



# Input–output interactions and optimal monetary policy

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## ABSTRACT

This paper deals with the implications of factor demand linkages for monetary policy design in a two-sector dynamic general equilibrium model. Part of the output of each sector serves as a production input in both sectors, in accordance with a realistic input–output structure. Strategic complementarities induced by factor demand linkages significantly alter the transmission of shocks and amplify the loss of social welfare under optimal monetary policy, compared to what is observed in standard two-sector models. The distinction between value added and gross output that naturally arises in this context is of key importance to explore the welfare properties of the model economy. A flexible inflation targeting regime is close to optimal only if the central bank balances inflation and value added variability. Otherwise, targeting gross output variability entails a substantial increase in the loss of welfare.

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## 1. Introduction

This paper deals with the implications of factor demand linkages for monetary policy design. We build a dynamic stochastic general equilibrium (DSGE) model with two sectors that produce services and manufactured goods. The gross output of each sector serves either as a final consumption good, or as an intermediate input in both sectors, according to a realistic input–output structure.

Factor demand linkages are empirically relevant<sup>1</sup> and their importance in the transmission of both sectoral and aggregate shocks has long been recognized by the literature exploring the sources and channels of propagation of the business cycle. Horvath (1998, 2000) shows that cross-industry flows of input materials can reinforce the effect of sectoral shocks, generating aggregate fluctuations and co-movement between sectors, as originally hinted by Long and Plosser (1983).<sup>2</sup> More recently, Bouakez et al. (2011) and Sudo (2008) have shown that factor demand linkages help at generating positive co-movement between non-durable and durable spending in the face of a monetary innovation, thus overcoming

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<sup>1</sup> Input–output structures are a pervasive feature of industrialized economies. Most of the goods in the economy are used for both consumption purposes and as intermediates in other sectors, in accordance with dense networks of factor demand linkages. Bouakez et al. (2009) and Holly and Petrella (forthcoming) report extensive evidence on the importance of input–output interactions. In this respect, we should note that the cost of intermediate goods corresponds to the largest share in the total cost of production. Dale Jorgenson's data on input expenditures by US industries show that input materials (including energy) account for roughly 50% of outlays, while labor and capital account for 34% and 16%, respectively.

<sup>2</sup> Kim and Kim (2006) show that a similar mechanism generates widespread co-movement of economic activity across sectors. In a similar vein, Carvalho (2009) explores the network structure of inter-sectoral trade.

the limits of standard two-sector models that feature heterogeneous degrees of price stickiness across sectors.<sup>3</sup> However, none of these papers has taken a normative perspective. The novel contribution of the present study is to explore how monetary policy should be pursued in a model with cross-industry flows of input materials.

In our framework the monetary authority cannot attain the Pareto optimal allocation consistent with the full stabilization of output and inflation. Thus, we explore optimal monetary policy under the assumption that the policy maker can credibly commit to a policy rule derived from the minimization of a social welfare function. The loss function balances, along with sectoral inflation variability, a preference to reduce fluctuations in aggregate consumption (or, equivalently, value added). Given the natural distinction between consumption and production in the presence of input materials, it is no longer irrelevant whether the monetary authority targets the output gap or the consumption gap. This result has important implications for both the transmission of exogenous shocks and the selection of policy regimes as alternatives to the optimal policy under commitment.

Introducing factor demand linkages into an otherwise standard two-sector model amplifies the loss of social welfare and alters the transmission of shocks to the system, compared to the benchmark economy without input materials. A distinctive feature of the model is that a technology shock to either sector also affects potential output in the other sector, even if preferences over different types of consumption goods are separable. Furthermore, factor demand linkages imply that the relative price of services not only affects the marginal rate of substitution between manufactured goods and services, but also exerts a positive (negative) impact on the real marginal cost in the manufacturing (services) sector. The relative magnitude of the second effect depends on the off-diagonal elements in the input–output matrix.

Beyond reconciling conventional two-sector DSGE models with a realistic structure of the economy, this paper detects important differences between the way monetary policy should be pursued and what is otherwise prescribed by the existing literature on multi-sector models without factor demand linkages. We compare the welfare properties of the model under alternative policy regimes and show that a flexible inflation targeting regime delivers a welfare loss close to that attained under the optimal policy. Most importantly, the central bank attains a smaller loss when fluctuations in aggregate or core inflation are balanced with those in real value added, compared to the loss induced by targeting gross output. We also consider the case of asymmetric price stickiness, which implies a natural divergence between core and aggregate inflation. Although such a difference is still relevant within our framework, targeting either core or aggregate inflation makes little difference in terms of welfare loss. By contrast, what matters is the term accounting for real volatility: in this respect, targeting the consumption gap entails substantial benefits compared to targeting the production gap. These results emphasize the distinction between consumption and production that naturally arises in this class of models.

The remainder of the paper is laid out as follows: Section 2 introduces the theoretical setting; Section 3 discusses the calibration of the model economy; Section 4 explores the Pareto optimal outcome; Section 5 studies the implementation of the optimal monetary policy under commitment and compares the resulting loss of social welfare with that attainable under a number of alternative policy regimes. Section 6 concludes.

## 2. The model

We develop a DSGE model with two sectors that produce manufactured goods and services, respectively.<sup>4</sup> The model economy is populated by a large number of infinitely-lived households. Each of these is endowed with one unit of time and derives utility from the consumption of services, manufactured goods and leisure. As in Bouakez et al. (2011) the two sectors of production are connected through factor demand linkages.<sup>5</sup> Goods produced in each sector serve either as a final consumption good, or as an intermediate production input in both sectors. The net flow of intermediate goods between sectors depends on the input–output structure of the supply side.

### 2.1. Producers

Consider an economy that consists of two distinct sectors producing services (sector  $s$ ) and manufactured goods (sector  $m$ ). Each sector is composed of a continuum of firms producing differentiated products. Let  $Y_t^s$  ( $Y_t^m$ ) denote gross output of the services (manufacturing) sector:

$$Y_t^i = \left[ \int_0^1 (Y_{ft}^i)^{\frac{\epsilon_i - 1}{\epsilon_i}} df \right]^{\frac{\epsilon_i}{\epsilon_i - 1}}, \quad i = \{s, m\}, \quad (1)$$

<sup>3</sup> Although the co-movement puzzle has been emphasized in connection with the dichotomy between durables and non-durables (Barsky et al., 2007), sectoral co-movement is an inherent feature of the business cycle (see, e.g., Hornstein and Praschnig, 1997; Christiano and Fitzgerald, 1998) that multi-sector DSGE models need to be able to replicate.

<sup>4</sup> Both types of consumption goods are non-durable. Petrella and Santoro (2010) study optimal monetary policy in a similar setting, assuming that consumers have preferences defined over both durable and non-durable goods.

<sup>5</sup> Throughout the paper we will refer to factor demand linkages as indicating cross-industry flows of input materials. If a specific feature of the framework is exclusively determined by the use of intermediate goods in the production process (i.e., inter-sectoral relationships are not essential) we will explicitly refer to input materials.

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