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The channels for indirect impacts

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Abstract: This paper discusses the channels of impact of an extractives activity on an economy by presenting a brief description supported by graphics of the different routes through which the direct economic and social impacts of these activities might be enhanced. These routes include those that often have the highest political profile, namely spending of government revenues. But the paper also discusses other routes and channels that arguably are far more important, such as the direct effects of corporate spend in local supply chains; the immediate 'multiplier' effects of these; the further multipliers that follows from significant wage growth in these supply chains as well as in the main extractive activity; the new downstream activities that may be built on the primary extractive activity; and the externalities that can accrue from the direct boost to skills training that a large extractive investment is likely to provide.

Keywords: extractives, economic impact, multiplier effects
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1 Introduction

The direct economic impact of the mining and oil and gas sectors in general, and of a new project in these sectors in particular, is fairly well established. For a new project this would be assessed as one part of the project proposal and appraisal. However, the full consequences, macroeconomic or otherwise, are still subject to some uncertainty and speculation, not least because any extractives project would be costly and non-marginal, and so would be likely to impact on a (national or local) economy in many and various ways. In this paper we consider the possible direct and secondary impacts, and in particular the various channels of effect. Only by identifying these channels in their entirety do we gain an understanding of the range of likely economic and social impacts and thereby find ways of estimating their significance. There is then a basis for formulating sound policy responses to promote the positive effects and to mitigate any negative effects.

We begin in Section 2 with a generic overview of the channels of effect, which serves as a framework for later discussion. The social and economic consequences of extractives activities arise from two principal channels: firstly the *industry* channel, and secondly the *public spending* channel (AfDB and BMGF 2015a, 2015b). The industry channel traces the income-generating and employment-creating consequences of all the spending that stems from the activity (investment and operations) through the economy. The public spending channel captures the effects of spending the (likely) significant tax and other government revenue generated by the activities (ICMM 2014b; Otto 2017).

The industry channel is discussed in more detail in Section 3 below, and the public spending channel in Section 6.

Primary effects via these two channels potentially lead to multiple secondary effects. The secondary effects may be substantial and might indeed be at least as large as the primary effects. In the case of the industry channel, some of these effects have been referred to as upstream and downstream effects (including backward and forward linkages), usually in the context of indirect effects on other production activity. But they may also spill over into final demand linkages and other economy-wide effects via employment and income generation. The direction and magnitude of these effects are complex, and are difficult to determine *ex ante*. There have been several attempts to do this empirically; the results are obviously specific to projects, economies, and circumstances. Section 4 of this paper reviews these methods, while Section 5 presents some selective results from the application of the methods in the context of mining activities.

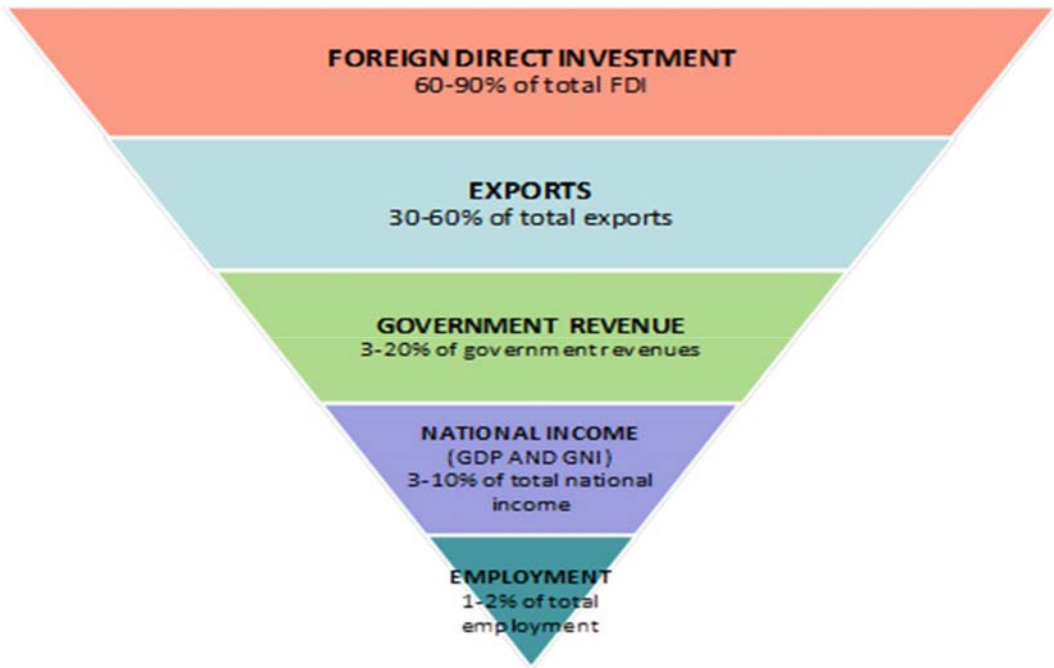
Finally, the second channel—public spending—is elaborated in Section 6, where we briefly set out the possible direct and indirect effects on human development via the public spending channel. Unlike in the industry channel, the effects here are less dependent on behavioural mechanisms and instead are heavily policy dependent,[1] so it is much more difficult to ascertain outcomes or to derive sound empirical estimates of general applicability. Hence much of our discussion on this matter is of a conceptual nature, although it does allude also to some empirical techniques that are relevant.

[1] The secondary industry effects are also influenced by policy, of course, but unlike in the public spending channel, behavioural and technological mechanisms play a substantial role.

2 Channels of impact

The extractives sector (mining and oil and gas) in some low- and middle-income economies is often significant, although there are vast differences in the sector's contribution to the major economic aggregates (gross domestic product (GDP), exports, fiscal revenues, etc.), both in comparison with other sectors in individual countries and in comparisons across countries (ICMM 2014b). For the case of mining (the situation for oil and gas is quite similar), the stylized facts are captured in Figure 1.

Figure 1: Macro-level contributions of mining in low- and middle-income countries[2]



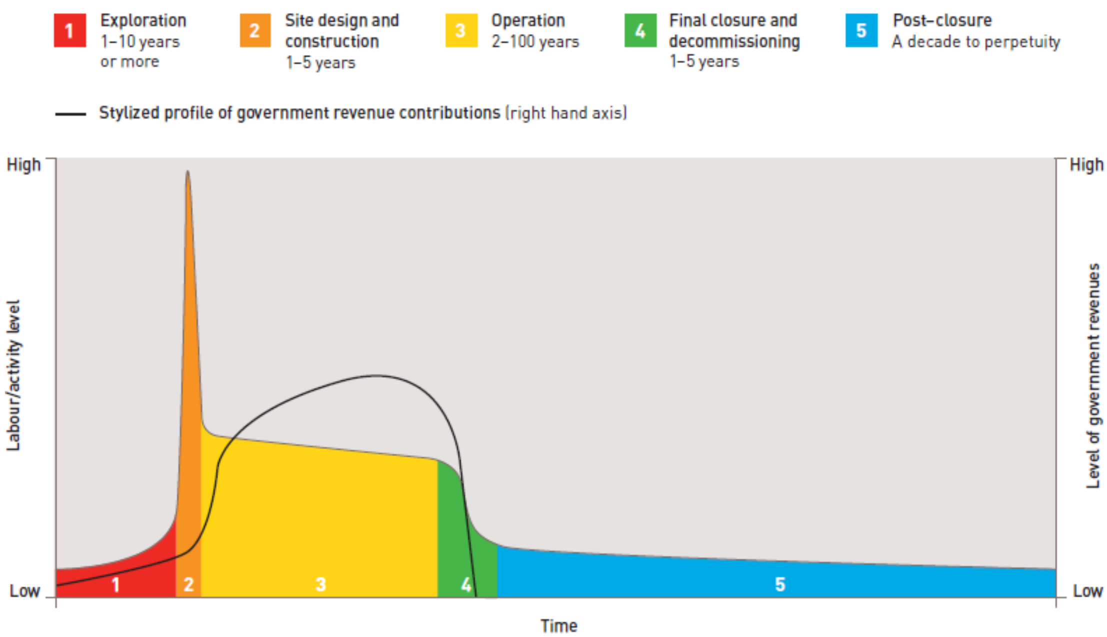
Source: ICMM (2014b).

The extractives sector dominates foreign direct investment (FDI) in many lower-income mineral (and oil and gas) economies; it constitutes a large share of exports; mineral taxation is often a significant share of total tax revenue; but perhaps surprisingly, the sector typically generates a relatively small share of the country's GDP (i.e. relative to other sectors). Mining and oil and gas activities are highly capital intensive, and employment in the mine (or oil field) is typically small relative to the size of its GDP contribution; hence direct employment also tends to be a small share of total national employment. These broad features are typical of the sector, although presented in this way they mask several channels of wider economic impact which need to be examined in more detail.

As a precursor to tracing through the channels of effect, first we consider the lifetime profile of a typical mining project (ICMM 2014b: 7).

[2] These stylized facts are based on a series of country case studies undertaken by the International Council on Mining and Metals (ICMM) over the past 10 years in a variety of mining countries in Africa, Asia, and Latin America.

Figure 2: Lifetime profile of a typical mining project



Source: ICMM (2014b).

Several phases can usefully be distinguished (Figure 2): exploration, site design and construction, operation, and finally closure and decommissioning. Each phase will create a distinct and potentially quite different direct economic impact. For instance, the exploration phase usually requires a relatively small number of highly skilled and technical personnel, possibly expatriate, with few local inputs. Hence the direct macroeconomic impact of this activity on the economy is probably relatively small. Similarly, in the closing down and decommissioning phase there will be little or no appreciable economic output, engaging a reducing and ultimately low level of employment, although the decommissioning and post-closure costs might be substantial. The phases that have the most significant direct economic impacts are the construction and operating phases, although the nature of the activities involved in these two phases may involve quite different direct effects. The construction phase will involve major capital expenditures along with a significant labour input, whereas the operating phase is typically less capital intensive and will have a distinctive employment mix. Clearly, the stage a project has reached within its life cycle will make a huge difference to the initial and overall impacts it will have on the economy (ICMM 2014b).

To illustrate the structure and paths of influence in the wider economy, Figure 3 shows in simple schematic form the principal channels of economy-wide impact of a mining or oil and gas activity. Note that here we focus on the *expenditure flows* (in constant prices[3]) and leave possible *price effects* to one side for the moment, even though price change effects could affect the size and hence the total influence of the expenditure flows. The direct spending arising out of extractives activities is shown in the first entry in the first row of Figure 3. This direct spending constitutes procurement of goods and services, employment (the payment of wages and salaries), and infrastructure spending. This initiates what has been termed the 'industry activity' channel (AfDB and BMGF 2015b). Here we concentrate on the construction and operating phases, where the extractives

[3] E.g., the prices in a given year, such as the initial year of the project.

activity is producing output, employing labour, and generating income. The discussion could extend to the start-up and decommissioning phases equally well, although the economic impact is lesser. Before any mineral extraction occurs there is extensive capital investment in equipment and associated construction costs in readiness for production. The construction phase also generates employment, which may be considerable in terms of numbers, albeit short-lived in terms of duration (perhaps three to four years).[4] The operating phase also requires material and labour inputs, although the mix differs from that of the construction phase. The figure shows the ultimate impact on living standards and human well-being (in boxes shaded in red). Thus the first impact on living standards derives from the incomes generated by extractives activity and thereby benefitting households. As shown in Figure 3, these benefits arise through a variety of different channels with eventual benefits for living standards.

The other major direct outcome of extractives activities arises from the revenues accruing to government in the form of taxes, royalties, and other fiscal revenues (Daniels et al. 2010; Otto 2016, 2017 forthcoming). This initiates the public spending channel. The revenues generated are likely to be large and significant, thus bolstering the financial inflows for government spending. However, and significantly, they are not evenly spread over the life cycle (Figure 2). These tax revenues when they arise can be used to fund a wide range of policy initiatives, both inside and beyond the mining and oil and gas sectors, including those related to economic promotion and to social and human development projects. It is for governments to design and implement the desired policy initiatives (AfDB and BMGF 2015a, 2015b). For example, there is now a large amount of experience to draw upon in implementing social protection at local and regional levels.

Figure 3 also shows expenditures and initiatives directly by extractives companies on community and social programmes, usually made independently (or partly independently) of central or local government. These include spending on schools, health centres, and community buildings in rural areas, where mines and extractive companies are often located Spending by government that impacts directly on well-being is shown in red.

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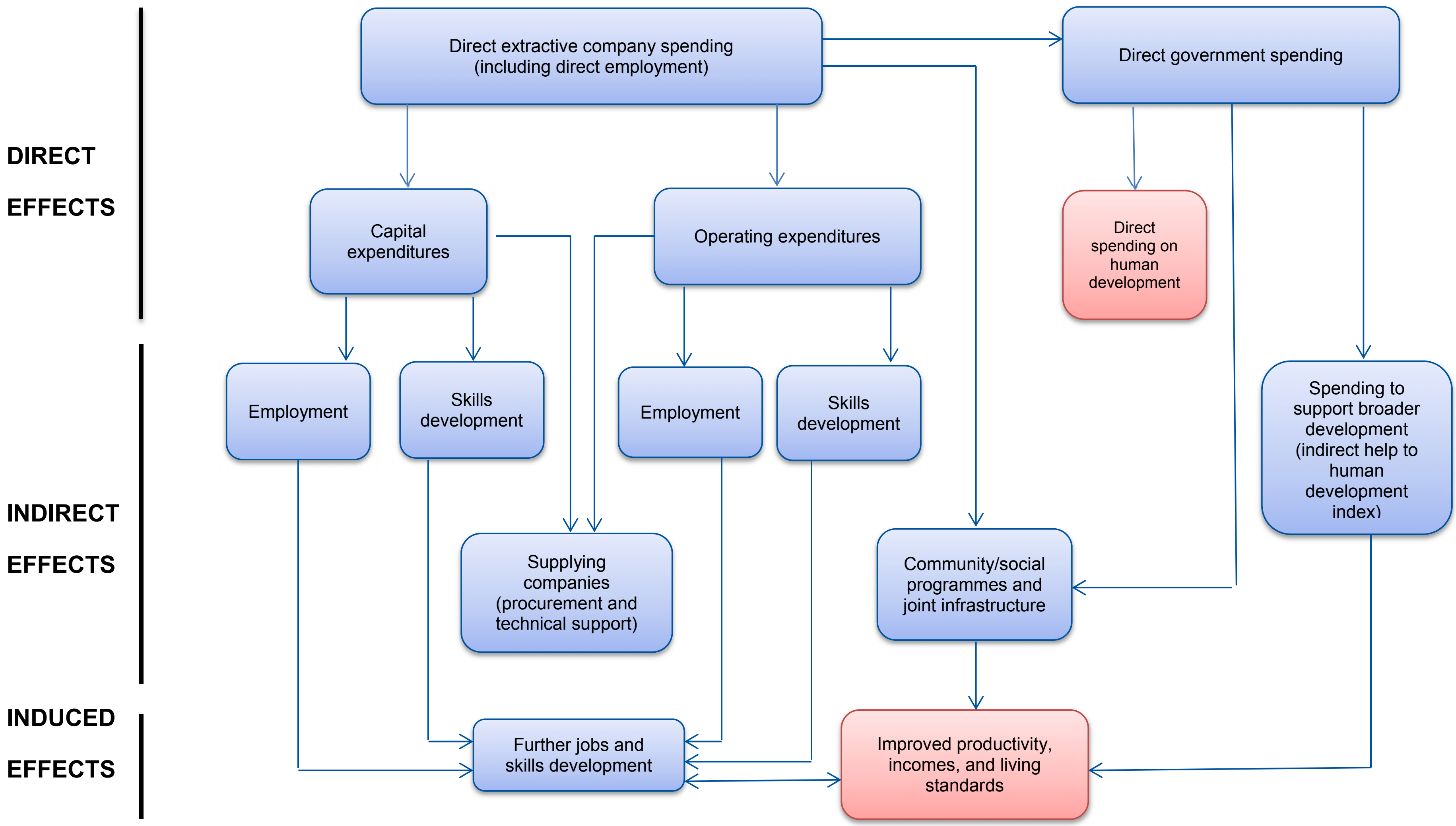
[4] Because of the high capital intensity of most mining and oil and gas projects, the numbers employed will generally be low relative to the levels of investment. However, there is likely to be more intensive employment during the construction phase than in the operating phase, and this can create significant opportunities. At the same time, the high skill requirements may initially at least require that expatriates and contract workers who come from outside the immediate region will constitute a significant proportion of those employed. There are exceptions to these broad generalizations. OPM (2009: 35) reports that in the case of the RMP gold mine in Romania, the direct employment in the construction phase was anticipated to be three times higher than in the operating phase, and expatriate employment to be a very low proportion of total employment in both phases.

Figure 3: Extractives activities and development: the main channels



Source: authors' illustration based on ICMM (2014b).

Table 1: Main components of production value for mining companies

Main components of production value	Examples	Typical shares of production value
Operating expenditures	Consumables, (fuel, power, tyres, reagents, water, transport, light engineering works)	50-65%
Capital expenditures (investment and depreciation)	Development and construction of sites, including parts and processing plants, installation of machinery and equipment	
Company salaries and wages	After-tax payment to labour providers; salary withholding taxes	10-20%
Company community spending	Projects in health, education, and income generation (in addition to essential mitigation and compensation matters)	0.5-1%
Taxes and other payments to government	Royalties; corporation tax; variable profits taxes	15-20%
Financing costs	Interest payments on short-term and long-term loans	15-20%
Profit for shareholders	Dividends to shareholders (includes both private and government investors; share buy-backs; retained earnings)	

Source: ICMM (2014b).

In order to give some indication of the relative magnitudes of spending by mining companies, Table 1 shows the main components of direct spending together with a broad approximation of their proportions of the value of production (the proportions in oil and gas are typically somewhat different). In both the construction and operating phases, the highest proportion of outlays is typically on equipment and consumables (goods and services), followed by taxes, financing costs, and profits. Wages and salaries account for between 15 and 20% of gross production value.

Referring again to Figure 3, the resulting impacts of extractives via the channels of impact we have identified do not stop at the initial direct spending effects. Secondary effects stem from the direct spending effects, and do so via both the industry activity channel and the public spending channel. Conceptually, the secondary effects via these channels are likely to be quite different from each other. In particular, the direct spending effects via the industry channel can precipitate some indirect effects via backward and forward linkages (as discussed later), and can also trigger further induced effects via spending out of the incomes generated. By contrast, the indirect effects via the public spending channel may arise because of the spending of any additional household incomes created perhaps by the government's spending designed to support broader development. Thus in Figure 3 the box showing the ultimate effect on living standards from income generation includes the total effect on incomes (direct, indirect, and induced) arising from the increase in economic activity.

It has been suggested by Auty (2004) and others that because of the capital-intensive nature of mining, backward and forward and final demand linkages are likely to be limited.[5] Indeed, for economies that have neither well-developed industrial sectors (producing, for example, capital goods) nor mineral processing sectors, the secondary production linkages may well be limited, at least in the short run. It is less easy to speculate on other final demand effects. Domestic income generated and paid to households, for example, is always likely to stimulate further production via a demand for domestically produced goods and services. More importantly, however, in the medium and long run, mining activities are quite likely to stimulate and catalyse a series of other impulses, e.g., via new companies (Auty 2004; ICMM 2014b). So the immediate and short-run effects, based on the pre-existing economic and institutional structure, are likely to underestimate the overall long-term effects to a significant degree.

Conceptually, it is relatively straightforward to estimate the short-term indirect (and induced) effects of mining (or oil and gas) activity via the industry channel—as we shall demonstrate in Sections 4 and 5. However, it is far less straightforward to estimate the *dynamic and long-term effects*. The best one can do is to identify possible consequences and seek evidence of their existence either directly or from previous studies. The public spending channel will also generate positive secondary effects that are both short and long term. These effects are *short term* in the sense that they rely on existing structures and the capacity to stimulate output, employment, and income. They are *long term* in the sense that public spending today can increase future capacity and so stimulate economic growth, or improve productivity, or make permanent improvements to social or economic institutions and infrastructure. Of course, there is already evidence that the secondary effects may not always be positive. The term 'Dutch disease' emerged in the late 1970s. Corden and Neary (1982) formalized the problem, and Auty (1993) and Sachs and Warner (1995) produced evidence that resource-rich economies tend to grow less rapidly than resource-scarce economies. This evidence, which is reviewed in related papers in Addison and Roe (2018 forthcoming), has been the subject of much subsequent debate, and has prompted a search for policies that have positive secondary outcomes. This is the main hallmark of what Di Boscio (2010) has called the 'post-global' or 'sustainable development' model (see also Lahn and Stevens 2017).

3 Industry channel: downstream and upstream multiplier effects

The specialized and capital-intensive nature of extractives activity, in all of the phases of an extractives project, means that the direct economic impact on an economy might appear to be fairly limited. Nevertheless, the direct impact will often not reflect the *total* impact on an economy—not simply on the local and regional economy in the proximity of the mines, but also on the national economy. The secondary effects could also prove to be significant. As we shall see, secondary effects may arise at several levels of the economy and in quite different ways.

As a general observation, much of the new mining activity in lower-income economies takes place in more remote areas, away from existing urban areas, in areas where the existing economic activity is most likely based on agriculture (or forestry, etc.). The new mining activity will lead to new communities, and often to new satellite production activities as a consequence. These arise from the creation of two kinds of production linkages as well as a final demand linkage, which Hirschman (1958) referred to as 'backward', 'forward', and 'final demand' linkages. Characteristically, in most developing countries the manufacturing and tertiary base is often quite

[5] This point is discussed in greater detail by Östensson (2017 forthcoming) and Östensson and Löf (2017 forthcoming).

weak. Hence many of the inputs into production (during both construction and operation) have to be imported.[6] However, the supply requirements for mining activity do create opportunities for existing domestic firms to sell to the mine, and also for new firms to enter upstream, in the short to medium term (backward linkages). Likewise, there may be downstream effects (forward linkages). Much mineral processing (e.g., smelting, refining, or material fabrication) usually takes place initially near to the final market rather than near to the mine, which means that many mineral products are exported in their raw (or crude) form. However, in time investment can in principle diversify[7] from mining per se and new profit-making opportunities arise domestically, thereby creating forward linkages within the domestic economy. Auty (2004) cites many examples of this evolutionary process, whereby mining has proved to be the catalyst for a diversified industrial region. These include the West Midlands (UK), Witwatersrand (South Africa), Ciudad Guayana (Eastern Venezuela), and Western Australia, amongst many others. It is therefore important to see the emergence of upstream and downstream effects as part of an evolution, a dynamic process of economic development. In achieving this, investment in transport and power infrastructure is especially critical if the objective is to achieve local processing that is competitive.

Direct final demand linkages from mining activity are less likely. The very nature of mining output means that this will not enter into the consumption bundle of households or government directly, nor will it form a part of fixed capital formation. The bulk of output that is not processed domestically (as intermediate output) will be exported. The principal final demand linkages will arise from spending out of incomes generated: thus it is more likely to be a secondary rather than a primary effect.

As well as considerations of extractives activity in the context of the structure of the whole economy, there is also an important regional dimension to all of this. The impacts of extractives activity are unlikely to be distributed across the whole economy. Many of the direct effects will be heavily localized (due to agglomeration economies, and to the proximity of labour and their wider communities), although some of the secondary effects will be more widely spread throughout the economy.[8] Di Boscio (2010) has described how the pattern of regional development associated with mining activity has evolved and changed over time. He has described how pre-1970 mining activity followed the regional or 'strong local linkage' model, where mineral ventures facing high transport costs were highly labour intensive and generated significant upstream (and often downstream) benefits. This has been supplanted by a more recent global or 'weak local linkage' model, characterized by lower transport costs and high capital intensity (with lower labour requirements), tending to generate lower upstream and downstream benefits. Hence the tendency has been for strong localization of the primary effects to be perpetuated, even with the evolution of mining technology and the changing economy-wide context. Di Boscio (2010) suggests that the global model has been supplanted by the sustainable development model since the 1990s.[9] This reflects the industry's desire to develop an approach that is more sustainable in socio-economic terms. It implies that companies are now more likely to engage more with the communities and government, and the effects and benefits are likely to be more widely spread than hitherto. However, there is a limit to how much benefit can be distributed locally, including via job creation,

[6] This is true of goods but less so of services, many of which can be obtained locally.

[7] Östensson (2017 forthcoming) discusses how sometimes this does not happen.

[8] In some (conflict) countries mining often takes place illegally, and this affects the nature and distribution of the activity and of any income generated.

[9] See Hodge (2017) on the meaning of 'sustainability'.

if governments are unwilling or unable to invest enough in supporting local infrastructure and institutions.

All of these primary and secondary effects will be subject to further multiplier responses. Hence, in addition to the identification of the primary effects of mining activity, there is a significant question as to how these multipliers might be estimated. We now turn to a review of the alternative methodologies before considering some estimates of impact multipliers for mining activity as obtained to date.

4 Measuring the size of secondary impacts

The measurement of secondary impacts of mining activity has proved to be a difficult challenge. Several studies (e.g., ICMM 2013, 2014a; Mogilevskii et al. 2015; OPM 2009) have been carried out in the context of either a new mining project or an existing mining enterprise, or as an assessment of the contribution of a mining industry as a whole in an economy-wide setting. The most obvious and longest-standing method of estimating secondary effects is to apply an informal approach based on informed judgement and rules of thumb. Of course, in the absence of reliable economy-wide data this might be the only possible approach, but the major downside is that it is quite difficult to defend the results or to test assumptions, so a more robust formal approach is usually preferred.

Three formal empirical methodologies have been used to assess secondary economic and social impacts. They are: input-output (or multiplier) analysis, computable general equilibrium (CGE) modelling, and econometric modelling. The first two methods may be described as *ex ante* (simulation) methods, whilst the latter is an *ex post* method that is finding increasing favour in project analysis. However, they should not really be viewed as alternatives; they have quite different objectives and serve different purposes. In Section 5 we consider the practical use of these methodologies, together with some estimates of the magnitudes of secondary effects of mining activities in particular countries.

Here we shall briefly consider the alternative approaches before reviewing some results. Two broad approaches have been pursued, which we may refer to as *ex ante* and *ex post* methods. The *ex ante* approach is effectively to examine the indirect effects on an economy via simulation models. The purpose is to pose 'what if?' questions rather than to carry out a forecast or prediction. Sometimes the economy in question is the local or regional economy rather than the national economy, but this choice is issue dependent and/or data dependent. Simulation models are used to estimate the possible effects under well-defined 'what if' scenarios as compared with a base case, rather than constituting predictions or forecasts per se. The most widely used simulation model is the input-output (I-O) model, usually with extensions (Bocoum 2000; ICMM 2013; NMA 2012; OPM 2009), but more recently CGE models have also been used (Downes et al. 2014; Mogilevskii et al. 2015; Tourism Research Australia 2013. Both approaches will be briefly outlined below, along with a short assessment of their relative merits. More recently, Moretti (2010) proposed an econometric method to estimate sectoral employment multipliers. Although this was not specific to the mining sector, other authors have subsequently applied the method to mining-related studies (e.g., Fleming and Measham 2014; Moritz 2015). By contrast with the simulation methods, this can be viewed as an *ex post* method, based on an analysis of sectoral data drawn from two separate historical time periods. It is not a straightforward matter to compare the two approaches, as they are underpinned by quite different conceptual premises.

4.1 *Ex ante* simulation models

I-O models

The 'indirect' output, income, and employment effects of an increase in mining output or of mine construction outlays have often been estimated via an I-O model (e.g., Ivanova and Rolfe 2011). These create the so-called multiplier effects. The principal assumptions underlying the standard I-O model are first, that the base year economy-wide input structure reflects the inherent input requirements of production sectors; second, that there is excess capacity in domestic production and an excess supply of labour. In many applications, the interindustry input-output structure is augmented by household income and expenditure coefficients to capture the income-generating and expenditure behaviour of households endogenously within the I-O model. These are usually referred to as the 'induced' effects. Both the indirect and induced effects are non-negative, so the corresponding multiplier effects inclusive of induced effects (commonly referred to as Type II multipliers) are always greater than those based only on interindustry (indirect) effects (Type I multipliers).

The main motivation underlying input-output multipliers is to capture the effects of production technology and household income-expenditure behaviour (i.e. a Leontief multiplier combined with a Keynesian multiplier). In practice these multipliers are usually calculated on the basis of average coefficients, but if the marginal responses differ from those on average, or if the base data on which the coefficients are calculated are out of date, then the results will be affected. Also, if there are supply constraints in the domestic supply of certain commodities or in supplies of labour (perhaps manifested by price increases which dampen demands), then the multipliers will be overestimated. The prime advantage of the input-output multiplier approach is simplicity and transparency. It shows, in summary form, a calculation based on a sequence of simple ratios in order to calculate the overall effects.

The I-O model works as follows. The final demands, $\mathbf{x}$, which trigger the sectoral output responses, $\mathbf{y}$, which in turn are directly linked to income and employment responses, are obtained from the well-known relationship:

$$\mathbf{y} = \left(\mathbf{I} - \mathbf{A}\right)^{-1} \mathbf{x} = \mathbf{Mx} \qquad [1]$$

where $\mathbf{A}$ is the coefficient matrix (which may or may not be augmented by household income and expenditure coefficients), and $\boldsymbol{M}$ is the resulting multiplier matrix. In the present context, the final demand vector, $\mathbf{x}$, represents the final output of the mining or minerals sector, or the mine construction costs. Thus, to examine the potential impact of a new mining project, there would be an annual stream of $\mathbf{x}$ vectors over the horizon of the project, from construction, operation, and termination. The resultant $\mathbf{y}$ vectors would be the estimated eventual output responses associated with each of the $\mathbf{x}$ vectors. The standard analysis can also be extended to other variables, which are linked directly to sectoral outputs such as employment, income, added value, or indeed environmental profiles such as emissions.

Sectoral multiplier responses, M_{ij}, are usually expressed in terms of outputs of sector i per unit output expansion of sector *j*. For other linked profiles, such as employment, where λ_i is the employment requirement per unit output of sector *i*, the employment multiplier in sector i per unit expansion of sector j is $\lambda_i M_{ij}$.[10] The 'units' dimension of this multiplier is therefore 'employment generated' per unit of 'output'. However, there are some well-known variants. To assess or report the result of the indirect (and induced) effects, the multipliers are often reported as a ratio of indirect (and induced) effects to direct effects. These have the advantage of being unit-free constructs. Whilst they have the attraction of being pure numbers, the main problem is defining what constitutes a 'direct effect' in this instance. For example, during the construction phase, mining output and employment is zero, although contractors do hire labour and incur other costs and outlays and there is well-defined construction output. Output multipliers are often more conceptually straightforward than the variants based on them.

CGE models

A second broad class of simulation models is represented by CGE models. These have also been used to assess the economy-wide effects and impacts of mining projects and extractive industries, although there are relatively few published examples (Downes et al. 2014; Mogilevskii et al. 2015; Tourism Research Australia 2013). The broad feature of the CGE genre is the incorporation of prices, institutional structure, behavioural responses, and some market-clearing behaviour in at least the product and factor markets. Although there are several variants amongst the recent applications (including those in unpublished papers), the core of any CGE model is a specification of optimizing behaviour for both producers and consumers. Most models now depart from the strict neoclassical paradigm, and structural or market rigidities are usually now included (which is especially important for low-income countries, where infrastructure deficiencies and market imperfections prevail). For example, there may be supply constraints in some domestic sectors and for certain kinds of labour, which dampen any supply response. Hence supply curves may be upward sloping or even vertical at some point, and not horizontal as in the I-O model. The underlying macroeconomic structure and the specification of the macro closure rules[11] in CGE models are crucial, and these can drive the results in all directions. Hence the flexibility allowed when characterizing the structural features of the economy in question also leads to model complexity, and CGE models may not necessarily offer a better means of simulating non-marginal impacts on an economy than simpler counterparts. By their very nature, CGE models obviously require more data than I-O models (CGEs are usually underpinned by a social accounting matrix[12]), and the functional specifications are considerably more complex.

Many analysts consider CGE models to be less transparent than I-O models, even though it is possible to configure a CGE model so as to conform to the features of an I-O model and therefore to be able to compare outcomes from alternative specifications. Rose (1995) has discussed the relationship between input-output analysis and CGE models. He suggested that to argue that one modelling approach dominates the other is sterile. Neither method purports to generate *forecasts*; they simply provide results of counterfactual experiments using models calibrated with the most representative data available and based on well-defined assumptions. The simulation approach is therefore ideally suited to an analysis of the likely impacts of mining projects. In sum, the results

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[10] λ can similarly be defined as GDP, or environmental output generated per unit of gross output. The resulting multipliers are referred to as GDP or environmental multipliers respectively.

[11] There are three principal macro closures in CGE models: government budget balance, investment-savings balance, and external balance. There are also micro closures, determining how the factor markets clear.

[12] A social accounting matrix is a comprehensive, consistent, and usually detailed representation of macro, meso, and micro data for an economy, showing transactions and transfers between economic agents (e.g., producers and consumers) and institutions. See Round (2003) for a full discussion.

of both methods can help to inform investment decisions and broader strategies to maximize the role of the extractives sector in development.

4.2 *Ex post* econometric models

A more recent approach to estimating multipliers has stemmed from the work of Moretti (2010). This has been applied in the context of job multipliers, and specifically for calculating job multipliers in the mining industry by Fleming and Measham (2014) and Moritz (2015). Following Fleming and Measham (2014), the general methodology is as follows. Based on census data for three years (2001, 2006 and 2011) forming two time periods (i.e. 2001–06 and 2006–11), the authors estimate the following equation:

$$\Delta E_{i,t}^{N} = \alpha + \beta \Delta E_{i,t}^{M} + \gamma d_{t} + \varepsilon_{i,t} \qquad [2]$$

where $\Delta E_{i,t}^{N}$ is the change in the log (employment in non-mining sector N) over two years, period t, and $\Delta E_{i,t}^{M}$ is similarly defined for mining, sector M. The variable d_t is a binary variable, which is one for the second period and zero for the first period. Thus d_t controls for possible structural variations across periods. The employment data were drawn from 568 local government areas in Australia. Pooling the data for the two periods means that the regression was based on 1,136 observations.

With the double logarithmic formulation the regression coefficients are interpreted as elasticities, from which the 'job multipliers' can easily be calculated given the known relative sizes of sectoral employment (e.g., mining vs non-mining). The main difficulty is in identifying the causal relationship between the variables, given that employment variables on both sides are endogenous. This is important, because within the context of determining a job multiplier we obviously have to interpret the results as 'one job (in mining) leading to "M" jobs (in non-mining)', etc. Hence, as suggested by Moretti (2010), instrumental variables (IV) or two-stage least squares estimation is preferred to ordinary least squares (OLS).[13] Moretti (2010) reports both, and it is noteworthy that his estimates under IV are considerably lower than those under OLS.

One significant feature of this method is that, as the estimates are based on actual (i.e. realized) employment data, the multipliers capture the employment outcomes resulting from *all* economy-wide effects. The method is, however, confined to job multipliers as defined above. It is not readily or easily extendable to income, tax, or environmental multipliers. As noted earlier, effects on environmental, income, and other profiles (defined earlier by λ—see also footnote 10) are usually linked to the resultant multiplier effects on economic activity, in particular on the level of output. Also, although the estimation is based on a structural model, it does not show the channels (or mechanism) of impact; it therefore simply represents a summary outcome of the whole process, without illuminating any details of the transmission mechanisms that are involved. In this regard it is also crucially important that account is taken of the endogeneity between the two jobs variables, and that the results truly represent a causal relationship.[14]

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[13] Significantly, Fleming and Measham (2014) do not report whether they applied IV methods of estimation or simply applied OLS.

[14] In particular, the correct method of econometric estimation may be crucial, as suggested by Moretti (2010).

4.3 *Ex ante* versus *ex post* methods

Whilst the econometric method of estimating multipliers is relatively recent and its use may be extended in future studies, it should be borne in mind that *ex ante* and *ex post* methods are quite different in concept. Numerically, they are slightly different. An *ex post* multiplier of 0.6 would be equivalent to an *ex ante* multiplier of 1.6 (as the latter includes the initial injection of demand/spending while the former does not). Thus, although it is possible to compare the numerical results, a comparison of the underlying premises of the methods (simulation vs econometrics) is not so straightforward. The *ex ante* approach is best for assessing the likely impact of a new mining project, while the *ex post* approach is more suited to assessing historical outcomes (although the latter can help to build a stock of knowledge about existing mining projects that might inform decisions around new projects).

As well as highlighting the known limitations of the input-output approach, Fleming and Measham (2014) also point out that, for a positive demand injection, the multipliers are always positive. They can never reflect a Dutch disease-type outcome, where the output and employment of a non-mining sector declines as a result of an output expansion of mining. This is a valid criticism. I-O models are fixed-price models, so they are not able to capture changes in relative prices such as those implicit in the exchange rate changes associated with Dutch disease. However, both Moretti (2010) and Fleming and Measham (2014) also claim that another deficiency of I-O models is that they ignore the (employment) effects on non-traded sectors. This is simply not true: services, construction, utilities, and indeed all domestic non-traded production sectors are included in a standard input-output table, and multipliers for all sectors are calculated accordingly. So if 'jobs' are the focus, job multipliers for non-traded sectors can always be included in standard input-output multipliers.

There are legitimate pros and cons of the different modelling approaches,[15] but it may be important to mention that there have been criticisms of the modelling approach as a whole. For example, Gittins (2012) is typical of those who have been highly critical of recent modelling work on the Australian mining industry, where multipliers have been calculated and potential impacts have been established. Gittins's most trenchant criticism appears to be of the general concept of indirect effects and multipliers:

> According to a press release issued by the Australian Mines and Metals Association, '213,200 people are directly employed in mining, oil and gas operations in Australia, with an additional 639,600 indirect jobs created by the resource industry'. Did you notice how the second of those suspiciously precise figures was precisely three times the first? (Gittins 2012)

Whilst Gittins and those who are critical of the modelling approach recognize there will be spillover effects, they offer no practical suggestions as to how these may be assessed. Denniss (2012), cited by Gittins, although heavily critical of modelling, is more circumspect. However, Gittins and Denniss are right to caution users to take careful heed of model assumptions, as these are crucial in determining the results that are generated. These problems are certainly not unique to the mining sector: they apply to all public policy debates in which model results help to inform decisions (other examples include trade policy reform in which extensive use is made of I-O and CGE models).

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[15] See especially Denniss (2012) for a discussion in an Australian context.

5 Estimates of impact multipliers for mining activity

5.1 I-O modelling

I-O and CGE models have been the dominant approach to date for estimating impact multipliers via the industry channel for mining activity. We do not attempt in this paper to provide a comprehensive review of the results. Rather, we review just two studies in some detail for comparison purposes, and refer briefly to the results of other studies. It is not possible to arrive at definitive general conclusions about the size of the multipliers, as they are bound to be heavily conditioned by economy-specific factors, as well as by factors to do with the precise ways in which the multipliers themselves have been calculated.

First, we should distinguish between three commonly used multipliers: output, income, and employment multipliers. The principle is the same for each. The multiplier is defined as the ratio of the total outcome divided by an initial (direct) outcome. For example, the output multiplier is the total gross output (of a particular sector, or of the economy as a whole), taking into account economy-wide interdependences and responses, that results from a unit initial change in gross output of, say, mining. Similarly, the total (wage) income generated by a one-unit increase in the (wage) income from mining would define the income multiplier, etc. Multipliers are pure numbers: they are unit-free.

Second, we have to distinguish between Type I and Type II multipliers. Type I multipliers take account only of the interindustry independence: these generate the direct and indirect effects (the input-output multipliers). Type II multipliers additionally take account of the Keynesian income-expenditure effects: the direct, indirect, and induced effects. A comparison between Type I and Type II multipliers is indicative of the extra economy-wide feedback effects, although for the purpose of using the results to estimate total impacts, only the Type II multipliers are of practical significance.

Table 2: Output multipliers for south-eastern Pará, Brazil

	Type I multipliers	Type II multipliers
Patronal agriculture	1.3	2.4
Peasant agriculture	1.2	2.3
Mining	**1.2**	**2.3**
Primary intermediate	2.0	3.1
Primary processing	1.8	3.0
Manufacturing	1.9	3.0
Wholesale	1.2	2.3
Retail and services	1.6	2.8

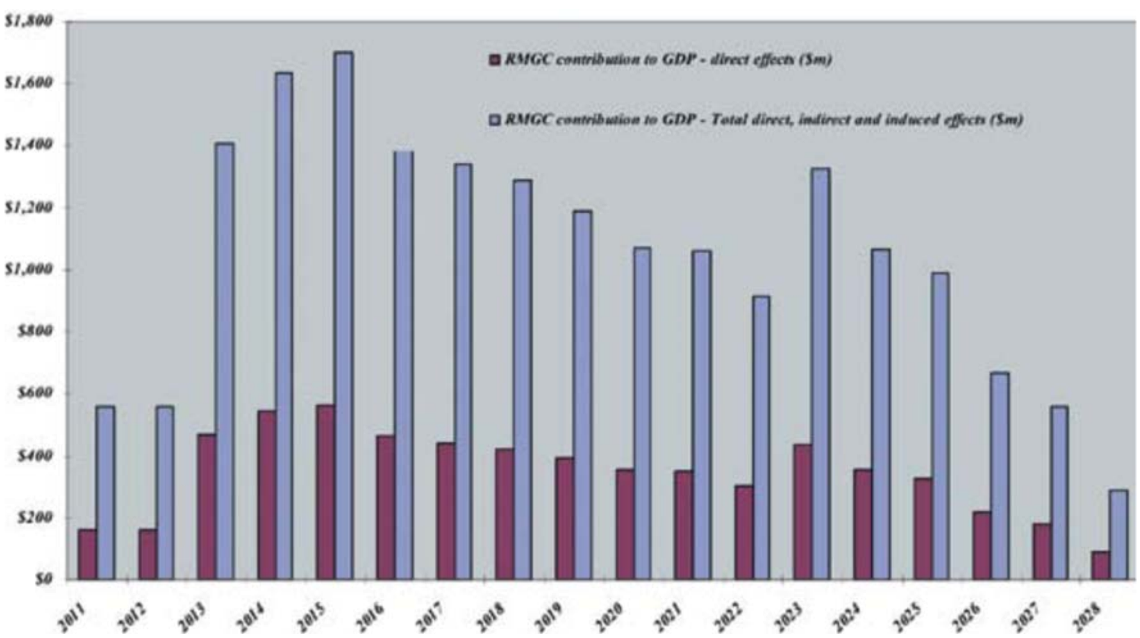
Source: ICMM (2013).

We now illustrate the use of this methodology in the context of a study of the mining sector in the south-eastern Pará region in **Brazil** (ICMM 2013). The full study was concerned with investigating the social and economic impact of mining at the national and local levels, as represented in a case study of Vale, Brazil's largest mining company in south-eastern Pará.[16] Table 2 shows the output multipliers for a selection of sectors, including mining. The Type I multipliers in the first column show the output effects on the whole south-eastern Pará regional economy that arise from a unit increase in final demand in each sector. Thus a R$1 increase in the demand for output of mining

[16] Filgueiras et al. (2017 forthcoming) examine other aspects of the Brazilian/Vale case.

is likely to lead to R$1.2 of output in the south-eastern Pará region as a whole. This is a small increase, but this is true of the increases that would result from R$1 increases in the demand for output for all other sectors. The reason why all the multipliers are so low is because the industry linkage in such a relatively small region is low. The Type II multipliers in the second column again show the total output effects in the south-eastern Pará economy arising from a unit expansion of final demand, but now the effects of household spending out of income generated are also taken into account. These multipliers are larger. For example, the multiplier for mining is 2.3, which means that, taking account of the spending effects of households out of the income generated from the increased production activity (i.e. the 'wage linkage' effect), a further R$1.1 of output is generated by mining in the south-eastern Pará region. It is useful to note that, while there is some variation in the total Type I stimulus across sectors, the additional stimulus due to the wage linkage (that is, the induced effect) is similar across sectors, i.e. about R$1.1 of additional output (column two minus column one). There is a simple technical reason for this. The multiplier model used does not differentiate between different types of labour or of households. Hence the income generated is spent according to one single pattern of expenditure, so that the induced multiplier effects will be the same, regardless of where the initial income is generated. Clearly, the multipliers for mining only apply in the operational phase, when there is mining output. But during the construction phase, to the extent that there is procurement of locally produced goods and services, the multiplier effect will be a combination of the output multipliers (as in Table 2) according to the mix of outputs of sectors stimulated by these procurements.

Figure 4: The direct and estimated total Rosia Montana Gold Mine Corporation contribution to Romania's GDP



Source: OPM (2009), reproduced with permission.

A second case study is useful for illustrating another feature of multiplier analysis. The input-output multipliers as described above and used in most studies are not derived from dynamic models. By 'dynamic' in this context we simply mean models with an explicit time dimension. However, the standard models are often used to estimate the equilibrium outcomes of a series of annual primary effects. The results do not show the time profile of the incidence of total effects, but they can be used to show the total effects in relation to the time profile of the primary impacts. This is best illustrated in relation to an example based on a study for **Romania** (OPM 2009). Figure 4 shows the direct and estimated total contribution to Romania's GDP arising from the Rosia Montana Gold Mine Corporation over a projected 18-year period. This covers two years in construction (2011–12) and 16 years of operation (2013–28). In this case the *direct* contribution to GDP in the two years of the construction phase is lower than that anticipated during the 16 years of the operation phase. But although there is variation year on year, the estimated *total* effect on GDP from the construction and operational phases of the gold mine is an *additional* 2.0 to 2.5 times the direct contributions (i.e. a multiplier of between 3.0 and 3.5).[17] However, the indirect and induced contributions shown for each year of the projection will not necessarily all materialize in that year; there will be lags as the repercussions work their way through the economic system.

Bocoum (2000) has utilized input-output multipliers to undertake a comparative study of the impacts of mining activities in countries at various stages of development and in different kinds of mining-related sectors. The study was based on the calculation of Hirschman linkages, so it provides some useful evidence on multipliers. Bocoum harmonized input-output tables for **Australia**, the **United States**, and **Chile**, and distinguished sectors for mining, mineral processing, mineral and energy manufacturing, and energy production. The results are reported in terms of Hirschman total linkages,[18] although they are based on (Type I) output multipliers and (Type II) income multipliers (not reported). The main results of her study are:

- The type of mineral activity affects the size and nature of the secondary effects (multipliers);
- Energy (coal, oil and gas) extraction shows a relatively small direct contribution to GDP, although it is important in terms of total multipliers;
- The overall contribution of non-ferrous mining to output and income is generally low, but it has strong linkages with domestic industries such as energy and other mineral-related activities;
- Non-metallic mining, with the diversity of its output, has the potential for stronger linkages than metallic mining;
- Mining services have strong backward linkages;
- Petroleum and coal transformation generate strong forward linkages;
- The agricultural and industrial chemicals sector is important in terms of output and income and total linkages.

IDC (2013) used the input-output methodology to explore the linkage between the mining and manufacturing sectors in **South Africa**. Again, based on 2012 data, the Type II output multipliers for the sector were estimated to be about 2.0. Mining is now a smaller share of exports compared with 1970, and also the value is lower in real terms. IDC (2013) also reports the changing structure of South Africa's mining sector between 1980 and 2012. It is now much more diversified, with gold becoming a diminishing proportion of mining sales. The backward and forward linkages with the manufacturing sectors remain strong.

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[17] The heights of the blue bars are approximately 3.0 to 3.5 times the heights of the red bars.

[18] Total linkages (TL) are defined as the sum of backward (BL) and forward (FL) linkages. A sector with a BL or FL greater than 1.0 is considered 'strong', so a sector with a strong BL and FL and a TL greater than 2.0 is considered to be a 'key' sector.

Rayner and Bishop (2013) applied the input-output methodology to obtain a 'broad measure' of the boom in natural resources in the **Australian** economy from about 2004 to the end of the decade. They used a sectoral context in which they distinguished between 'resource extraction activity' (coal, oil, gas, iron ore, etc.) and 'resource-related activity' (business services, construction, etc.). Based on an input-output table, the total direct contribution of the resource sector to Australian GDP in 2011–12 was 11.5%. On the basis of Type I multipliers, they estimated that a further 6.5% of GDP was attributable to resource-based activity (an implied Type I multiplier of 1.57). If the wage link had been included, then the Type II multiplier would have been well in excess of 2.0.

Finally, a recent large-scale input-output study for the **United States** (NMA 2012) considers the economy-wide contributions of US mining. Based on a large regional input-output table for 2012, the study is an exemplar of its kind. The mining sector includes three subsectors: mine operations, mining support activities, and transport of output from the mine. This underlines one of the problems of comparability across studies. It is not always clear just how comprehensive the output measure is (i.e. how exactly 'mining' is being defined). Transport and ancillary services are important examples of this ambiguity. Using this broad definition of mining activity, the study estimates that the sector contributed 0.64% of US GDP in 2012. But based on a calculation of Type II multipliers, taking account of backward linkages and induced effects, the contribution to GDP rose to 1.4%. The implied Type II multiplier for the sector and for the US as a whole is 2.2. The variation in the multipliers for different branches of mining across US states is considerable. However, focussing on the results for the mining sector as a whole, the Type II multiplier for California is 4.7, and for New York and New Jersey even higher (9.4 and 11.6 respectively). These values would imply that there is a huge secondary effect of mining activity in these states. But in all cases where the multipliers are very high, the *direct* contribution of mining to GDP, in the state and nationally, is quite modest. Nevertheless, this does suggest that upstream effects might be significant when economic activity is broadly based and well developed.

5.2 CGE modelling

Relatively few CGE-based studies to assess mining activity per se are available in published work, but two examples will help to illustrate what can be achieved with this approach. A main feature of CGE models is their ability to deal with price shocks and changes in relative prices. For example, unlike in I-O models, the real exchange rate effect of Dutch disease can be captured in CGEs. The models are complex and there is often a great deal of specificity in terms of data, assumptions, and model specifications, which makes comparisons difficult to manage.

Downes et al. (2014) attempted to estimate the effects of the mining boom in **Australia** over the decade from the mid-2000s. The 'boom' encapsulated a tripling of the world price of mining exports together with a sharp increase in investment in mining. Their objective was to assess the impact of these shocks on living standards, and to investigate whether the economy experienced negative effects due to Dutch disease. Their overall assessment was that, because of the requirements by mining for manufactured goods, the negative effects due to Dutch disease were not strong. However, the results do show that manufacturing output was about 5% below what it would have been without the resource boom. Also, overall living standards (measured by the change in real disposable household income per capita) were significantly higher than they would have been without the boom, although there were differences across household groups according to the sectors from which they drew their incomes. For example, households relying on income generated in import-competing industries did less well. The study showed that the boom benefitted households as a whole through several channels: higher employment, higher real wages, and lower average tax rates. The study illustrated several features of the CGE methodology referred to in the previous section. In particular, unlike the input-output methodology, it shows the role of prices, which may precipitate both negative and positive effects of seemingly positive shocks. In addition, it shows that the configuration of the model affects the model outcomes.

As a means of verifying their specification, Downes et al. (2014) reported on the performance of their model compared with that of some other Australian models. An unrelated study by Tourism Research Australia (2013) also carried out a CGE model-based study of the impact of the mining boom on tourism. Many of their key aggregate results were broadly similar to those of Downes et al. (2014), but they were able to report wide variation of outcomes at a state-wide level. In terms of contributions to GDP, there were losers as well as gainers from the mining boom.

In a classic example of this genre, Mogilevskii et al. (2015) assess the impact of the Kumtor gold mine on the economic and social development of the **Kyrgyz Republic**. The authors adapt a dynamic CGE model developed by the World Bank, and calibrate it to the Kyrgyz economy. Kumtor is the largest enterprise in Kyrgyzstan, so its impact is highly non-marginal. The aim of the study was to estimate not only the direct contributions but also the multiple spillover (secondary) effects in the context of the country's long-term development. Mogilevskii et al. simulate three scenarios in terms of gold production and then estimate the effects on the main macroeconomic variables. There is little disaggregation within the model to facilitate a detailed impact analysis. Also, the results are heavily conditioned by the model assumptions (i.e. the model 'closure' rules), where in particular the labour market clearing assumption is quite simple. Mogilevskii et al. conclude that there is little scope for increased employment in the mining enterprise, and that a main benefit of Kumtor is its substantial contribution to the government budget and social spending.

CGE simulation models permit several policy-relevant extensions to be added to the basic economic framework. For example, there are many examples using CGEs to examine the income distribution consequences of macroeconomic policy shocks (e.g., changes in trade policy). But there are also examples where the likely distributional (or gender or environmental) consequences of extractives projects/policies have been examined via simulation models. Andersen and Faris (2002) examined the possible consequences for the economy of **Bolivia** of an increase in natural gas sales to Brazil. As part of their exercise they demonstrated that, while there would be a likely increase in wages and incomes of all groups in society (and hence the policy would be good for growth and poverty alleviation), there would also be an increase in inequality: smallholders and informal-sector workers would not benefit by as much as those in the formal sector. Likewise, in an interesting series of studies of large-scale mining in **Mongolia**, based in part on CGE models, Kahn et al. (2011) report on the significant gender differences in the benefits (and costs) accruing from the mining boom. In that example, less than 10% of the workforce in extractives was female (and these were employed mainly in service support roles), whereas most of the risks (health, social, and family disruptions) were borne by women.

The assessment of environmental consequences of extractive industries is an ongoing issue, to prevent, mitigate, and control the environmental damages and negative social impacts, improve environmental management, and ensure compliance with environmental standards. There will be primary and secondary environmental effects, which again can be captured via simulation models: both I-O and CGE models can be used to do this. Thiele (1999) used a basic CGE model for environmental policy evaluation of the **South African** mining sector. The results, linking sectoral outputs to hazardous waste (air emissions, waste water, and solid/liquid waste), are fairly embryonic and are only indicative of how the models might be developed further. These examples demonstrate that CGE and simulation models are flexible and potentially useful aids for examining wider policy consequences of extractives sector expansions.

5.3 Econometric modelling

The *ex post* econometric approach was originally used by Moretti (2010) in the context of estimating the long-term employment multiplier at the local level in the US. Specifically, he quantified 'the long-term change in the number of jobs in a city's tradable and non-tradable sectors generated by an exogenous increase in the number of jobs in the tradable sector, allowing for the endogenous reallocation of factors and adjustment of prices' (Moretti 2010: 9). The estimation was based on time series census data from 2001 to 2011. In common with the CGE approach (and unlike input-output), because it uses data on 'initial' employment and 'eventual' employment, effectively the method takes into account endogenous price changes.

Fleming and Measham (2014) applied this approach in order to estimate local job multipliers of mining in **Australia**. The application of the econometric methodology is fairly straightforward: the data are drawn from data on employment changes for two five-year periods, 2001–06 and 2006–11. The application of the Moretti methodology (see equation [2] above), with mining employment as right-hand side variables, yielded estimates of job elasticities at the sectoral level. Using census data to determine base year employment shares, the authors then calculated local job multipliers. Although it is possible for elasticities to be negative, implying that job increases in mining might lead to job losses in other sectors, virtually all were positive, and seven were found to be statistically significant. These included elasticities for wholesale and retail trade, transport, financial services, real estate, and other services; construction was close to being significant too. Most of these imply job multipliers that are greater than one (i.e. they are greater than 2.0 in concordance with the input-output multiplier definition of multipliers). Elasticity estimates for manufacturing were positive, although agriculture was slightly negative (neither was statistically significant). All of this implied that mining had significantly positive spillover and secondary effects in terms of employment across almost all sectors of the economy.

The Moretti approach has also been used by Moritz (2015) on data for a more geographically focussed mining region in northern **Sweden**. Due to data limitations, his industrial sector definitions are far more aggregated, and the results are generally not statistically significant. Based on his estimates, except for the sector 'government services', all of the multipliers are positive. However, they are slightly lower than those obtained by Fleming and Measham for Australia; this may be due to the fact that the Swedish regions are smaller and the industrial spread is narrower. Overall, the positive secondary effects of mining activity are confirmed.

6 Public spending channel

6.1 Direct impacts on human development

The second principal channel through which mining activity impacts on human development is the public spending channel. Table 1 above suggests that typically between 15% and 20% of the production value of mining activity accrues as taxes and other revenue to government, perhaps even more in the cases of some kinds of extractives (e.g., oil and gas). These revenues create the funding which can be used by government to enhance human development in two broad ways:

- Directly, through spending on social sectors: e.g., current spending and capital spending on health and education facilities, as well as on social protection programmes including cash transfer schemes;

- Indirectly, through spending to enhance economic growth and development, i.e. by boosting capacity in the economy for further income generation and social investment.

'Human development' is open to wide interpretation and definition. It is often defined in terms of three dimensions: health, education, and living standards. Living standards are usually measured in terms of a money-metric criterion, such as real per capita income (or similar). Thus 'living standards' are mainly determined by incomes generated in production directly or indirectly, and these are predominantly governed by outcomes through the industry channel discussed previously. However, the living standards dimensions through health and education and other social spending can be strongly influenced through the public spending channel.

As Witter and Jakobsen (2017) argue in a parallel paper in this series, the case for investing natural resources revenues in social sectors is strong.[19] They identify several main channels for this potential impact:

- Creating a better-educated and healthier workforce that tends to be more productive, contributing to increased economic growth;

- Developing domestic human capital to help sustain and improve growth in industries besides extractive industries;

- Capturing the 'demographic dividend' (a fall in infant mortality in high-mortality populations initially boosts population growth, slowing economic growth; however, fertility then decreases as families choose to have fewer children when they realize that the mortality rate has changed);

- Generating knowledge for the future and creating healthier populations, thus feeding into a virtuous circle;

- Capturing potential temporary macroeconomic externalities (healthier and better-educated populations can help to generate, for example, higher savings rates and increased flows of FDI, bringing in new technology and thereby increasing trade and contributing to job creation);

- Building social cohesion and politically stable societies—this is particularly important in post-conflict and fragile states.

The authors also note that inclusive growth also requires attention to low-income households. A growing body of evidence indicates the potential benefits of cash transfers: these help to tackle poverty in the short run, improve social cohesion, boost local economies, and build human capital in the long term.

However, Witter and Jakobsen (2017) also point to a risk of natural resource revenue flows, which have a propensity to distract from results-driven questions ('what do we want to achieve?'), leading instead to a focus on expense-driven questions ('we have funds, what should we spend them on?').

[19] However, that case does rest on the assumptions that these sectors are given a high priority in the national government's development plans, especially in lower-income countries, and that this spending has the potential to lead to high economic returns.

In order to try to address this risk, AfDB and BMGF (2015c) have developed a framework of analysis that identifies the key questions that can be used to inform investment decisions in the social sectors and so help to produce coherent results.

The *ex ante* decisions for governments in this area are difficult to make. Similarly, the *ex post* effects on outcomes for human development via the public spending channel are difficult to assess. For this purpose it is possible to use indicators such as income per capita or consumption per capita, which are both *outcome* measures. But it is more usual to use *input* measures for health and education—such as school enrolment, hospital visits, or bed occupancy. More broadly, any increase in public spending on education and health that is clearly facilitated by revenues generated by mining activity can itself be seen as a useful indicator of a potential enhancement of human development.[20]

6.2 Indirect effects via the public spending channel

For many developing countries, the start of a mining- or oil-related activity takes place at an early stage of development (and in many cases it has preceded political independence). Many argue that resource extraction should be seen as a helping hand to achieve the eventual transformation and socio-economic development of the economy, and not as an end in itself (see also Lahn and Stevens (2017), who see transformation and diversification as a key aim of the policy for extractives). Additional public revenues generated from the extractives sector can clearly provide governments with the means to help to facilitate this process of transformation, diversification, and development in various ways (AfDB and BMGF 2015b). Here are a few examples:

Investing in infrastructure

Most low-income countries—particularly in Africa—are known to have huge infrastructural deficits: a gap between the infrastructure that they need and that which they actually have in place. These deficits in turn constitute a serious brake on growth, irrespective of whether the country concerned has the advantage of natural resources wealth. However, the availability of additional public revenues from extractive resources provides an opportunity to at least make a dent in such deficits. Whilst there is no guarantee that an improvement in capacity and infrastructure will have a positive impact, there are some obvious ways in which such spending can help to generate benefits by enhancing economic growth. Prime examples are improvements in access to the electricity grid, communications, roads, and transport networks. However, Henstridge and Page (2012) caution that the benefits from such investments are not automatic. For example, if construction faces bottlenecks, then any new investment could force up costs and prices, thereby reducing output more generally for any increase in nominal investment.[21] Further, the scale of the available resource revenues in most country cases may be small relative to the size of the infrastructure deficit. Hence those revenue need to be used judiciously, and often in partnership with larger sums from private investors, if they are to make any real impact on the infrastructure problem. Public policies (e.g., for electricity pricing) would also need to be aligned sensibly in order to achieve the best possible outcomes from any new investments.

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[20] Although this does of course assume that the money is reasonably well spent and not wasted.

[21] They report, for example, that there is some evidence that the marginal costs of construction in Uganda rose in 2010–11 as a result of rapid public investment.

AfDB and BMGF (2015b) cite Chile, Indonesia, and Malaysia as examples of countries that have successfully managed the transformation from economies that were heavily resource-based to those that are now more broadly based. These transformations were, at least in part, the result of a strategic view and subsequent public policy actions taken and associated public spending in each country. The well-known danger here is that of poor selection of the new strategic industries for the future. The availability of large resource revenues can all too easily be used to provide public support to industries whose basic commercial viability is lacking and where eventual financial failure may therefore be the outcome.

Apart from big-ticket strategic actions, other examples include public investments to help strengthen an economy's smaller firms via either technical guidance or financial support; the creation of special economic zones; new training initiatives targeted at new emerging industries; and other improved productivity-enhancing initiatives via research and development and enterprise development. In this regard, ongoing work by Sutton (2009 onwards) and associates on 'enterprise maps' is noteworthy. These are inventories of profiles of leading companies in each major industry in selected countries in sub-Saharan Africa, designed to trace the origins of current industrial capabilities. The aim is to help potential investors, as well as policymakers who are concerned with fostering industrial development, to identify promising targets to link more fully into the supply chains of local extractive companies and their overseas associates. So far five countries have been profiled, spanning industries in agribusiness, manufacturing, and construction.

As presented here, the decisions about the 'best' use of additional public revenues from extractive industries come down to an apparently simple choice: providing direct help to boost local living standards in the short term, or investing public funds in broader development initiatives for the longer term. In practice those decisions—mediated as they are through messy budgetary processes that are themselves impacted by political considerations and serious informational deficits (e.g., how much revenue may be available in each future year)—will rarely be taken in any clear and scientific manner. However, wise and well-organized governments will do their best to use such frameworks as are available to guide their thinking and to weigh the choices available to them with the greatest possible care. In particular, there is also a strong case to try to link the benefits of the two public spending routes by embedding decisions about them within a clear set of economic and industrial policies that build explicitly on the stimulating effects that are certain to come from mining and other extractives projects.

7 Conclusions

The social and economic impacts of the extractives industries in a development context are potentially wide ranging. In this paper we have set out the framework and channels of impact, identifying two principal channels, namely the industry channel and the public spending channel. Of these, the public spending channel is perhaps the best known, most discussed, and best documented. The effects on human well-being through this channel are direct and easily understood: they stem from the spending of tax revenues on public projects, especially on health, education, and community projects. This channel is also fundamental to the case that host governments make for extracting more tax revenue from mining activities. But the industry channel—being generally much larger—can also have major impacts on broader economic areas as well as human development and well-being via the generation of income and the increase in domestic economic activity. This paper has shown that a good deal of this income generation is secondary. It is fundamentally dependent for its magnitude on the existing economic structure of a country and how this structure can (and might) develop in future, and this in turn is influenced by economic and industrial policy as well as by public spending. Governments need to address this potential, and their own role in realizing it, with as much seriousness as they lobby for more tax revenue to spend on their own account.

In this paper we have focussed much attention on the industry channel, setting out the various ways in which the secondary effects can be (and have been) ascertained and ultimately measured. Formal methods have relied on economic models which fall into two broad categories: *ex ante* and *ex post* models. *Ex post* models—although currently popular for assessing historical consequences (e.g., non-mining jobs that result from new jobs in mining)—are not so effective when applied *ex ante*. But even the *ex ante* models are only as good as the data and model specifications that are employed. The capacity to do this modelling work—and to collect the data—needs to be embedded in a sustained institutional setting, rather than being generated in one-off efforts.

There are by now many examples of the use of multiplier models to examine the secondary effects of mining and extractive industrial activity. Not surprisingly, the secondary effects are stronger in more developed economies where more domestic upstream and downstream activity is generated. In economies which are predominantly agrarian and have a weak industrial base, the secondary effects on other industries are inevitably lesser. But what the multiplier studies also tend to show is that the induced economic effects arising from the spending out of the incomes generated (directly and indirectly) are often very significant. Furthermore, it is clear that these induced effects might be even stronger if the industrial base of any host country were to be broadened and expanded. All of this reinforces the case for a dedicated economic and industrial policy to accompany mining and extractives projects, so that the strongest possible social and economic benefits will flow via both the industry and public spending channels. It is all too easy to overlook especially the induced effects that are more diffuse and so less visible than the other types of mining impacts.

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