortages critical to the further development of the target sectors.

#### *Facilitating Start-Up Capital (VC) access*



A typical problem facing businesses in geographically and economically remote areas is inadequate access to funding. A lack of angel investors and venture capital is a problem that is rife across Canada. Nowhere is that more acutely felt than in small communities. This problem stems from a lack of experience by Canadian investors and fund managers.

Angel investors often fill in the investment gaps for SMEs. These investment gaps typically arise at the stage of growth that has exhausted friends and family as a source of funding but is not yet adequately advanced for formal investment funds (between \$500K and \$2M). Angel investors are increasingly creating clubs and teams to invest funds. While angels are hard to find in Canadian cities, the problem is far worse in rural settings.

Venture capitalists (VC) typically fund businesses in the early stages of growth, but at a more advanced stage than angel investors entertain (between \$1M and \$20M). VC funders are typically looking for SMEs with a proven track record looking to grow. Canadian VC fund managers lost confidence after the dot com bubble and have failed to develop the experience necessary to operate effectively in Canada (Deloitte 2010).

While there is a limited role for regional government to play in this area, there may be a marketing opportunity. It would be worth investigating if marketing regional investment opportunities beyond the Kootenays would have a positive impact on the amount of angel or venture capital available.

#### *Promote development of traded industry sector*

A traded industries create products and services that are traded across regions. These typically produce manufactured (secondary industry) products that are not resource dependent or services that are mobile and generate high levels of productivity, wage growth and tend to drive regional consumer demand (Porter 2004).

#### **SME Specific Considerations**

Most literature on this topic of productivity and productivity measurement is by default focused on larger companies. It is, after all, the large companies that have entire departments devoted to accounting, purchasing, supply chain management. It is the large companies that have the resources to track all of the important information required for a thorough analysis of productivity.

The focus of this project, however, is on SMEs. While there is not a large body of work devoted to productivity measurement in the context of SMEs, there are some important considerations that can be teased from the literature. The SME context is largely defined by significantly more binding resource constraints (Achanga et al. 2005).

### *Leadership*

In many SMEs, the line between manager and floor worker is blurred if existent. Many SME owners started their companies because of their expertise at creating the product (or service), not because of their business acumen. SMEs are chronically poor in the field of management and leadership. A lack of training, coupled with the pressures of performing an overwhelming number of roles leads management to focus on short-term crisis management rather than long-term strategic guidance. Any questionnaires developed for SMEs should take this into consideration and guide users to improve on this front.

### *Finances*

Most SMEs have little-to-no competence in financial management. Specifically, the sophistication of financing arrangements tends to be very low. Because of the limited financing experience, there tends to be considerable hesitation when considering hiring consultants and laying out money to implement new programs. There tends to be a high degree of fear surrounding changes that will require plant shut-downs or investment into skills training when the benefits will be seen only in the long term.

### *Human Capital*

Employees of SMEs tend to have lower levels of education and a smaller generalized skill-base. The ability to adapt to new philosophical approaches may be limited. The ability to infuse the staff with an innovative approach to production may be more difficult than in organizations with highly educated staff. This obviously cannot be said of all employees in the SME setting, but it requires consideration nonetheless.

### *Organizational Culture*

The process of improving the operational productivity of an organization requires a revamping of the organization's culture. This is challenging in the most progressive organizations. SME culture tends to be created by the personality of the owner. There is far less distinction between the "owner" and the "organization". Because it is the reflection of a single individual, there will tend to be less flexibility and compromise built into the culture.

### **Tools**

Measuring productivity in an objective fashion gives managers a solid benchmark against which they can measure progress. However, subjective measurement of performance has been found to be an effective tool when objective measures are impossible (Kemppila 2001). Measuring attitudes toward innovation and progressive business development are one such measure. Where possible coupling subjective measures with objective measures is preferable.

Of the online productivity improvement tools that have been reviewed, the Productivity Alberta product is the stand out. Their online tool combines the best of many different systems, is presented elegantly and completely, and it pushes users

to continue the process independently while inviting them to engage with the host organization. The Productivity Alberta product is the model to be emulated.

It is recommended to include some objective measure of productivity. This will offer users of the proposed tool a solid benchmark against which to gauge their success. This would be used in concert with the subjective benchmarking that is the norm. Having this one additional benchmark would allow a truthing of perceived results against an objective standard.

Since the Productivity Alberta tool was designed with a larger firm size in mind than is typically present in the Kootenay region of BC, some tailoring would be appropriate. Specifically, the tool should consider the resources available to smaller firms. The resource shortfalls are particularly acute in: management skills, financing, existing levels of education and embedded skill and in organizational culture.

## Conclusion

Productivity improvement is the key to increasing competitiveness in any business arena, attracting business to the region and to improving the incomes of the regional labour pool. BC, due to its structural and cultural environment, lags behind Canada in terms of productivity. The optimist sees an opportunity for gains to be had by all with some focused efforts.

The development of an online productivity improvement tool modeled after the Productivity Alberta tool is recommended and is certain to be well received. A tool that is designed to direct operational management toward value creation, waste elimination and an innovative approach (to all aspects of the organization) will help local businesses improve. Provision of reference material and tailored training to follow up on the use of the online tool would be greatly complementary.

The Productivity Alberta tool could be modified to consider the SME context more explicitly. Specifically, questions designed to highlight the importance of leadership, skills development, financial management and organizational culture in SME organizations will increase the applicability of the tool in the Kootenay context. The leadership of SMEs tend to be owner/operators who tend to associate the success of their businesses with personal value. Wording questions to promote potential gains, rather than shortcomings, will help uptake.

Finally, both the business community and the different municipal governments can continue to create a competitive environment. Additional efforts to facilitate cluster development, strong regional education and skills development, and capital access will accelerate any gains made individually by regional businesses.

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## Appendix 1      Productivity Measurement

Firms produce stuff. We assume that they use the best technology available – efficiency. If they improve performance it must be one of: improved inputs, increased efficiency (firm was underperforming) or technological improvement.

The very first thing that should be considered is exactly what we are measuring. This may seem an odd question given our simple expression of productivity in equation (1). However, trying to define either output or input in any but the simplest examples, we encounter difficulties.

Consider a youngster running a paper route. The input side of their operation could not be simpler: newspapers and some effort. Except newspapers and effort do not share units; we measure effort in hours and newspapers in a simple unit count. Typically, we use the payments made to the inputs to create a common measurement, dollars.

Once prices are used to provide common measurement ground we have instantly changed the nature of what is being measured. By weighting inputs by prices, we solve one problem and create another. Prices change over time and there is no guarantee that the price of youngster's efforts and the newspaper change equally or simultaneously. We encounter similar problems measuring output when there is more than one product or service offered, which is typically the case.

The solution to changing prices is to use price indices. Price indices correct for variable changes in prices over time. A price index can reset all current prices to price levels that prevailed in a reference period (Laspeyres type), apply current prices to previous levels of production (Paasche type), or find some average between the two (Fisher or Tornqvist types). Appendix B gives a technical description of several types of price index.

So, prices provide a critical common unit of measure between inputs and outputs. But, since productivity is a measure of *quantity* of output to *quantity* of input, we must then use price indices to ensure that the measure of productivity only responds to changes in quantities.

### Total Factor Productivity

The most general form of productivity measurement is Total Factor Productivity (TFP). TFP measures the level of total output over total inputs.

$$(2) \quad TFP = Q/X$$

where Q is the quantity of all outputs and X is the quantity of all inputs.



When we introduce prices for the purposes of common measurement between outputs and inputs, we wind up with the following equation:

$$(3) \quad TFP_L^{t/s} = \frac{\sum_{m=1}^M P_m^s q_m^t}{\sum_{n=1}^N w_n^s x_n^t}$$

which can be read as, TFP in the current period, t, using the reference period (old), s, prices is equal to the sum of current outputs valued in reference period prices (today's gross income if old prices prevailed) divided by the sum of current inputs valued in reference period costs (total expenses if old prices prevailed).

This measure of TFP gives a ratio of output to input. Measuring TFP gives a level of productivity that we can use to compare different firms, using different technologies and operating in different markets. This could be useful at highlighting, for example, the impacts of technology or regional differences in inputs.

TFP levels offer a flexible way to compare between units of production, but they do suffer from embedded prices. Remember with TFP measures, we must choose a set of reference period prices. It would be inappropriate to compare TFP measures in different time periods if prices have changed dramatically. While we are correcting for price, large changes could be indicative of an important fundamental change in either inputs or outputs or could simply distort the measurement mathematically.

### Total Factor Productivity Growth

**Total Factor Productivity Growth (TFPG)** is interpreted as the sum of **Embodied Technical Change** and **Disembodied Technological Improvement** (source).

Embodied Technical Change refers to: the efficient use improving capital, learning by doing and managerial efficiency (source). These are changes that are embodied in the resources being used. Disembodied Technological Change is harder to peg but is generally attributed to: research and development (R&D), innovation and a developing knowledge base (sources). These are changes that do not have an obvious or easily measured linkage to the production process.

We can also use TFP to determine how productivity has changed over time. Total Factor Productivity Growth (TFPG) builds in a standard of comparison over time. TFPG between reference period, s, and current period, t, is measured as:

$$(4) \quad TFPG^{s,t} = \frac{TFP^t}{TFP^s} \quad \text{or} \quad (5) \quad TFPG^{s,t} = \Delta Q^{s,t} - \Delta X^{s,t}$$

Equation (4) gives an index of growth. An index offers us the ability to quickly determine percentage growth. Equation (4) reads, Total Factor Productivity Growth between reference period, s, and current period, t, is equal to TFP in the current period divided by TFP in the reference period, s. This index tells us what percentage of gains cannot be accounted for by increases in inputs.

Equation (5) gives a value of the growth between period  $s$  and period  $t$  measured in reference period,  $s$ , prices. Equation (5) reads, Total Factor Productivity Growth between reference period,  $s$ , and current period,  $t$ , is equal to the difference between output growth and input growth. This measure of TFPG gives a value of the gains not accounted for by increases in inputs. If we are using prices for a common unit, output growth is growth of gross revenues and input growth is growth of gross expenses.

TFPG is attributed to one of two types of improvements: technical change (efficiency) or technological change (the “art” of production). Efficiency of production refers to how close a system gets to producing the maximum amount of output possible with the given inputs and existing system of production. Technological change refers to changes to the entire system. These changes can come in many forms, from R&D to management practices to application of new techniques.

TFPG can likewise be corrected for price changes using Laspeyres, Paasche, Tornqvist or Fisher price indices. Unlike TFP measures, TFPG measures are appropriate for comparisons between time periods. In fact, this is their best use. Because TFPG is a growth measure, rather than a level measure, it is not appropriate for comparisons between production units. TFPG will tell nothing about the actual levels of productivity in two different units of production.

### Multi-Factor Productivity

Many firms have production systems that are directed toward a particular combination of outputs, using a particular combination of inputs. These combinations are typically referred to as “bundles” because the combined outputs (or inputs) are bundled together as a unit. Examining the bundled production leads us to Multi-Factor Productivity (MFP) measurement.

### Single-Factor Productivity

We are often concerned with the contributions of one particular input (we frequently pay close attention to Labour Productivity, for example). This may be directed at any of our four input classes: Labour, Land, Capital, or Enterprise. This would be represented as:

$$(6) \quad SFP = Q/X_i \quad , \text{ where } X_i \text{ is input } i \text{ (land, labour, capital, or enterprise)}$$

That is to say that we can extract the contribution to TFP from Labour, from Capital, from Land or Natural Resources, and from Enterprise or the owners. This is a marginal measure that looks at the contribution of one factor input. That is to say that it gives a sense of the contribution of the last unit of that input. It should be

noted that this value would change if there were a significant shift in the relative production weights of the inputs.

### Measurement Issues and Limitations

While the concept of productivity is quite simple, (output/input), we have illustrated a number of difficulties that arise when we try to measure the output or the input of a real-world firm. Unfortunately, the price indexing issues are only the tip of the iceberg.

#### *Input Quality*

Anyone who has worked on computers for the last ten years can understand how the quality of a product, like “computers”, can change dramatically over a relatively short period of time. Without question, the quality of computers today is vastly superior to the quality of computers just ten years ago. Including some measure of input quality change is important so we do not mistakenly attribute productivity gains from improved input quality to some other factor, like innovative management.

The common assumption is that price and quality are tied together. Using input prices as a quality weight would correct this problem if price and quality are truly correlated. However, those same people who have observed an increase in the quality of computers have undoubtedly noticed that the prices have stayed roughly constant (despite inflation prevailing over the time period), and in some cases have even fallen. Clearly, we cannot assume the link between price and quality will always hold.

#### *Labour Input*

We have seen some of the issues that arise in measuring different inputs, where we must value-weight by price, and in measuring changes in input qualities over time, where we might use price weights as a proxy for quality. Measuring labour requires similar processes. Labour is measured in hours worked. However, different people have different skill levels and we must correct for this.

Typically, an assumption is made regarding the correlation between wages and skill level. Specifically, we assume that wage levels are indicative of the quality of labour. We can find many examples where high wages are not associated with a high level of skill, but we must use some system to deal with these differences.

#### *Capital Input*

The contribution of capital poses yet another measurement issue. Capital is usually purchased up front, then is gradually used over the span of its life. There is a cost to tying up money in capital. This is typically reflected in interest rates if the money is borrowed. Even if the money has been set aside, we use the interest rate as it is a good approximation of the opportunity cost of tying up the funds.

The more interesting practical issue is how we determine the quantity and value of services provided by the capital during operations. Because capital provides services over a time-frame that is typically longer than a productivity measurement period, it would be misleading the entire price-weighted value of capital to one period.

To address this issue of the “flow of capital services”, we could use generally accepted accounting practices with respect to depreciation. Depreciation, after all attempts to capture the rate of use of capital. However, if we choose to use the Statistics Canada methodology, our results will be more comparable to a large database of productivity figures. A full treatment of the Statistics Canada methodology is provided in Appendix X.

Quality issues arise with capital, just as they have with all other inputs. Many different firms choose cheaper, lower quality capital if they face binding financial constraints. As with most factors of production, we cannot say that the correlation between quality and price is perfect. However, we can choose price as a proxy for quality provided we are careful in applying the concept.

#### *Capacity Utilization*

Related to Capital Input is the idea of capacity utilization. Imagine our paper-route winding through the streets and only delivering papers to every third house. For the distance walked and the effort exerted, we could easily have increased the output with negligible increases in effort. In this case, we are operating below capacity.

If we measured productivity in both cases and compared the case of delivering to every third house to the case of delivering to two of three houses, we would find that productivity jumped dramatically. This would not be a result of great improvements in real productivity, grounded in technology, experience or innovation. This gain would be a result of increasing the capacity utilization.

Because of the difficulties associated with determining the capacity of any given operation, its best to look for some proxy indicator. The most common proxy, in industrial settings, is to use electricity consumption as a proxy. The underlying assumption is that capital only draws power when it is being used. Since electrical bills are broken down by kWh, or units of consumption, this is the most appropriate measure of electricity consumed (not the monetary value).

#### *Land Use*

Another often overlooked resource is our Land-base, or natural resources. The services rendered by land and the natural environment is different than those services rendered by capital or labour.

At the economy level, the land base is fixed. However, for an individual firm, the quantity of land resources used is rationed by the price level. And, those prices change over time. Price indexing is required as a result.

Like capital, the purchase of land ties-up money that could be otherwise used productively. There is an opportunity cost associated with the purchase of land. It is also difficult to quantify the flow of services from the land resource. Typically, rental rates are used as a proxy for the sum of the opportunity cost and user cost of land services.

#### *Owner/Operator Issues*

With a focus on SMEs, we will encounter a high proportion of sole-proprietor firms. In the case of owner/operators, the owner provides labour services to the production process but is not paid in wages. In this case, the typical solution is to apply the going wage rate for similar activities in the labour market.

#### *Taxes*

Any taxes on inputs should be included as part of the price of those inputs. Despite the fact that they represent a transfer, for the firm, they represent a real cost. This would include any property taxes paid on land holdings. However, any taxes charged to customers should not be included in productivity calculations. They do not constitute income and do not contribute value to the output.

#### *Data Limitations*

The current study is focused on the productivity of Small to Medium Sized Enterprises (SMEs). SMEs, generally, do not have the same resources available for accounting or performance tracking as their large industrial counterparts do. The result is that the data collected may not be as exhaustive as we would like, nor easily converted to the format that works best for productivity measurement.

Wages and skill levels often lack the linkage that is seen in larger organizations. Due to they typically smaller surpluses, SMEs frequently fail to compensate workers to the same level that would be paid for similar quality labour inputs in larger organizations. Attention must be paid to any quality indexing using wages as a proxy.

Because of the wide range of activities that the owner of an SME will perform in the course of normal operations and the lack of performance tracking that is typical in SMEs, it may be prohibitively difficult to find appropriate wage proxies for the owner's activities. It may prove difficult to understand all the classes of work performed. It will definitely be difficult to track the allocation of the owner's time. And, it may be difficult to find an appropriate comparison in the local economy.

Another class of information that tends to be overlooked in SMEs is price information on inputs. Large corporations often have supply management teams who will maintain databases on prices, competitors and seasonal changes. All of

this contributes enormously to efficient supply management. This information will also contribute to accurate price indexing over multiple periods.

### *Measures of Output*

Given that we are constructing a price weighted value of production, we may consider a couple of different ways to construct this value. Output can be measured as either Gross Output or Economic Value Added (EVA).

Gross Output is the measure of output that has appeared in all of the productivity measurement formulae given in this paper so far. Gross output is the sum of price times quantity across all outputs of the firm.

Because we are interested specifically in the contributions of labour, capital and management /ownership activities, we may remove the contributions of intermediate goods. Intermediate goods are necessary for production but don't often contribute to productivity improvements. The exception is where providers of intermediate goods have realized great productivity improvements and have passed some of the benefits to downstream users.

If we want to look at productivity without considering intermediate goods, we use measures of EVA. EVA is defined as:

$$(6) \quad \text{EVA} = \text{NOPAT} - (r \times K)$$

where NOPAT is Net Operating Profit After Taxes,  $r$  is the rate of payment to capital, and  $K$  is quantity of capital.

In this formulation, NOPAT removes payment for intermediate goods. The second term,  $r \times K$ , gives a measure of payment to capital, leaving the contribution of labour and the management/ownership. The EVA measurement is a good measure of output when we want to concentrate on the contribution of this human element.

Productivity measurements based on EVA can be very useful at the firm level. We can also manipulate EVA to give a measure of EVA per employee (EVAE). EVAE has the added benefit of correcting for firm size. Thus, productivity based on EVAE can be used in comparing between firms of different size. EVAE is given by:

$$(7) \quad \text{EVAE} = \text{EVA} / \text{number of employees}$$

### *Underlying Assumptions*

In all modeling exercises there are assumptions that must be made. The main assumption that is assumed in all these measures of productivity is that the firms in question experience constant returns to scale (CRS). This implies that every firm being managed has achieved minimum efficient scale (MES).

This assumption is required to allow us to attribute all productivity gains to either technical change or technological progress. If increasing returns to scale (IRS) or decreasing returns to scale (DRS) are present, there will be scale effects embedded in productivity values.

Scale effects refer to the efficiencies that firms experience when changing the size of their operation. For instance, a sole mechanic building a car will build a car at a much higher cost than a team of mechanics at a Ford plant. This is largely due to IRS derived from the level of specialization in a production line environment, bulk buying power, and being able to spread fixed costs over a greater quantity of output.

By the same token a small software development firm may produce programs at a lower cost than a monolithic firm like MicroSoft or Sony. This may be due to DRS rooted in lower levels of beaurocracy and red-tape. At some size, most firms will experience rising costs due to the inefficiencies of beaurocracy.

### *Indexing*

Because productivity is often measured for firms or industrial sectors with distinctly different structures, productivity levels may not be comparable. By way of example, it may not be sensible to compare labour productivity between a local mom and pop bakery and a trans-national baked goods plant.

The practice of indexing can go a long way to addressing issues of comparability. Using indices allows observers to follow percentage changes rather than changes in the absolute value.

## Appendix 2      Glossary

Q = Output

L = Labour

w = wage + supplementary payment to Labour

$\dot{L}$  = Rate of Labour Consumption = w

K = Capital

i = interest rate

$\dot{K}$  = Rate of Capital Consumption = depreciation + i

X = Input vector

A(t) = Rate of Technical Change

R = Revenues

P = Vector of output prices

C = Costs

W = Vector of input prices (wages, interest, P<sub>x</sub>, etc)

Bahri & St.Pierre

NOPAT = Net Operating Profit After Taxes

EVA ~ Economic Value Added

EVA = NOPAT - (r x K)

ROIC = NOPAT / K

EVAE = EVA / Number of Employees

corrects for firm size

EVA - (w x L) = ROIC + ROE (enterprise)

Diewert

Total Factor Productivity       $TFP = Q/X$

Total Factor Productivity Growth

$$TFPG = \Delta Q - \Delta X = \frac{\text{Technical } \Delta}{\text{Technological } \Delta}$$

$$= \text{Embodied } \Delta + \text{Disembodied } \Delta$$

$$= \Delta \text{ Technical Efficiency} + \text{Technological } \Delta$$

Labour Productivity       $LP = Q/L$

Labour Productivity Growth       $\Delta LP = \Delta Q - \Delta L$

Capital Productivity       $KP = Q/K$

Capital Productivity Growth       $\Delta KP = \Delta Q - \Delta K$

Diewert



$$MFP = \frac{Q}{X} \quad , \text{ where } X \text{ is a "bundle" of inputs}$$

$$MFPG^{s,t} = \frac{MFP^t}{MFP^s} \quad , \text{ where } s \text{ is the reference period and } t \text{ is the comparison period}$$

$$TFP = \frac{Q}{X} \quad , \text{ where } X \text{ is total inputs}$$

$$TFPG^{s,t} = \frac{TFP^t}{TFP^s} \quad , \text{ where } s \text{ is the reference period and } t \text{ is the comparison period}$$

$$SFP = \frac{Q}{X_i} \quad , \text{ where } X_i \text{ is input } i$$

$$SFP G^{s,t} = \frac{SFP^t}{SFP^s} \quad , \text{ where } s \text{ is the reference period and } t \text{ is the comparison period}$$

$$R^t = Q^t \cdot P^t \quad \text{or} \quad R^t = \sum_{m=1}^M p_m^t q_m^t \quad \text{Revenues}$$

$$C^t = X^t \cdot W^t \quad \text{or} \quad C^t = \sum_{m=1}^M w_m^t x_m^t \quad \text{Costs}$$

$$TFPG = \frac{Q^t / X^t}{Q^s / X^s} = \frac{Q^t / Q^s}{X^t / X^s}$$

$$TFPG^{s,t} = \frac{\left[ \frac{R^t / R^s}{P^t / P^s} \right]}{\left[ \frac{C^t / C^s}{W^t / W^s} \right]} \Rightarrow \frac{R^t / C^t}{R^s / C^s} = TFPG^{s,t} \times \left[ \frac{P^t / P^s}{W^t / W^s} \right]$$

Quantity Aggregates:

$$\sum_{n=1}^N w_n^s x_n^t \quad \sum_{m=1}^M p_m^s q_m^t$$

Comparison period inputs and outputs evaluated at reference period prices

$$\sum_{n=1}^N w_n^t x_n^s \quad \sum_{m=1}^M p_m^t q_m^s$$

Reference period inputs and outputs evaluated at comparison period prices

Paasche-type Price Index

$$P_P = \frac{\sum_{m=1}^M p_m^t q_m^t}{\sum_{m=1}^M p_m^s q_m^t}$$

Laspeyres-type Price Index

$$P_L = \frac{\sum_{m=1}^M p_m^t q_m^s}{\sum_{m=1}^M p_m^s q_m^s}$$

Paasche-type Input Price Index

$$P_P^* = \frac{\sum_{n=1}^N w_n^t x_n^t}{\sum_{n=1}^N w_n^s x_n^t}$$

Laspeyres-type Input Price Index

$$P_L^* = \frac{\sum_{n=1}^N w_n^t x_n^s}{\sum_{n=1}^N w_n^s x_n^s}$$

Laspeyres-type TFP index

$$TFP_L^{t/s} = \frac{\sum_{m=1}^M p_m^s q_m^t}{\sum_{n=1}^N w_n^s x_n^t}$$

$$TFPG_L^{s,t} = \frac{\left[ \frac{\sum_{m=1}^M p_m^s q_m^t}{\sum_{n=1}^N w_n^s x_n^t} \right]}{\left[ \frac{\sum_{m=1}^M p_m^s q_m^s}{\sum_{n=1}^N w_n^s x_n^s} \right]} = \frac{(R^t/R^s)/P_P^{s,t}}{(C^t/C^s)/P_P^{*s,t}}$$

$TFP_P^{t/s} = DNE$

$$TFPG_P^{s,t} = \frac{\left[ \frac{\sum_{m=1}^M p_m^t q_m^t}{\sum_{n=1}^N w_n^t x_n^t} \right]}{\left[ \frac{\sum_{m=1}^M p_m^t q_m^s}{\sum_{n=1}^N w_n^t x_n^s} \right]} = \frac{(R^t/R^s)/P_L^{s,t}}{(C^t/C^s)/P_L^{*s,t}}$$

Fisher TFP Index

$$TFPG_F^{s,t} = \sqrt{TFPG_L^{s,t} \times TFPG_P^{s,t}}$$

StatCan

Treatment of depreciation

LS = Lifespan of Capital

$\tau = \text{age\_of\_capital}$

$$\delta = \frac{2}{L}$$

$\beta = \text{curvature\_coefficient} = 0.75$  for structures, 0.5 for machines

$$\text{dep}(\tau, L) = \left\{ \begin{array}{l} \delta(1-\delta)^{(\tau-1)} \\ \frac{L - (\tau - 1)}{L - \beta(\tau - 1)} - \frac{L - \tau}{L - \beta\tau} \\ \frac{1}{L} \end{array} \right\}$$

top term is for geometric,  
middle term delayed, and  
bottom term linear